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Education and Training Interventions to Improve Emergency Department Triage Accuracy and Decision-Making among Nurses: A Systematic Review

Khalid Abdullah S. Alharbi*, Faridah Mohd Said

Lincoln University College, Wisma Lincoln, No. 12-18, Jalan SS6/12, 47301 Petaling Jaya Selangor, Malaysia

**Corresponding Author's Email: khalidalsaleme@gmail.com*

ABSTRACT

Background: Accurate triage is a critical component of timely emergency care, but there is considerable variation in acuity assignment and mis-triage across Emergency Department (ED) settings. Under-triage has important patient safety implications such as delayed care and unnecessary deterioration. Education and training are common methods for improving triage decision-making, but the most effective methods are unknown. **Objectives:** To synthesize evidence on education and training interventions used to improve triage accuracy and decision-making among emergency nurses across multiple five-level triage systems, using the Canadian Triage and Acuity Scale (CTAS) as the primary reference framework. **Methods**: Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed. The search was conducted in the databases Medline/PubMed, Scopus, and Google Scholar up to 16 March 2026. Studies included an assessed education, training, or decision-support intervention targeting triage for emergency nurses. Outcomes were measured as acuity assignment accuracy, under-/over-triage, interrater reliability and decision-making skills. Narrative synthesis was used for the findings because of the heterogeneity in study designs. **Results:** Seventeen studies met inclusion criteria, spanning CTAS, Emergency Severity Index (ESI), Korean Triage and Acuity Scale (KTAS), Australasian Triage Scale (ATS), and South African Triage Scale (SATS) contexts. Interventions comprised refresher education, mobile and gamified applications, e-learning, simulation, problem-based learning, and electronic decision support. Most studies reported positive findings regarding triage performance post-intervention, but effect sizes varied across systems and settings. Training effects may diminish over time without reinforcement, and barriers to implementation included workload, fatigue, and organizational factors. **Conclusion:** Structured, interactive, and reinforced methods, including technology-facilitated decision support where available, may contribute to triage competency maintenance and patient safety. However, effects are heterogeneous across triage systems and settings, and findings from non-CTAS systems should not be directly generalized to CTAS.

Keywords: Canadian Triage and Acuity Scale (CTAS); Decision-Making; Education; Emergency Nursing; Systematic Review; Training; Triage Accuracy; Triage

INTRODUCTION

Triage in the Emergency Department (ED) entails quick categorization of patients according to urgency levels to maximize patient movement, minimize unnecessary hospitalization, and enhance satisfaction (Alhabdan *et al*., 2019). It is an essential emergency nursing decision-making task, and correct and timely decisions will influence care trajectories and resource distribution (Alshurtan *et al*., 2024). Multiple five-level triage systems are used internationally, including the CTAS, the ESI, the ATS, the KTAS, and the SATS. Although these systems share common acuity-level structures, they differ in assessment criteria, operational contexts, and validation histories. The CTAS is a five-level system designed to prioritize assessment and treatment and facilitate consistent allocation (Hall *et al*., 2025). Nevertheless, the accuracy of CTAS and inter-rater reliability depend on the setting, patient population, and experience of nurses, which indicates the necessity of continuous training and standardization (Allen *et al*., 2015). Since triage leads to downstream prioritization, bed location, clinician focus, and diagnostic style, consistency is the key to patient safety and performance.

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The effects of mis-triage extend beyond individual patients. Under-triage exposes time-sensitive conditions to dangerous delays. Sax *et al*. (2025) reported that under-triaged cases of subarachnoid hemorrhage waited more than 33 minutes for antihypertensive orders, and aortic dissection cases waited more than 8 minutes for diagnostic computed tomography (CT). Small delays can also impede the recognition of sepsis, stroke, and acute coronary syndrome, particularly during periods of crowding, night shifts, or mass-casualty incidents where delays accumulate to cause harm (Hinson *et al*., 2018). Over-triage represents a misuse of limited resources and contributes to worsening crowding; reducing over-triage has been linked to better throughput (Sjöstedt *et al*., 2026). Kingswell *et al*. (2025) associated triage errors with unsafe delays, clinical deterioration, increased pain, higher in-hospital mortality, and broader consequences for public trust and regulatory compliance.

The process of triage decision-making is complex, depending on clinical severity, comorbidities, nursing knowledge, cognitive burden, and situational pressures (Goldstein *et al*., 2017). Triage can be enhanced through education, with workshops, case-based learning, simulation, and e-learning demonstrating positive results (Butler *et al*., 2023). Competence is prone to decline over time through skill atrophy, decreased practice, guideline updates, and drift from standardized criteria (Varndell *et al*., 2019). This evidence supports regular booster refreshes rather than single training episodes (Hinds *et al*., 2025). Refresher training is therefore vital to ensure accuracy (Zagalioti & Ziaka, 2025). Electronic decision support, such as electronic CTAS (eCTAS), may standardize data capture and optimize agreement, whereas algorithms and artificial intelligence (AI) approaches may support classification and risk identification (Liu *et al*., 2025). Although the evidence base has been growing, synthesis is still limited regarding which educational designs best enhance triage accuracy and sustain gains among emergency nurses (Hardy & Calleja, 2019). This review uses CTAS as a primary reference framework while incorporating evidence from comparable five-level triage systems to interpret training methods. Non-CTAS studies are used to support the interpretation of educational approaches and are not presented as direct CTAS outcome evidence.

Objectives of the Study

To identify education and training interventions that enhance emergency department triage accuracy and clinical decision-making. To evaluate the effects of these interventions on triage performance and examine the factors influencing their effectiveness and sustainability.

METHODOLOGY

A systematic literature review was carried out according to PRISMA 2020 guidelines (Page *et al*., 2021). Eligible studies comprised interventions that focused on triage and were designed to improve triage accuracy and clinical decision-making, including education, training, refresher courses, simulation, e-learning, or decision support (El Arab & Al Moosa, 2025). The main population studied was emergency nurses; emergency triage workers who were not nurses were only included if the intervention involved transferable processes of triage decision-making. CTAS studies were prioritized, but similar systems, such as the ESI, Australasian Triage Scale (ATS), KTAS, and SATS, were included where relevant to structured acuity assignment. Experimental, quasi-experimental, observational, and qualitative designs were included. Exclusions comprised editorials, commentaries, studies without relevant outcome data, and studies unrelated to triage training (Saban *et al.,* 2026). CTAS evidence was treated as the primary source, with non-CTAS evidence used only to provide context for transferable training approaches.

A search was done in Medline/PubMed, Scopus, and Google Scholar until 16 March 2026. The keywords for core search concepts were CTAS terminology (Canadian Triage and Acuity Scale,; Paediatric Canadian Triage and Acuity Scale, Paed CTAS), triage performance outcomes (accuracy, interrater reliability, kappa, under-triage, overtriage), education/training terms (simulation, e-learning, workshop, and refresher), and clinical roles (emergency nurse, triage nurse). An example search string combined: (CTAS or Paed CTAS) and (train* or educat* or simulation or e-learning) and (emergency nurse* or triage nurse*) and (accurac* or reliab* or decision making or kappa or under-triage or over-triage). Reference lists of eligible studies were also screened. Titles and abstracts were screened after duplicate removal, followed by full-text eligibility review. Data extracted included study design, setting, triage system, intervention type and duration, participants, outcomes, and follow-up. Methodological quality was appraised using the Mixed Methods Appraisal Tool (MMAT), which supports appraisal across qualitative, randomized, non-randomized, descriptive, and mixed

methods designs (Hong *et al*., 2018). Risk-of-bias considerations were interpreted narratively according to design, comparator use, outcome measurement, follow-up, and implementation limitations. Of 423 records identified, 264 were screened after duplicate removal; 145 underwent full-text review, and 17 met eligibility criteria (Figure 1).

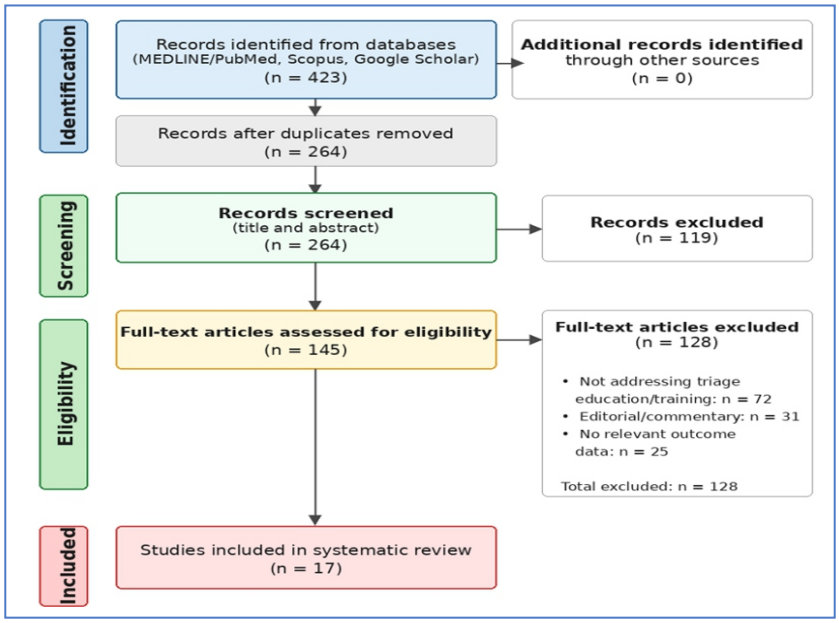

Figure 1: PRISMA Flow Diagram of Study Selection

RESULTS

Seventeen studies were included (Table 1), comprising quantitative pre-post and quasi-experimental designs, several randomized controlled trials, and one qualitative focus-group study (Wolf *et al*., 2018). Studies were conducted across Canada, the United States, Europe, Asia, and Africa. Only three studies (Atack *et al*., 2005; Rankin *et al*., 2013; McLeod *et al*., 2020) explicitly evaluated CTAS; the remainder examined ESI, KTAS, ATS, SATS, trauma triage, or mass-casualty triage. Non-CTAS studies were retained because they evaluated education or decision-support mechanisms relevant to structured nurse-led acuity assignment, but their findings are interpreted as transferable evidence rather than direct CTAS effects. Most studies used pre-post designs to measure triage accuracy via chart audit, case vignettes, or standardized scenario evaluation. Sample sizes ranged from small groups of nurses to extensive chart-review samples. The diversity of study designs, outcome definitions, and measurement procedures precluded meta-analysis and necessitated narrative synthesis.

Table 1: Summary of Included Studies on Triage Education and Training (n = 17)

Study	Country	Triage System	Design/Sample	Intervention	Key Findings
Zagalioti *et al*. (2023)	Greece	Structured Triage System (STS)	Pre-post; n=36 emergency nurses	45-min e-learning + simulation scenarios; post-test 2 weeks later	Correct-answer performance improved after training ($p < 0.001$), including vigilance/safe-service items ($p < 0.001$).
Vatnøy *et al*. (2013)	Norway	Medical Emergency Triage and Treatment System-Adult (METTS-A)	Descriptive intervention; pre-post	Standardised triage using vital parameters +structured symptom/sign algorithms	After implementation, nearly two thirds of patients were assessed using vital parameters and structured symptom/sign algorithms.
Atack *et al*. (2005)	Canada	CTAS	Mixed methods; n=23 interviews; 367 chart audits	Online CTAS course (6-week)	Post-course chart audit of 367 records showed improved CTAS accuracy; interviews noted implementation challenges.
Rankin *et al*. (2013)	Canada	CTAS	Randomised controlled trial (RCT); n=132	Web learning; intervention group had mandatory tutorial, graded discussion, workplace project	Online CTAS learning improved accuracy; mandatory tutorial, graded discussion, and workplace project supported practice transfer.

Campbell *et al*. (2022)	United States	ESI	Quasi-experimental pre/post; n=33 nurses; 495 charts	Weekly video-simulated cases via mobile + feedback; 12 weeks	No statistically significant improvement after 12 weeks; findings from 495 charts suggested video cases may be adjunctive rather than sufficient alone.
Brosinski *et al*. (2017)	United States	ESI	Evidence-based staff development; chart reviews pre/post	ESI refresher training (1 month within a 7-month project)	Under-triage decreased after the 1-month refresher project, regardless of nurse experience.
Wolf *et al*. (2018)	United States	General	Exploratory qualitative focus groups; n=26	Explored barriers/facilitators to accurate acuity assignment	Focus groups with 26 nurses highlighted standardisation needs; accuracy varied across nurses and units.
Conti *et al*. (2022)	Mozambique	SATS	Quasi-experimental; before/after	SATS introduced in 3 health centres; nurse-assigned codes compared to expected	SATS implementation in three health centres improved referral structure, but accuracy remained limited in some acuity categories.
McLeod *et al*. (2020)	Canada	CTAS + electronic CTAS (eCTAS)	Pre/post implementation; multi-centre EDs	eCTAS real-time triage decision-support tool	Inter-rater agreement and data accuracy improved after eCTAS implementation without substantially increasing triage time.
Chumvanichaya *et al*. (2025)	Thailand	Mass-casualty triage	RCT; n=83 (41 traditional, 42 virtual reality)	2-week intervention; lectures for both groups; virtual reality group used immersive 3D materials	SORT accuracy was higher with virtual reality than traditional training (14.39 vs 12.09, $p = 0.001$).
Moon & Kim (2024)	South Korea	Game-based triage educational app	Experimental; n=27 ED nurses	Triage training using game-based educational app	Triage accuracy increased from 4.30 ± 2.00 to 5.33 ± 1.47 ($p = 0.039$); over-triage decreased ($p = 0.004$).
Mohebbi *et al*. (2023)	Iran	ESI	Quasi-experimental; n=57 nurses	Lecture-based vs outcome-based education	Decision-making increased from 2.94 to 4.37 in lecture-based education and from 3.02 to 4.83 in outcome-based education; neither method was clearly superior.
Gholizadgougjehyaran *et al*. (2022)	Iran	ED triage	Interventional pre/post; 350+350 patient records	Virtual triage training	Post-training records (350 pre/350 post) showed improved triage accuracy and fewer triage errors.
Recznik *et al*. (2019)	United States	ESI	RCT; emergency department nurses	Simulation vs paper-case refresher training	Simulation and paper-case refresher training both produced substantial improvement in pediatric triage accuracy.
Jang *et al*. (2021)	South Korea	KTAS	Quasi-experimental	Problem-based learning for self-efficacy of triage nurses	Problem-based learning improved KTAS classification agreement and triage self-efficacy.
Ghazali *et al*. (2020)	Malaysia	Adult trauma triage	RCT; n=143 nurses and officer assistants	Adult trauma triage training and education	Adult trauma triage training significantly improved decision-making skills and triage accuracy over time ($p < 0.001$).
Pontisidis *et al*. (2024)	Greece	ESI & ATS	Quasi-experimental; n=117 nurses	Triage training and education	ESI and ATS accuracy improved immediately post-training ($p < 0.001$) but declined at 3-month follow-up; over- and under-triage decreased.

Training was provided in various formats: refresher education, problem-based learning, e-learning packages, mobile applications, simulation/virtual reality (VR), and electronic decision support using structured algorithms. A key pattern emerged: interactive and multimodal interventions (simulation, gamified apps, blended e-learning) tended to produce larger and more consistent accuracy gains than passive or single-mode approaches. CTAS-focused studies evaluated online training and eCTAS support, whereas comparable-system studies tested refresher education, virtual triage training, and scenario-based approaches. Simulation was represented by refresher training studies (Recznik *et al*., 2019). Mobile and gamified delivery was represented by app-based training (Moon & Kim, 2024). Asynchronous e-learning was represented by CTAS online learning (Rankin *et al*., 2013). VR was represented by mass-casualty triage training (Chumvanichaya *et al*., 2025). Mass-casualty and non-nurse studies were used only to inform training format, not to estimate CTAS-specific nursing effects.

Improvements in Triage Accuracy

Organized education enhanced correct triage decisions and reduced under- and over-triage across multiple systems (Pontisidis *et al*., 2024; Brosinski *et al*., 2017; Alreshedi *et al*., 2025). A consistent pattern was that structured training improved accuracy in immediate post-intervention assessments. Strengths of the evidence include the use of chart audits and standardized scenarios in several studies, which provided objective outcome measures. However, a notable contradiction was reported by Campbell *et al*. (2022), who found no statistically significant improvement with video-simulated cases over 12 weeks, suggesting that delivery mode alone may be insufficient without interactive components or reinforcement. Gamified and mobile methods improved accuracy in one study (Moon & Kim, 2024), and web-based learning with structured activities enhanced CTAS accuracy (Rankin *et al*., 2013). Electronic decision support also improved reliability: eCTAS improved inter-rater agreement in Canadian emergency departments (McLeod *et al*., 2020), and standardized algorithms enhanced the assessment of vital parameters (Vatnøy *et al*., 2013).

Effects on Triage Decision-Making and Skills

Triage decision-making was reinforced through education and system support, extending beyond final acuity scores to encompass systematic assessment behaviors. A clear pattern emerged: problem-based learning improved KTAS classification agreement and self-efficacy (Jang *et al*., 2021), while simulation supported rapid assessment, categorization, and allocation (Pontisidis *et al*., 2024).

Standardized instruments enhanced utilization of key parameters and systematic algorithms (Vatnøy *et al*., 2013), and real-time eCTAS improved consistency at Canadian emergency departments, though the evidence represents decision-support rather than education-only evidence (McLeod *et al*., 2020). A key contradiction concerns sustainability: Pontisidis *et al*. (2024) reported that accuracy gains peaked immediately post-training but declined at three-month follow-up, consistent with skill-decay literature (Maehle *et al*., 2017). Furthermore, outcome-based and lecture-based education both produced improvements without clear superiority (Mohebbi *et al*., 2023), suggesting that pedagogical approaches may be less critical than reinforcement and practice. A significant barrier identified across studies was that workload, fatigue, and complex presentations can override trained behaviors (Wolf *et al*., 2018), and organizational barriers impeded post-training application (Ghazali *et al*., 2020).

DISCUSSION

The findings of this review suggest that structured, practice-based, and reinforced training can enhance triage performance, but effects vary across systems and settings. The heterogeneity of included studies limits direct comparability: CTAS-specific evidence derives from only three studies, while the majority examined other triage systems operating in different clinical and organizational contexts. Therefore, caution is warranted when generalizing findings from ESI, KTAS, ATS, or SATS studies to CTAS implementation. The variability in outcomes may reflect genuine differences in system design, training culture, and ED environment rather than intervention failure. Triage is a high-stakes, time-sensitive activity conducted under cognitive load and environmental pressure, which helps explain why passive or short-term single-mode interventions produced less significant and less durable gains (Campbell *et al*., 2022; Wolf *et al*., 2018).

Patient safety risks associated with incorrect triage are considerable. Even minor errors in acuity assignment in facilities operating at or near capacity can create dangerous delays for patients with sepsis, stroke, myocardial infarction, or aortic dissection (Sax *et al*., 2025). Under-triage is particularly harmful because deterioration may remain unnoticed until the patient's condition worsens in the waiting area. Such delays may result in missed diagnostic timeframes, delayed sepsis activation, delayed stroke or ST-Segment Elevation Myocardial Infarction (STEMI) response, and failure to escalate care when initial presentations are not severe, especially in older or atypical patients (Kim *et al*., 2026). Over-triage also represents a misuse of resources and increases waiting times; reducing it has been linked to improved flow in pediatric emergency departments (Sjöstedt *et al*., 2026). Both types of mis-triage undermine system safety, making triage education a system-level priority.

Electronic decision support represents a distinct category of intervention that can promote consistent

acuity allocation at the point of care, despite fatigue or cognitive burden (McLeod *et al*., 2020). The evidence from McLeod *et al*. (2020) supports eCTAS standardization and inter-rater agreement but should be interpreted as decision-support evidence rather than education-only evidence. While emerging technologies such as artificial intelligence may offer future adjunctive support for triage decision-making, this review focused on educational and training interventions, and AI-specific evidence was not among the included studies. Further research is needed to evaluate how educational interventions interact with technological supports in routine clinical practice.

Skill deterioration over time supports the argument that one-time training is insufficient in dynamic environments where rules, staff, and processes change. Refresher education as continuing professional development, with audit-and-feedback cycles, appears to be the most effective approach to maintaining decision quality (Hinds *et al*., 2025). Obstacles identified throughout the literature point to organizational issues beyond individual capacity. Accuracy is compromised not only by knowledge gaps but also by limited system support; workarounds may emerge when nurses must adapt to inadequate resources. Organizational interventions should complement educational interventions: sufficient staffing, protected triage positions, real-time decision support, and regular feedback (Wolf *et al*., 2018).

Triage education should be positioned as continuous competency maintenance within professional development cycles, rather than limited to orientation. Combining competency assessment with frequent chart audit and feedback on under- and over-triage rates provides a viable mechanism for detecting gaps before harm occurs (Brosinski *et al*., 2017). Triage systems in large or highly complex emergency departments should include electronic decision support that incorporates objective vital-sign data and structured algorithms (McLeod *et al*., 2020).

Effective programs involve a combination of a brief didactic basis, multiple case/scenario exposures, simulation when available, and reinforcement of vital sign use and acuity modifiers. Active, multimodal learning is usually more successful than passive methods (Butler *et al*., 2023). Practical limitations such as time pressure, interruptions, and escalation decisions should be practiced. Microlearning through short booster vignettes about high-risk presentations and common modifier errors can be administered between shifts using local audit findings (Zagalioti *et al*., 2023). Feedback and accountability can be combined with mobile microlearning to reach a broader audience despite shift limitations (Moon & Kim, 2024).

Proposed Framework for Sustaining Triage Competency

It is suggested to use a five-component framework: (1) onboarding and baseline assessment using standardized cases before independent practice; (2) six-month refresher cycles based on blended e-learning, scenario practice, guideline updates, and local audits; (3) real-time decision support as part of workflow, such as eCTAS, to prompt structured assessment and flag high-risk presentations; (4) audit-and-feedback dashboards for under/over-triage, modifier use, and time-to-provider; and (5) governance meetings to review safety indicators and update training. A learning management system (LMS) can provide microlearning and completion tracking, while electronic health record (EHR) analytics can identify drift and trigger specific boosters. The triage screen should include a version-controlled CTAS playbook for just-in-time reference (Hall *et al*., 2025).

Limitations

Several limitations must be acknowledged. The studies included varied in design, intervention type, and outcome measures, which limited direct comparisons. Follow-up periods were generally short, and improvements were frequently not sustained. Most importantly, only three of seventeen included studies examined CTAS specifically; the majority investigated ESI, ATS, KTAS, SATS, trauma triage, or mass-casualty triage. These systems operate in different clinical contexts with distinct assessment criteria, and their findings may not be directly generalizable to CTAS. This heterogeneity was the primary reason narrative synthesis was employed instead of meta-analysis. Qualitative findings provide contextual understanding but cannot quantify effect sizes. There may also be publication and language bias.

Future Scope

Future research should prioritize CTAS-specific educational interventions to address the current gap in direct evidence. Longitudinal studies exceeding twelve months are needed to determine optimal refresher intervals and model skill-decay curves. Comparative effectiveness research should examine which training modalities—simulation, blended e-learning, gamification, or problem-based learning—produce the most durable gains within specific triage systems and ED environments. Implementation research should investigate how education can be embedded in high-pressure workflows and which organizational conditions sustain training gains over time. Under- and over-triage rates should be standardized as primary outcomes to enable future meta-analysis and policy synthesis. The interaction between educational interventions and technological supports, including electronic decision support, warrants further investigation in routine clinical practice.

CONCLUSION

This review makes a unique contribution by systematically examining education and training interventions for emergency triage across multiple five-level systems while using CTAS as a reference framework. The evidence indicates that structured, interactive, and reinforced training activities—including refresher training, scenario-based learning, blended e-learning, and electronic decision support—are associated with improved accuracy, increased inter-rater agreement, and reduced mis-triage across various systems. However, these findings should not be overgeneralized from non-CTAS systems to CTAS, given differences in operational contexts and assessment criteria. Some studies did not observe statistically significant improvement, and gains diminished without reinforcement. Key evidence gaps remain; only three CTAS-specific studies were identified, longitudinal data beyond three months are scarce, and the comparative effectiveness of different training modalities within CTAS contexts has not been established. Maintaining triage competence requires a combination of strategies: structured multimodal capacity building, frequent refresher cycles with audit and feedback, and organizational conditions that support accurate triage in everyday practice.

CRediT Authorship Contribution Statement

K.A: Study conception and design, data collection, analysis and interpretation of results, and draft manuscript: F.S: Visualization. The authors reviewed the results and approved the final version of the manuscript.

AI Assistance Declaration

During the preparation of this manuscript, the authors used generative AI tools to assist with language enhancement and grammar correction. After utilizing these tools, the authors reviewed and revised the content thoroughly and take full responsibility for the final version of the manuscript.

Conflict of Interest

The authors declare that they have no competing interests.

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