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Teaching Models in Pain Medicine under a Multidisciplinary Framework: Current Status and Advances

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Abstract

Objective: To analyze the disciplinary characteristics and current status of pain medicine education in China within a multidisciplinary framework, summarize representative reform practices at home and abroad, and propose strategies for constructing competency-oriented teaching models for pain medicine.

Methods: This study adopts a narrative review and analytic approach. Relevant national policy documents, competency-based medical education (CBME) frameworks, and published literature on pain medicine education were synthesized, together with representative teaching practices from Chinese medical schools and teaching hospitals. The analysis focused on curriculum structure, teaching methods, assessment models, and interdisciplinary integration in pain medicine.

Results: Pain medicine, as a highly interdisciplinary subspecialty of anesthesiology, is increasingly recognized as a key "bridging discipline" for comprehensive pain management. However, current curricula in China are still dominated by fragmented, discipline-based content and traditional models of didactic teaching plus department-based clinical instruction. Pain-related topics are often dispersed across multiple courses, with limited systematic training in multidisciplinary collaboration, whole-course management, and humanistic care. In response to the "New Medical Sciences" initiative and CBME, emerging trends include: (1) reorganization of teaching around clinical problems and pain disease spectra; (2) integration of multidisciplinary team (MDT)–based contextual teaching; (3) expanded use of CBL, PBL, team-based learning, interprofessional education, simulation/VR, and blended online–offline models; and (4) a shift from knowledge- and skill-based assessment to multidimensional, competency-oriented evaluation using OSCEs, formative and multisource assessment, and milestone frameworks. Nonetheless, major challenges persist in top-level curriculum design, depth of multidisciplinary integration, faculty development, incentive mechanisms, educational resources, and the methodological rigor of effectiveness research.

Conclusion: Pain medicine education in China is undergoing a critical transition toward multidisciplinary, problem-oriented, and competency-based models, but remains in an exploratory stage with uneven development. Establishing tiered competency frameworks and curriculum standards, reconstructing curricula around authentic care pathways, building stable interdisciplinary teaching teams, strengthening multicenter educational research, and improving policy and incentive systems are essential to forming a new, high-quality paradigm for pain medicine education. These efforts are key to cultivating interdisciplinary pain specialists capable of delivering comprehensive, patient-centered pain management in modern healthcare systems.

1.Introduction

Pain has been widely recognized in modern medicine as the "fifth vital sign," alongside respiration, pulse, blood pressure, and body temperature. The quality of pain assessment and management has therefore become an important indicator of both healthcare quality and the level of humanistic care. As a discipline that primarily serves patients with chronic pain, pain medicine plays a central role in the comprehensive management of pain. With rapid population aging and the growing burden of chronic diseases such as cancer, the number of patients with chronic pain in China has been steadily increasing[1]. This trend has led to a marked rise in the demand for pain

prevention and treatment and has created broad prospects for the development of pain medicine.

Pain medicine is a specialized discipline dedicated to the diagnosis and management of pain and pain-related disorders. It is not only a core component and major subspecialty within anesthesiology, but also an emerging, highly interdisciplinary field that overlaps extensively with multiple clinical specialties, including surgery, internal medicine, neurology, psychiatry, obstetrics and gynecology, and dermatology[2]. In clinical practice, it focuses on the comprehensive management of chronic pain and encompasses etiological diagnosis, pain assessment, multimodal analgesia, interventional and minimally invasive techniques, rehabilitation, and psychological interventions. Consequently, pain medicine is inherently characterized by a high degree of multidisciplinarity and knowledge integration.

Within the medical education system, pain medicine serves as a crucial "bridging discipline" that links anesthesiology training with broader clinical practice. Its primary learners include undergraduate and postgraduate students majoring in anesthesiology, as well as residents enrolled in standardized anesthesiology training programs. Compared with traditional single-discipline courses, pain medicine places higher demands on learners' multidisciplinary competencies in both clinical practice and research[3]. On the one hand, standardized management of chronic pain in clinical settings depends not only on solid specialty knowledge, but also on the application of various auxiliary technologies and cross-disciplinary support. For example, commonly used pain-related imaging and interventional techniques—such as C-arm fluoroscopy, computed tomography, and ultrasound guidance—require pain physicians to understand the underlying physical and imaging principles and to apply and interpret these modalities accurately in clinical contexts. On the other hand, at the level of basic and clinical research, studies on conditions such as neuropathic pain and cancer pain often involve multiple disciplines, including neurobiology, chemistry, physics, statistics, nanotechnology, molecular biology, and oncology. This necessitates that pain researchers possess broad scientific horizons and strong interdisciplinary collaboration skills. From the perspective of disciplinary attributes and developmental patterns, pain medicine is thus intrinsically and prominently multidisciplinary and places strong emphasis on the integration of knowledge across fields.

Over the past decade, the continuous emergence of new concepts and technologies in pain medicine has markedly advanced clinical practice, while at the same time posing substantial challenges to traditional teaching models. On the one hand, the rapid evolution of interventional analgesia, minimally invasive techniques, and neuromodulation requires that teaching content be continuously updated and aligned with current practice. On the other hand, as a relatively young discipline within the anesthesiology framework, pain medicine still lags behind in terms of professional development [4]. Notable deficiencies persist in areas such as the integration of theoretical teaching with clinical practice and the cultivation of multidisciplinary collaboration. In daily clinical work, many non–pain specialists continue to underestimate the importance of pain management, and mechanisms for multidisciplinary cooperation remain underdeveloped. As a result, a significant proportion of patients experience prolonged periods of either "untreated pain" or "inadequately treated pain."From a medical education perspective, pain teaching in many medical schools and teaching hospitals remains relatively "invisible" or "subsidiary." Pain-related content is often fragmented and dispersed across courses such as anesthesiology, surgery, internal medicine, and neurology, rather than being organized into an independent, systematic curriculum. Existing teaching objectives tend to emphasize disease-specific knowledge and isolated procedural skills, with insufficient attention to core competencies such as multidisciplinary integrative thinking, concepts of longitudinal (whole-course) pain management, humanistic care, and doctor–patient communication. This situation is increasingly misaligned with the demands of contemporary pain practice. Meanwhile, the implementation of the national "New Medical Sciences" initiative and the promotion of competency-based medical education (CBME) have imposed clearer requirements on pain medicine education[5]. These reforms emphasize multidisciplinary integration and competency orientation, and call for curricula and teaching models that are restructured around patient-centered problems and core clinical competencies.

Against this background, systematically reviewing the current status and recent advances in pain medicine teaching within a multidisciplinary framework is of substantial theoretical and practical significance. Such work can inform the optimization

of curriculum structures, the innovation of teaching methods, the refinement of training objectives, and the overall improvement of training quality. In this article, we first examine the disciplinary attributes of pain medicine and its multidisciplinary foundations, and analyze the traditional structure and existing basis of current teaching models. We then summarize recent educational reform practices and exploratory approaches driven by multidisciplinary concepts. Finally, based on a critical appraisal of existing achievements and remaining gaps, we propose strategies and recommendations for further improving the teaching system of pain medicine.

2. Disciplinary attributes and multidisciplinary foundations of pain medicine

With the rapid transition of China's healthcare system toward smart healthcare and precision medicine, the deep integration of information technology with medical services and the need for interdisciplinary collaboration are expected to increase substantially [6]. In this context, there is a growing and very real demand for "hybrid" pain specialists who not only possess solid medical expertise, but also have the capacity to understand, integrate, and apply knowledge across multiple disciplines. The number of patients with chronic pain in China has already exceeded 300 million. This enormous patient population poses an unprecedented challenge to the delivery of high-quality, comprehensive pain management and underscores the importance of systematic discipline development and talent cultivation in pain medicine.

Pain diagnosis and management (hereafter referred to as pain medicine) is an interdisciplinary clinical discipline centered on the assessment, diagnosis, treatment, and long-term management of pain. It embodies attributes of clinical medicine, basic medical sciences, and the humanities and social sciences. Its scope covers both acute and chronic pain, a wide spectrum of pain conditions and related syndromes, and includes etiological diagnosis, classification and assessment, multimodal analgesic strategies, interventional and minimally invasive techniques, rehabilitation, and psychological interventions[7]. In essence, pain medicine is a major subspecialty of anesthesiology, while being closely intertwined with surgery, internal medicine, neurology, psychiatry/psychology, obstetrics and gynecology, dermatology, and other fields, making it a prototypical composite clinical discipline.

However, current discipline development and training practices reveal persistent problems of "difficult communication and slow integration" across specialties. On the one hand, the prevailing vertically structured, single-specialty–oriented training model focuses primarily on cultivating competence within one discipline and is insufficient to meet the systematic, multidisciplinary demands of modern pain diagnosis and management. On the other hand, relatively underdeveloped mechanisms for cross-disciplinary collaboration and personnel mobility hinder the establishment of stable and efficient platforms for multidisciplinary exchange and cooperation. The overall shortage of interdisciplinary pain specialists has become a key bottleneck limiting the high-quality development of the field.

From the perspective of pain itself, its onset and maintenance are not only closely related to pathological changes in the peripheral and central nervous systems, but are also strongly influenced by psychological status, emotional experience, social support, and cultural background. Consequently, psychology, sociology, humanistic care, and medical ethics are indispensable components of pain management. Effective pain care should reflect a comprehensive application of the biopsychosocial model, rather than a unidimensional intervention restricted to the biomedical domain.

These disciplinary attributes and practical needs determine that teaching in pain medicine cannot be confined to a single clinical specialty or a narrow set of technical skills. Instead, training should prioritize the development of the following core competencies[8]:

1.Systematic pain assessment based on multidimensional information

The ability to integrate data from medical history, physical examination, imaging and laboratory tests, as well as psychosocial assessment, in order to conduct standardized, comprehensive pain evaluation and classification.

2.Comprehensive, whole-course decision-making tailored to individual patients

The ability to formulate individualized management plans—grounded in evidence-based medicine and guideline recommendations—that incorporate pharmacological treatment, interventional and minimally invasive procedures, rehabilitation,

psychological interventions, and health education, with sustained attention to longitudinal follow-up and long-term outcomes.

3.Multidisciplinary teamwork and communication

The ability to work effectively within teams composed of physicians, nurses, rehabilitation therapists, pharmacists, and other professionals, with a clear understanding of respective roles and responsibilities, and to engage in efficient information exchange and shared decision-making.
Humanistic care and professionalism
Sensitivity and empathy toward patients' physical and psychological suffering, respect for patients' rights throughout the diagnostic and therapeutic process, and sustained attention to quality of life and restoration of social functioning, thereby embodying the requirements of medical humanities and professional ethics.
The development of these core competencies fundamentally depends on curriculum structures and teaching models explicitly oriented toward multidisciplinary integration, rather than on traditional fragmented, discipline-based teaching[9]. Interdisciplinarity is not only an inherent requirement for the growth of pain medicine itself, but also an important indicator of progress in clinical medicine as a whole. At present, there remains an overall shortage of professionals who can systematically integrate multidisciplinary knowledge on a medical foundation and who are capable of comprehensive pain management and research. This gap makes it increasingly difficult to fully meet the practical needs of pain prevention and control in the era of smart healthcare and precision medicine.
Therefore, exploring and establishing training models for pain medicine that are characterized by deep multidisciplinary integration, and systematically enhancing the overall level of discipline development, have become urgent tasks for the present and the foreseeable future. Advancing the field of pain medicine and improving the quality of pain prevention and treatment will better meet the population's diverse health needs, promote social harmony and stability, and support the sustainable development of the health sector.
In summary, by virtue of its pronounced multidisciplinarity and the immense clinical and societal demand, pain medicine has become an important growth area in contemporary medical education and discipline construction. Building training models that cultivate hybrid, interdisciplinary pain specialists aligned with current and future needs is of strategic significance for advancing the discipline and strengthening national capacity in pain prevention and control.

3.Traditional structure and current foundations of teaching models in pain medicine

(1) Curriculum structure in pain medicine

In most current undergraduate medical programs, painrelated content is predominantly embedded in a "chapterbased" manner across multiple courses, such as anesthesiology, internal medicine, surgery, orthopedics, and neurology. A small number of universities have introduced electives titled "Pain Medicine" or "Pain Diagnosis and Treatment," but these are usually restricted or general electives with limited contact hours and scope[10]. As a result, they provide insufficient support for the systematic construction of a comprehensive knowledge framework in pain medicine.
In related disciplines such as nursing, rehabilitation, and pharmacy, topics including pain assessment tools, the use of analgesic drugs, and basic principles of analgesia are also covered. However, these contents likewise appear as brief segments within broader courses—such as medicalsurgical nursing, rehabilitation assessment, and clinical pharmacology—rather than within an independent, coherent course devoted specifically to pain.
At the postgraduate and standardized residency training levels, painrelated teaching relies largely on clinical practice in anesthesiology, pain medicine, and related rotating departments, with bedside teaching, outpatient/inpatient shadowing, and operating room observation as the primary modalities[11]. On this basis, some standardized training centers in pain medicine or relevant specialties have developed more structured modules of theoretical instruction and skills training, such as interventional analgesia, nerve block techniques, and postoperative pain management. Overall, however, traditional departmentbased clinical teaching delivered by attending physicians remains the dominant model in current pain medicine education.

(2) Traditional teaching approaches and main characteristics

Overall, current teaching related to pain medicine still follows a traditional model of "didactic classroom teaching plus departmentbased clinical instruction." Its main characteristics include:

1.Classroom teaching is primarily knowledgecentered

Theoretical instruction focuses mainly on basic pain mechanisms, diagnostic criteria for common pain conditions, and key points of conventional treatment. Lectures are predominantly teachercentered, supplemented by a limited number of case presentations and inclass questions[12]. Emphasis is placed on systematic coverage and memorization of knowledge points, with relatively little attention to contextualized presentation or competency training from the perspectives of comprehensive pain management and multidisciplinary collaboration.

2.Clinical teaching is largely confined to singledepartment perspectives

In clinical practice, learners typically participate in ward rounds, outpatient consultations, and case discussions within a single department, learning painrelated diagnostic and therapeutic processes as viewed from that specialty. For example, in anesthesiology/pain clinics, students are mainly exposed to nerve blocks, interventional analgesia, and postoperative pain management, whereas in orthopedics, the focus is on pain associated with bone and joint disorders[13]. Teaching is thus framed largely within departmental boundaries, with limited explicit exposure to crossdisciplinary care pathways and teambased models.

3.Skills training emphasizes procedural steps

Skills training centers on the procedural aspects and key points of specific techniques, such as epidural analgesia, peripheral nerve blocks, and certain minimally invasive interventional procedures[14]. Instruction focuses on demonstration of steps and training in basic operational standards, while comparatively less attention is given to the multidisciplinary knowledge base underpinning these procedures (e.g., imaging principles, anatomical variations, multidimensional prevention of complications) or to clarifying how these techniques fit within broader diagnostic and therapeutic decisionmaking.

4.Assessment is dominated by knowledge and singleskill testing

Assessment typically relies on final written examinations, periodic tests, and procedural skills examinations, with evaluation indicators concentrated on knowledge acquisition and whether specific skills meet prescribed standards[15]. Systematic and contextualized assessment of teamwork skills, interdisciplinary communication, concepts of longterm management for chronic illness, and humanistic care remains limited.

(3) Major limitations and shortcomings

The traditional teaching model described above has undoubtedly played a positive role in helping students acquire fundamental painrelated knowledge and singlediscipline skills, and in providing an initial understanding of pain management. However, when compared with the developmental requirements of modern pain medicine and the practical needs of comprehensive chronic pain management, multiple shortcomings become evident.

First, the training objectives are relatively narrow in scope. Existing goals are often restricted to "mastering the diagnosis and treatment of common pain conditions," with insufficient explicit and operational delineation of core competencies such as comprehensive pain management, multidisciplinary collaborative care, and wholecourse management with longterm followup[16]. This lack of clearly articulated competency targets makes it difficult to systematically guide the overall design of teaching content and methods.

Second, course content is fragmented. Painrelated knowledge is dispersed across different disciplinebased courses, and each specialty tends to address only pain problems closely related to its own domain, from its own perspective, without a unifying conceptual framework or overarching logic. As a result, students often struggle to construct an integrated understanding of "pain medicine" as a distinct field from this "jigsaw puzzle" of information, which in turn hinders their ability to apply knowledge comprehensively in clinical contexts.

Third, authentic multidisciplinary care processes—such as those involving multidisciplinary teams (MDTs)—are seldom presented in current curricula and assessments. There are few structured opportunities in classroom or clinical teaching to simulate or participate in MDT consultations, joint ward rounds, or interdisciplinary case conferences[17]. Consequently, learners rarely experience a genuine team setting in which they must identify problems, share information, and collaborate in decisionmaking, and thus have limited opportunities to develop early awareness and practical skills in multidisciplinary cooperation.

Fourth, learning remains predominantly passive, and activelearning strategies are underutilized. Teaching is still largely lecturebased, with limited use of problembased learning (PBL), casebased learning (CBL), teambased learning (TBL), and other approaches that promote active engagement and higherorder thinking. Systematic training in soft skills—such as doctor–patient communication, humanistic care, psychological interventions, and health education—also remains insufficient, making it difficult to fully align education with the strong emphasis that pain management places on patient experience and quality of life.

Against the backdrop of ongoing "New Medical Sciences" initiatives and competencybased medical education (CBME), these issues and tensions have become increasingly prominent[18]. This has prompted universities and training centers across China to explore teaching reforms in pain medicine guided by multidisciplinary integration, thereby laying a practical foundation for subsequent innovation and optimization of teaching models.

4. New trends in teaching models for pain medicine in a multidisciplinary context

Driven by advances in multidisciplinary integration and the national "New Medical Sciences" initiative, teaching in pain medicine has begun to exhibit several notable emerging trends[19].

1.From disciplinebased to problem or disease spectrum–based organization

An increasing number of teaching designs now adopt typical pain problems or disease spectra—such as acute postoperative pain, chronic low back pain, cancer pain, and neuropathic pain—as the primary organizing axis. Relevant knowledge from multiple disciplines is then integrated around these core themes, replacing the traditional approach in which content was segmented by individual specialties or organ systems.

2.From singledepartment teaching to multidisciplinary and MDTbased contextual teaching

In some teaching hospitals, real multidisciplinary consultations, outpatient clinics, and ward rounds have been incorporated into teaching activities. Pilot formats include MDT demonstration clinics, joint case conferences, and interdisciplinary ward rounds, enabling learners to observe and participate in genuine multidisciplinary decisionmaking processes and to appreciate integrated care pathways for complex pain conditions.

3.From passive listening to active learning

Activelearning strategies such as problembased learning (PBL), casebased learning (CBL), and teambased learning (TBL) are being increasingly applied in pain education. By engaging students in typical clinical scenarios, smallgroup discussions, and guided literature searches, these approaches foster problemsolving abilities, critical thinking, and evidencebased reasoning, and help cultivate learners' initiative and selfdirected learning skills.

4.From singleoutcome assessment to multidimensional comprehensive evaluation

In addition to traditional assessments of theoretical knowledge and technical skills, some programs have begun to incorporate formative assessment, evaluation of team performance, communication skills, and humanistic qualities[20]. These efforts represent initial attempts to construct competencyoriented evaluation frameworks that better reflect the core capabilities required for contemporary pain practice.

Across different institutions and training centers, these trends have given rise to diverse implementation pathways and several representative teaching models, collectively laying the groundwork for more systematic reform of pain medicine education in a multidisciplinary context.

5. Representative practices and advances in multidisciplinary pain teaching in China and abroad

(1) MDT-based contextual and team-based teaching

The multidisciplinary team (MDT) model is a fundamental form of clinical practice in pain medicine and provides a highly intuitive vehicle for delivering multidisciplinary teaching. Building on routine MDT services, several tertiary hospitals have developed MDT demonstration clinics, teaching ward rounds, and multidisciplinary case conferences as structured teaching formats.

In these settings, teachers from multiple disciplines—including anesthesiology/pain medicine, orthopedics, neurology, oncology, rehabilitation, psychiatry/psychology, nursing,

and pharmacy—participate jointly in teaching[21]. Representative complex or challenging pain cases are selected, and students are organized into groups to role-play different professional disciplines. They are tasked with obtaining medical histories, designing pain and functional assessment plans, and drafting comprehensive treatment strategies. During the debriefing phase, teachers from each discipline provide feedback and supplementary explanations from their respective professional perspectives, helping students understand each specialty's focus, reasoning process, and basis for decision-making.

Studies have shown that such MDT-based, contextual, team-oriented teaching helps students grasp the overall process of pain management, strengthens their awareness of cross-disciplinary communication and teamwork, and fosters identification with the professional role and value of pain medicine.

(2) Case- and problem-driven interdisciplinary teaching (CBL/PBL)

Case-based learning (CBL) and problem-based learning (PBL), centered on typical clinical cases or problems, are being increasingly applied in pain education[22]. Teaching designs typically focus on common yet etiologically complex and management-diverse conditions—such as chronic low back pain, trigeminal neuralgia, diabetic neuropathic pain, and cancer pain—and construct interdisciplinary scenarios around these entities.

Students are usually required to prepare before class by reviewing complete case records, searching relevant literature, and viewing teaching videos[23]. During class, under the joint guidance of teachers from multiple specialties (e.g., anesthesiology/pain medicine, neurology, oncology, rehabilitation, psychiatry/psychology, and pharmacy), they engage in small-group discussions to systematically map out differential diagnoses, assessment pathways, and comprehensive treatment strategies. Throughout this process, concepts from imaging, pharmacology, rehabilitation therapy, psychological interventions, and lifestyle management are naturally integrated into the discussion.

Research indicates that CBL/PBL approaches not only increase students' learning motivation, but also promote integration of basic and clinical knowledge, enhance clinical reasoning, and support evidence-based decision-making—features that are highly consistent with the multidisciplinary and competency-based orientation of pain medicine education.

(3) Interprofessional education (IPE)

Pain management is inherently collaborative and strongly dependent on interprofessional cooperation. Some institutions have therefore experimented with interprofessional education (IPE) by bringing together medical, nursing, rehabilitation, and pharmacy students in shared teaching units[24]. These units often revolve around tasks such as optimizing postoperative analgesia pathways, designing home follow-up plans for chronic pain, or developing patient education programs.

Role assignments within the team reflect each profession's functions and responsibilities. Through collaborative work, students jointly complete pain assessments, treatment planning, and the design of patient education materials[25]. Teachers then provide feedback and evaluation focusing on three main dimensions: team collaboration, communication, and understanding of professional roles.

Studies suggest that IPE helps break down professional silos, enhances students' appreciation of other professions' contributions, and improves team communication and coordination, thereby laying a foundation for future MDT-based pain practice.

(4) Simulation-based teaching and virtual reality technologies

Procedural skills and emergency management are critical components of pain education. To balance safety with effectiveness, simulation-based teaching and virtual/augmented reality (VR/AR) technologies are being used with increasing frequency.

High-fidelity simulators and standardized patients are employed to train scenarios such as severe postoperative pain, opioid-induced respiratory depression, and acute severe pain in emergency settings[26]. Students repeatedly practice assessment, decision-making, and communication in realistic but controlled environments. In addition, VR/AR and virtual simulation platforms are used to model interventional procedures such as nerve blocks, transforaminal endoscopy, and radiofrequency ablation, enabling students to familiarize themselves with anatomical structures and imaging localization before operating on real patients, thereby enhancing procedural understanding and risk awareness.

Research has shown that simulation-based education improves procedural proficiency, self-confidence, and awareness of patient safety, and may help reduce novice errors in clinical practice.

(5) Digital and blended teaching models

The development of information technology has created new resources and learning modalities for pain education. Many teaching units have begun to build microlectures, instructional videos, case libraries, and online question banks focused on pain, thereby offering students flexible, on-demand learning opportunities[27].

Blended (online–offline) teaching models are increasingly being adopted. Online components are used primarily for theoretical preparation, case review, and self-assessment, whereas offline sessions focus on high-value interactions such as in-depth discussion of challenging problems, MDT simulations, and hands-on skills training[28]. Some schools also use learning analytics functions on online platforms to track students' learning behaviors and mastery levels, providing data to support adaptive adjustments in instructional design.

Evidence suggests that blended learning can improve classroom efficiency and foster students' self-regulated learning capabilities, making it a promising direction for the modernization of pain medicine education.

6. Current status and developments in assessment of teaching in pain medicine

At present, assessment in pain medicine education still relies mainly on written examinations, oral examinations, and procedural skills tests, with a primary focus on theoretical knowledge and the mastery of individual technical skills[29]. Key dimensions such as teamwork, communication, professionalism, and humanistic care are evaluated less systematically and often remain underemphasized.

With the advancement of multidisciplinary teaching models, assessment systems are gradually becoming more diversified and competency-oriented[30]. On the one hand, objective structured clinical examinations (OSCEs) and multi-station assessments have been introduced into pain education. Assessment stations are designed around scenarios such as pain assessment, formulation of postoperative analgesia plans, and communication with patients and their families. Standardized patients and structured rating scales are used to evaluate students' clinical reasoning, communication skills, and decision-making performance in simulated yet realistic contexts.

On the other hand, formative and multisource assessment has been increasingly incorporated into courses. Indicators such as classroom participation, performance in group discussions and case presentations, and quality of reflective journals are integrated into overall evaluation. Teachers, peers, and other health professionals[31] (e.g., bedside nurses, rehabilitation therapists) jointly participate in the assessment process, providing a more three-dimensional picture of students' performance and developmental trajectory in authentic team settings.

In addition, some training centers, guided by the principles of competency-based medical education (CBME), have begun to construct milestone-based assessment systems linked to specific core competencies, such as "conducting standardized pain assessment," "developing multimodal analgesia plans," and "communicating and collaborating effectively within multidisciplinary teams." Through repeated, context-rich assessments at different stages of training, these systems evaluate whether trainees have achieved the expected milestones, thereby promoting alignment among educational objectives, teaching activities, and evaluation standards.

Overall, assessment reform in pain medicine education has begun to show a positive trend toward competency-centered, multi-tool–supported evaluation. Nonetheless, important gaps remain in the standardized construction of indicator systems, rigorous validation of the reliability and validity of assessment instruments, and investigation of the relationship between assessment outcomes and objective endpoints such as patient prognosis and healthcare quality[32]. These areas warrant further refinement and deepening in future educational practice and research.

7. Major challenges in current research and practice

Although reforms in teaching models for pain medicine within a multidisciplinary framework have made tangible progress, they remain largely in an exploratory phase and face several notable challenges.

First, top-level curriculum design and standard-setting remain underdeveloped. At the

national and professional levels, explicit training objectives and curriculum standards for "pain medicine" as a relatively independent educational module are still lacking. Substantial variation exists across universities and training centers in terms of content selection, depth of instruction, and allocation of teaching hours[33]. The absence of a unified core competency framework and minimum curriculum requirements undermines the standardization and comparability of training outcomes.

Second, the depth and quality of multidisciplinary integration require improvement. Some current practices are still limited to "multi-specialty serial lectures" or simple juxtaposition of subject-specific content, rather than genuine integration organized around clinical problems[34]. Misalignment of teaching objectives across disciplines and loose content linkage make it difficult for students to develop a truly integrated understanding of pain management, and their ability to transfer and apply such learning in real clinical contexts remains limited.

Third, faculty development and mechanisms for interdisciplinary collaboration are relatively weak. The number of educators who combine a background in pain medicine with formal training in medical education and the capability to design interdisciplinary courses is limited[35]. Teachers from non-anesthesiology/pain specialties may lack sufficient motivation and institutional support to participate in pain teaching. Organizational and management mechanisms for cross-departmental and cross-professional collaborative education are not yet fully established.

Fourth, the workload required for teaching reform is misaligned with current incentive structures. Innovative pain teaching often demands substantial time and effort from faculty for curriculum development, case selection and curation, construction of simulation scenarios, and assessment design[36]. However, within existing frameworks for academic promotion, performance appraisal, and scholarly evaluation, recognition of teaching innovation, interdisciplinary instruction, and CBME-oriented practice remains limited, thereby weakening faculty motivation for sustained, in-depth engagement.

Fifth, the evidence base for educational effectiveness remains relatively weak. Most existing studies are single-center and small-sample, and evaluation indicators tend to focus on students' subjective satisfaction and short-term performance on knowledge tests or skills assessments[37]. There is a lack of medium- and long-term follow-up on clinical competency development, career trajectories, and objective outcomes such as patient safety and treatment effectiveness. Consequently, high-quality evidence supporting the superiority of specific teaching models is still insufficient.

Lastly, educational resources for pain teaching are unevenly distributed across regions and institutions. Current reform efforts are concentrated mainly in large comprehensive universities and high-level teaching hospitals. Many regional colleges and non-affiliated teaching hospitals face marked shortages of specialized faculty, representative case resources, and digital teaching infrastructure[38]. High-quality educational experiences and resources have not yet been effectively shared and widely disseminated, which to some extent constrains improvement in the overall quality of pain medicine education nationwide.

8. Future directions and recommendations for the development of pain medicine as a discipline

In the context of increasing multidisciplinary integration, further optimization of teaching models in pain medicine should be advanced in a coordinated manner across multiple dimensions, including curriculum standards, system design, faculty development, teaching methods and technological support, educational research, and policy safeguards.

First, a tiered competency framework and curriculum standards for pain medicine should be established, aligned with the "New Medical Sciences" initiative and the principles of competency-based medical education (CBME). These standards should clearly define the core competencies and milestone outcomes expected for undergraduate and postgraduate students, residents/specialists, and learners in related professions such as nursing, rehabilitation, and pharmacy[39]. On this basis, relatively unified course objectives and essential content standards can be formulated, thereby providing normative references for curriculum development and teaching assessment across different training institutions.

Second, the curriculum system should be reconstructed around clinical problems and authentic care pathways. Typical pain-related conditions—such as acute postoperative pain, chronic non-cancer pain, cancer pain and palliative

care, and neuropathic pain—can serve as core disease spectra[40]. Following the logical sequence of "assessment–diagnosis–treatment–follow-up and long-term management," a spiral curriculum structure should be developed that integrates basic pain mechanisms, pharmacology, imaging, interventional techniques, rehabilitation therapies, and psychological interventions[41]. Vertical and horizontal integration across basic and clinical sciences, and across single and multiple disciplines, is expected to foster a coherent and comprehensive understanding of pain medicine.

Third, sustained efforts are needed to build stable and efficient interdisciplinary teaching teams and coordination mechanisms. Medical schools, affiliated hospitals, and relevant departments can jointly establish pain medicine teaching teams with clearly defined roles and responsibilities for faculty from different disciplines within the curriculum[42]. Regular consultation, joint lesson planning, and structured teaching feedback mechanisms should be implemented. Frontline clinicians can be engaged as part-time or adjunct faculty through institutional and cross-institutional appointments. In parallel, systematic training in medical education, curriculum design, and assessment methods should be provided to teachers to enhance their capacity for interdisciplinary teaching.

Fourth, deeper integration is required among MDT-based teaching, interprofessional education (IPE), simulation-based teaching, and digital/information technologies within the overall curriculum design. MDT-based scenario teaching, case- or problem-driven learning, and simulation/virtual training should be incorporated into a unified instructional pathway rather than implemented as isolated pilots[43]. By fully leveraging virtual simulation platforms and online course resources, an integrated model of "online knowledge construction–offline contextual experience–hands-on skills training" can be developed to systematically enhance students' comprehensive competencies and learning experience.

Fifth, multicenter collaboration and high-quality educational research should be strengthened. Multiple teaching units should be encouraged to jointly undertake pain education reform projects using harmonized study designs and shared evaluation indicators. Through pre–post comparisons, parallel controlled studies, and long-term follow-up, the impact of different teaching models on learners' clinical competence trajectories and on objective patient outcomes can be systematically evaluated[44]. Such work will help generate evidence with higher methodological rigor to inform policy-making, refinement of standards, and broader dissemination of effective practices.

Finally, policy frameworks and incentive mechanisms require further improvement. The relative weight of pain education and multidisciplinary training should be increased within talent development plans, professional title promotion, and performance appraisal systems[45]. Faculty members engaged in curriculum development and educational reform in pain medicine should receive appropriate recognition of workload, along with material and honorary incentives[46]. In addition, mechanisms should be explored to incorporate high-quality teaching achievements into academic evaluation systems. These measures would help create more attractive career development pathways for outstanding educators and teaching teams in pain medicine, thereby providing institutional support for the sustainable and high-quality development of education in this field.

Conclusion

Multidisciplinary integration is intrinsic to pain medicine and constitutes a core, unavoidable theme in contemporary pain education. In China, teaching models for pain diagnosis and management are currently undergoing a critical transition from traditional, single-discipline, fragmented knowledge transmission toward approaches that emphasize multidisciplinary collaboration, problem orientation, and competency-based training. The implementation of innovative models—including MDT-based scenario teaching, case-based learning (CBL), problem-based learning (PBL), interprofessional education (IPE), simulation and virtual reality technologies, and blended online–offline instruction—has opened promising avenues for enhancing students' abilities in pain assessment, clinical decision-making, teamwork, and humanistic care.

From a national perspective, however, pain education reform still follows a pattern of "numerous isolated initiatives, strong performance in a few leading institutions, but limited overall impact." Significant shortcomings remain in top-level design, the depth of curricular integration, faculty capacity building, and the strength of the evidence base supporting educational effectiveness.

Looking ahead, under the strategic guidance of national policies and professional societies, it will be crucial to further clarify the role and positioning of pain medicine within the medical education system, to develop tiered and operational competency frameworks and curriculum standards, and to promote multicenter collaboration and sharing of high-quality educational resources. Through these efforts, a new paradigm for pain education—characterized by rational structure, distinctive features, and demonstrable effectiveness—can be gradually established. With sustained institutional support and ongoing pedagogical innovation, it should be possible to cultivate a cadre of high-quality health professionals capable of delivering comprehensive pain management and functioning effectively within multidisciplinary teams to meet the evolving needs of modern healthcare.

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Competing interests

The authors declare that they have no competing interests.

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