Journal of Infrastructure, Policy and Development 2024, 8(8), 6199.
https://doi.org/10.24294/jipd.v8i8.6199

Article

Analysis of development, delivery and impact of an affordable emergency trauma skills workshop designed for a middle-income environment

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CITATION

Zhuang S, Tan J, Mbori NJR, et al. (2024). Analysis of development, delivery and impact of an affordable emergency trauma skills workshop designed for a middle-income environment. Journal of Infrastructure, Policy and Development. 8(8): 6199. https://doi.org/10.24294/jipd.v8i8.6199

ARTICLE INFO

Received: 4 May 2024
Accepted: 29 May 2024
Available online: 21 August 2024

Abstract: Background: Despite China's 1.4 billion population and massive investment in improving medical education, there is no transformational national or international course focused on emergency trauma care. In order to overcome recognized deficiencies, we developed an affordable knowledge and skills workshop called Essential Trauma Critical Care China (ETCCC). **Methods:** Pre-course and post-course MCQs were used to test knowledge and simulation scenarios quantified clinical competence. Structured feedback was obtained. To evaluate the effect of ETCCC on staff performance, we analyzed the clinical records and questioned resuscitation team peers for trauma patients requiring resuscitation room intervention in the 10 consecutive patients before and after the workshops. **Results:** During 2022–2023, five workshops were delivered to participants from six hospitals in two Chinese provinces. Cost per participant did not exceed US$125. Fifty-eight doctors and 37 nurses participated. For all delegates pre-course knowledge scores increased from mean 35% to 70% post-course. 99% (n = 82/83) participants reached the required standard in the post-course written test. Post-course skills tests scores were mean 67% for doctors and 84% for nurses. Nurses demonstrated significant improvements in the rate and quality of trauma history acquisition as well as triage skills after the course (all $p < 0.01$). Doctors scored significant improvement in the areas of leadership and teamwork, care of cervical spine, circulation assessment and fluid resuscitation (all $p < 0.02$). **Conclusion:** Essential Trauma Critical Care China (ETCCC) is the first economically developed medical educational tool shown to improve performance of emergency room staff. Its success may have relevance for trauma-care education in similar medium-resource environments.

Keywords: essential trauma critical care; CME; staff performance; development; medical education

1. Introduction

Medical education plays a crucial role in the advancement of clinical medicine, encompassing institutional education, postgraduate education, and continuing education (Klapper, 1973). Postgraduate medical education is vital in training physicians and ensuring their competency (Long, 2001). In China, the concept of postgraduate medical education is relatively recent.

In developed countries the trained and skillful emergency room (ER) trauma team is well-established and based on principles which evolved in and from the Advanced Trauma Life Support® (ATLS®) program. This is 'a systematic, concise approach to the care of a trauma patient developed by the American College of Surgeons (ACS) Committee on Trauma and was first introduced in the US and abroad in 1980'. In

mainland China the ATLS course is currently delivered via Hong Kong-approved faculty in a single nearby city (Shenzhen). In 2020 a total of five courses were planned.

The international certification program 'International Trauma Life Support' (ITLS), is provided through two 'Chapters' in Beijing and Shanghai, however these focus on paramedics and pre-hospital care (Williamson et al., 2011). Neither the international certification in trauma care for nurses 'Trauma Nursing Care Course' (TNCC) nor other regional trauma courses designed for East Africa (Ologunde et al., 2017; Peter et al., 2016) and the Indian subcontinent (Joshipura, 2008) are available in China. Consequently, an inter-professional workshop designed to meet the needs of the ER nurse and physician is lacking.

In China in 2017 there were 77.1 million new cases of injury severe enough to warrant health care hospital intervention and 733,517 trauma deaths (Duan et al., 2019). Trauma remains the highest single cause of death between ages 1 and 40 (Yang et al., 2013), in the top three of all premature deaths (Yang et al., 2013), and in the top five of all deaths from any cause in the countryside (He et al., 2005). The physiological consequence of acute trauma beyond the 'golden hour' for action means that the most critically injured patients cannot survive transfer over long distances to obtain haemodynamic stabilization and life-saving treatment. It is imperative that local emergency room (ER) teams in town and city hospitals with limited resources can have access to a course which will equip them with the basic tools needed to improve survivability for this group of patients.

Widespread deficiencies throughout China are:

- Despite sporadic attempts to introduce formal emergency room training (Xu, 2016), in most ERs there is no formal or systematic training to develop a pool of critical knowledge/skills, leading to poor leadership and suboptimal development/maintenance of core skills and team-working (Wang et al., 2013).
- Inadequate front-door triage resulting in delay in treatment delay for some patients (Wang and Xu, 2007).
- Poor nurse-doctor and doctor-doctor interaction due to rigid professional roles leading which reduces good quality team-working (Yang and Hao, 2018).
- Defensive medicine resulting in poor interdisciplinary communication and suboptimal decision-making, for example a potentially harmful choice of investigation or treatment (He, 2014).
- Financial disputes and poor doctor-patient/family relationships resulting in delays in essential monitoring, treatment and safe transfer (Li et al., 2016).

In order to overcome the first three deficiencies, and to ease problems related to the fourth and fifth, surgical specialists, ER and intensive care consultants from a network of Beijing university hospitals collaborated together to design a knowledge and skills workshop called Essential Trauma Critical Care China (ETCCC). Planning meetings commenced in early 2020, with full development of the course completed by June 2021. Its development was consistent with the principles outlined below:

Summary of teaching and assessment standards:

- Three trained faculty plus one patient-volunteer/actor.
- A two-day course to fit a weekend. For course content.
- Two rooms (seminar room and simulation room).
- Delegate number restricted to twenty individuals per workshop.

- A variety of proven, effective teaching methods:
  - Bilingual teaching, lectures with 'handouts' supplied via social media. Course reading material made available in advance for participant preparation.
  - Summary pathways for memorization. These are critical algorithms for assessment and control of a) airway and cervical spine; b) breathing and oxygenation; c) circulation and hemorrhage; d) head and neurological injury.
  - Demonstration and practice skills and simulation scenarios.
  - Pre-Course and post-course knowledge tests and simulation scenarios as pass/fail.
  - Extensive question-bank for test papers.
  - Extensive series of clinical scenarios for demonstration, practice and skills-test representing a realistic range of severe traumatic conditions, and all based on memoizable assessment and management algorithms.
  - Opportunity for borderline participants to undergo a 'rescue' skills test.
  - Continuing medical education (CME) accreditation and certification.
- Participant feedback.
- A requirement to assess clinical impact of the course were delivered to an entire department.

Faculty-training: The lead faculty member was trained to ATLS, and APLS instructor standard. Other faculty members were initially chosen on the basis of enthusiasm and sympathy with the objectives of the program. Seniority was not a basis for choice of faculty. All faculty staff developed scenarios and exam questions and took part in compulsory scenario practice during the week prior to each course and during simulation-room set-up. New faculty were chosen from successful and enthusiastic participants identified during previous courses.

Course content: Care was taken to align the content with World Health Organization—International Association of Trauma Surgery and Intensive Care (WHO-IATSIC) Guidelines for Essential Trauma Care priorities. Guidelines established by the World Health Organization suggest that stabilization and treatment of patients with severe trauma should preferably be provided where there are facilities for general surgeons to work. Accordingly the course was designed to meet the needs of these classes of hospital—namely 'specialty' and 'tertiary' hospitals in China (Mock et al., 2006). Several ATLS principles were viewed as mandatory (e.g., leadership and team-working; 'ABCDE' principles, treat each newly identified life-threatening injury in order before moving-on; patient-centered as opposed to defensive approach). Ali et al. have demonstrated teaching effectiveness of the ATLS program among practicing physicians as measured by improvement in OSCE scores, adherence to trauma priorities and maintenance of an organized approach to trauma care (Ali, Cohen, et al., 1996). However, considering the factors listed above, the final configuration of ETCCC differed significantly from ATLS. Incorporating nurses into the trauma team was seen as a key objective. Nurses participated in the entire course in the same way as doctors; their knowledge tests were identical. However, their role in the simulation scenarios involved patient triage (based on Early Warning Score assessment (Morgan et al., 1997) and collection of data on patient history (Allergy, Medication, Past medical history, Last meal, traumatic Event—AMPLE), and in

assistance to the trauma team leader. ETCCC was designed with the requirements of Chinese healthcare environment in mind so that core pathways, knowledge and skills were modified to suit local requirements. In a medium resource environment, the workshop was designed so that the local ER capabilities guided the direction of each care-pathway with minimal compromise to patient safety; for example, according to the availability of 'Focused Assessment with Sonography for Trauma (FAST)-scan, resuscitation-room x-ray or the level of local neurosurgical and intensive care facilities.

Course costs: Costs were kept to a minimum by holding the workshop in the hosting hospital which also allowed accurate appraisal of the local ER environment. For courses in China to be self-sustaining it is usual for faculty to receive some modest remuneration for out-of-hours work; together with costs of faculty travel, accommodation and simulation consumables the total cost did not amount to more than US$125 for each participant. The local host provided basic resuscitation room equipment for role-play support according to a list which conformed to the resources of the local ER. A bespoke delegate and faculty group was formed during each course conversing within a free-to-use social media platform in order to share course materials and solicit confidential feedback.

According to Moore's Expanded Outcomes Framework for Planning and Assessing CME Activities (Moore et al., 2009), the most impactful evidence of effective CME are changes in physician performance patient health and community health. At the outset we aimed to collect evidence of meaningful effects in behavior and outcomes.

The aim of this study, then, was to assess the impact of ETCCC in changing Emergency Room staff attitudes and real-life behavior to the benefit of seriously injured patients.

2. Materials and methods

Data collected by ETCCC faculty and secretariat to identify the success or otherwise of the CME activity are outlined in **Table 1**.

At the end of each course, all participants were requested to give feedback on a structured evaluation form using a 5-point Likert scale designed to assess subjective aspects of acceptance, learning and competence. Pre-course and post-course MCQs were used to test knowledge acquisition and retention. Competence was evaluated using simulated patient scenarios in an Objective Structured Clinical Examination (OSCE) format. Specific methods to assess satisfaction, knowledge and competence are documented.

Performance: To evaluate the effect of ETCCC on staff performance, we analyzed the clinical records and questioned resuscitation team peers for serious trauma patients requiring resuscitation room intervention in the 10 sequential patients prior to the workshops and 10 sequential patients after the workshops. Parameters evaluated are documented.

Patient and community health: Review of medical records used to assess performance included data on patient condition at point of discharge from the emergency room to the appropriate specialist care facility in the hospital.

Statistics: Parametric data were expressed as means and standard deviation. Non-

parametric data were expressed as median and range. Descriptive statistics were applied by using SPSS® v.19. Discrete non-parametric data were compared using Fisher's exact test or Yates' chi-square test. Continuous non-parametric data was compared using Wilcoxon test. Parametric data was compared using Student's t test and correlated using Pearson's test. A '*p*' value less than 0.05 was considered statistically significant.

Table 1. Assessing levels of ETCCC effectiveness according to Moore's expanded CME framework.

Level	Moore's expanded CME framework	Description	ETCCC assessment criteria
1	Participation	The number of physicians and others who participated in the CME activity	Attendance records
2	Satisfaction	The degree to which the expectations of the participants about the setting and delivery of the CME activity were met	Feedback survey
3A	Learning (Declarative Knowledge)	The degree to which participants state what the CME activity intended them to know	Pre-course and post-course tests of knowledge
3B	Learning (Procedural Knowledge)	The degree to which participants state how to do what the CME activity intended them to know how to do	A. Pre-course and post-course tests of knowledge B. Feedback survey
4	Competence	The degree to which participants show in an educational setting how to do what the CME activity intended them to be able to do	A. Simulated clinical scenarios B. Feedback survey
5		The degree to which the health status of patients and community improves due to changes in the practice behavior of participants	Pre-course and post-course assessment of performance
6 and 7	Patient and Community Health	The extent to which the health status of patients and the community improves due to changes in participants' practice behavior	Pre-course and post-course assessment of patient physiology

3. Results

During 2022–2023, five workshops were delivered to participants from six hospitals in two Chinese provinces. All were designated 'level 3' hospitals, meaning that there was a complete set of surgical emergency services at each site.

Participation: Fifty-eight doctors and 37 nurses participated (61%/39%). Twenty-one doctors were in training. Thirty-seven had completed specialist training (15 ER room specialists, 7 orthopaedic surgeons, 6 general surgeons, 3 intensivists, 2 neurosurgeons, 4 others).

Subjective satisfaction, declarative and procedural knowledge and competence: There was no significant difference in feedback results from nurses, junior doctors or senior doctors. 85% of delegates would 'always' or 'mostly' recommend the workshop to a similar colleague. Even higher percentages found that the didactic teaching material, faculty demonstrations, and faculty-critiqued practice scenarios were 'entirely' or 'mostly' useful for their clinical practice (**Table 2**).

Objective declarative and procedural knowledge: Utilizing identical tests for doctors and nurses, there was no significant difference in score obtained from them. For all delegates pre-course knowledge scores increased from mean 35% to 70% post-course (**Table 2**).

Table 2. Lower levels of CME effectiveness.

Level	Moore's expanded CME framework16	Method	Specific assessment	*N*	Units of assessment % 'always' or 'mostly'	Statistical Significance
2	Satisfaction	Feedback surveys	Recommendation to a colleague	58	90%	-
3A	Subjective declarative and procedural knowledge	Feedback surveys	Teaching material, lectures and scenario demonstrations usefulness	58	91%	-
4	Subjective competence	Feedback surveys	Faculty-critiqued practice trauma scenarios usefulness	56	96%	-
					Score/100± SD≠	-
3B	Objective declarative and procedural knowledge	Pre- and post-course knowledge tests	Doctor	48	42 ± 14(pre) 81 ± 15 (post)	$p < 0.001$
			Nurse	36	34 ± 10 (pre) 70 ± 15 (post)	$p < 0.001$
4	Objective competence	Simulated skills test	Doctor	47	67 ± 16	-
			Nurse	36	84 ± 13	-

SD≠ = standard deviation.

The mean doctors' pre-course knowledge score was 42%, as expected significantly improving to 81% after the course. For nurses the equivalent improvement was from 34% to 70% (all $p < 0.001$). Pre-course and post-course knowledge scores were correlated ($r = 0.544$, $p < 0.001$). However, there was no significant correlation between post-course knowledge and post-course skills scores ($r = -0.189$, $p = 0.09$). 99% ($n = 82/83$) of participants reached the required 'pass' standard in the post-course written test. Doctors had significantly higher pre- and post-course knowledge scores than nurses (pre-course $p = 0.001$, post-course $p = 0.001$). However, the percentage gain in score was similar for doctors (+110%) and nurses (+107%).

In one hospital three courses were delivered to serve the entire staff of a large emergency room. From weekend 1 to weekend 3, both doctor and nurse post-course knowledge scores increased significantly (mean total scores; week 1 = 52%, week 2 = 75%, week 3 = 81%, $p < 0.001$). However, there was no significant increase in doctor or nurse post-course skills scores over this period (mean total scores; week 1 = 77%, week 2 = 87%, week 3 = 80%, $p = 0.5$).

Post-course skills tests scores were mean 67% for doctors and 84% for nurses. Content was different for doctors and nurses' skills tests, but knowledge tests were identical. Differences in scores between centers could largely be accounted for by the different balance of nurses and doctors in the cohort.

Performance and patient health effects: Basic epidemiological and injury-related data from patients treated did not differ significantly before and after the course (**Table 3**). Nurses demonstrated significant improvements in the rate and quality of trauma history acquisition as well as triage skills. Doctors scored significantly higher in quality of leadership and teamwork. Care of cervical spine and circulation assessment and fluid resuscitation also managed better after the course. Results of these subjective and objective tests of performance are recorded in **Table 3**.

Table 3. Pre and post-course performance based on subjective and objective criteria.

			Pre-ETCCC group	**Post-ETCCC group**	**Statistical significance**
Demographics and Condition on entering ER	Number		10	10	
	Age	mean and SD≠	44.7±16.6	40.7 ± 13.4	p = 0.6
	Gender	male/female	7/3	7/3	p = NS¶
	Time of admission	08.00–18.00	3	5	p = 0.7
		08.00–08.00	7	5	
	Type of trauma	blunt/penetrating	9/1	10/0	p = NS¶
	Major system affected	MSKΦ	4	4	-
		Head	3	3	-
		Thorax	1	3	-
		Abdomen	2	0	-
	Earliest EWS* score	median and range	4 (0–7)	3 (0–8)	*p* = NS¶
	Earliest neurological disability#	A	7	7	
		V	0	0	*p* = 0.4
		P	0	3	
		U	3	0	
Performance (subjective)	Nurse-trauma history accrualΔ	yes/no	2/8	10/0	*p* = 0.001
	Doctor leadership	score/10 (mean and SD≠)	3.0 ± 0.8	7.4 ± 1.0	*p* < 0.001
Performance (objective)	Doctor teamwork	score /10 (mean and SD≠)	3.1 ± 1.0	7.4 ± 1.0	*p* < 0.001
	Nurse-trauma history accrual	Cases with all items complete (yes/no)	2/8	9/1	*p* = 0.007
		Total number of items completed/50	35/15	47/3	*p* = 0.004
	Nurse-Collection of EWS# at triage	yes/no	0/10	9/1	*p* = 0.0003
	Doctor-early protection of c-spine protection	yes/no	0/10	7/3	*p* = 0.005
	Doctor-assessment of shock before fluid challenge	yes/no	0/10	6/4	*p* = 0.01
	Doctor - infusion volume in ER	/mL (mean & SD≠)	1475 ± 558	250 ± 373	*p* = 0.00002

≠ SD = standard deviation. Φ MSK = musculoskeletal. * EWS = Early Warning Score. ¶ NS = non-significant. # A = Alert; V = responds to speech; P = responds to pain; U = unresponsive. Δ Physician assessment of whether the nurse had taken responsibility for collecting the important parts of the trauma history.

From review of the medical records used in assessing performance, all patients left the ER either in a stable condition to go to a specialist surgical ward or, if hemodynamically or neurologically unstable to go to the operating room. No patient in either group died in the emergency room. Physiological parameters on leaving the emergency room improved in patients treated before the course and after the course (pre-course mean EWS scores improved from 4.0 to 1.2, and after the course from 3.5 to 1.5). Although data was collected, patient numbers were insufficient to assess the effect of the course on patient health.

4. Discussion

ETCCC was designed to meet several criteria:

- In-course use of modern, effective educational techniques.
- Held in a hospital setting familiar to the participants.
- Combines nurse and doctor training in a single course with identical didactic knowledge but different skills and role requirements.
- Sufficiently and sustainably affordable to be supported by the limited departmental education budgets of Chinese ERs.
- Effective in improving staff performance.

In order to test the effectiveness of the course beyond levels 1-4 of Moore's expanded CME framework, we assessed the effect of the course on performance, both subjective and objective. Since the course was designed to train the entire staff of an emergency room, it was possible to do this by medical notes-review and staff survey. In theory it would be possible to measure patient health improvements given sufficient volume of patient data; but we were not able to accrue these data in this study.

Several authors have investigated the effect of trauma courses on knowledge and competence by repeating MCQ tests and Objective Structured Clinical Examination after delivery of the course (Ali et al., 1996; Ali et al., 2002; Blumenfeld et al., 1998). Some have used self-reporting surveys to assess subjective improvement in performance (Ologunde et al., 2017; Pemberton et al., 2013; Peter et al., 2016). Very few authors have been able to investigate real-life performance of staff and the impact on injury mortality and morbidity (Hedges et al., 2002; Jayaraman et al., 2014). Improvement in community trauma outcomes have been demonstrated before and after ATLS introduction but were unadjusted for confounding factors (Ornato et al., 1985). The evidence of effectiveness and impact of trauma courses have not been rigorously tested (Jayaraman et al., 2014). In China, Wang et al. have reviewed clinical parameters before and after introduction of ATLS-type training in a single hospital in 2006 (Wang et al., 2010). They found that time to surgery for unstable patients was reduced following introduction of ATLS principles. We were unable to reproduce the volume of trauma patients to assess this parameter of performance however we have assessed doctor and nurse performance across a range of goals set by ETCCC, and all showed a marked improvement.

The correlation between pre- and post-course knowledge scores, but not between knowledge and simulation scores suggests a level of independence between knowledge and practical competence. The value of separate knowledge and skills tests is confirmed by these results. Where a course was delivered to staff in the same hospital over three weekends participants who joined in a later course scored significantly higher in pre-course knowledge, but not post-course knowledge or skills. Since no exam question appeared more than once we considered that a longer period during which pre-course learning material was available could have been responsible for this improvement.

Several similar continuing medical education (CME) courses have been designed for low and middle incomes settings. The National Trauma Management Course in India is accredited by the IATSIC and represents a standardized education in trauma life-support skills. However educational standards, certification, and continuing education and evaluation requirements for doctors involved in trauma remain unresolved and the course is not designed for nurses or paramedical staff (Joshipura, 2008). The Primary Trauma Care (PTC) Course is a 2-day course designed for doctors

and nurses in East Africa. Its effects on self-reported qualitative improvements in trauma care have been published (Ologunde et al., 2017). In a low-income environment Pemberton et. al. reported on the added value of an inter-professional trauma training scheme involving nurses, paramedics and doctors (Pemberton et al., 2013). They identified empowerment of non-physicians and improved teamwork as a major benefit of this type of course.

Trauma emergency care is a complex and time-sensitive task that necessitates a multidisciplinary medical team comprising well-trained professionals, including surgical and orthopedic residents (Steinemann et al., 2011). These teams are often assembled temporarily to address individual trauma cases, with team members typically lacking structured training together (Steinemann et al., 2011). Research indicates that ineffective communication and poor teamwork are prevalent in trauma emergency care, with studies suggesting that enhancing teamwork can enhance patient safety (Bergs et al., 2005; Holcomb et al., 2002; Sugrue et al., 1995). Although nurses started from a lower base knowledge level, our results show that the improvement in nurse knowledge score after the course was similar to that gained by doctors (107% and 110% incremental increase respectively). Both doctors and nurses demonstrated both subjective and objective improvement in ER resuscitation performance after the course. Improvements in teamwork were a key objective of ETCCC.

ATLS is a comprehensive and regularly updated training program which is the gold-standard for trauma care throughout the developed world (American College of Surgeons' Committee, 2013). Despite China's 1.4 billion population and massive investment in improving medical education, there is no transformational national or international course focused on this important patient need. WHO trauma guidelines are translated into English, Arabic, French and Russian, but not Chinese. ETCCC is the first widely affordable Chinese language course designed to be compliant with these guidelines. In China, fees for the ATLS course are approximately US$1800 per delegate. These remain unaffordable for around 95% of front line emergency medicine staff (Xu, 2016). The economic cost of ETCCC (less than US$125 per participant) was a key factor in the involvement of all members of the ER team as course participants. Nurses traditionally have a low social status in China (Yang and Hao, 2018), so that higher fees would likely prove to be prohibitive. In our model most ER departments were willing to defray ETCCC costs through use of educational funds. However, at least one city hospital which showed interest eventually declined to support the course for financial reasons, indicative of the fragile environment in which intensive postgraduate medical training competes with other priorities for funding.

Limitations of this study: There are several limitations; the most advanced components of Moore's framework for CME effectiveness that is improvements in patient and community health—could not be assessed. This would require a larger number of participants and a greater number of cases for analysis of improvement in physiological parameters, morbidity and mortality following introduction of the course in the future research. Delivery of the course to individual hospitals now included a mandatory review of pre-and post-course trauma records and staff questionnaire in order to accrue this information. In addition, we do not know the durability of course knowledge and skills gained. It seems likely that the principles of trauma care are maintained for longer than cognitive knowledge (Ali et al., 1996).

ATLS certification lapses after 4 years (Blumenfeld et al., 1998), and for ITLS after 3 years. Ali et al. (2002) showed that attrition of knowledge was greater in low-volume trauma centers and the frequency of refresher courses should take account of this (Ali et al., 2002).

ETCCC is supported by a Chinese university system, and further dissemination to hospitals which meet the WHO definition of 'specialist' or 'tertiary' hospitals (Mock et al., 2006) could be achieved via locally trained and approved faculty in smaller towns and cities at a provincial level (Peter et al., 2016); the 'cascading course' model.

5. Conclusion

Essential Trauma Critical Care China (ETCCC) is the first economically designed educational tool shown to improve performance of emergency room staff. Its success may have relevance for trauma-care education in similar medium-resource environments.

Author contributions: Conceptualization, JT and DEP; methodology, JT, SZ and DEP; software, JT and SZ; validation, JT, SZ and DEP; formal analysis, JT; investigation, JT; resources, JT and DEP; data curation, JT and SZ; writing—original draft preparation, SZ; writing—review and editing, SZ, JT and DEP; visualization, JT and SZ; supervision, DEP; project administration, SZ, JT, NJRM and FX; funding acquisition, DEP. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by grants from the National Key Research and Development Program of China (Project No. 2022YFC2407500).

Conflict of interest: The authors declare no conflict of interest.

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