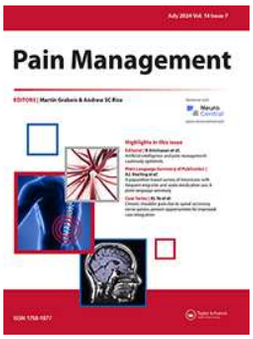

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EDITORIAL

Artificial intelligence and pain management: cautiously optimistic

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Artificial Intelligence (AI) is transforming various industries by developing algorithms that harness big data to improve efficiency, boost productivity, reduce costs and enhance the decision-making process. AI has already been applied in several healthcare settings and has demonstrated great promise in identifying inefficiencies and streamlining clinical workflow for healthcare providers [1]. AI-powered tools assist physicians and care teams with routine tasks and reduce the time and resources required for duties, such as data entry and visual inspection [2]. AI-assisted and AI-integrated paradigms are also likely to play a pivotal role in future medical education and physician training [3]. As in other medical areas, AI holds immense potential to revolutionize the diagnosis, assessment and management of pain. However, AI tools must be adopted with caution prior to their incorporation into common clinical practice [4–6]. This editorial outlines the opportunities and the caveats of incorporating AI into pain management as the starting point for a broader and necessary conversation within the research and clinical community.

1. Potential opportunities in assessment, diagnosis & management of pain

The opportunities for AI in the pain field are enormous, but the most apparent ones come from defining unambiguous decision points that can provide specific and quantitative outputs.

One of the most apparent opportunities for AI in pain management is in determining the likely etiology of pain. Using AI to identify trends in medical records and provide a personalized diagnosis has already been applied in other healthcare practices [7]. Specifically, AI algorithms are used in pain management to identify potential sources of pain in many ways. A possible approach is automated analysis of imaging tools, such as X-rays, MRIs or CTs, that will help in the differential diagnosis of low back pain, e.g., spinal stenosis, disc degeneration and lumbar facet arthritis. While correlation between imaging studies and pain sourcing is not precise, an AI-based approach can factor other human pain biomarkers like activity levels, pain index, past history of pain and electromyographic data to determine a probable diagnosis. Systematic reviews suggest that the best-performing systems can diagnose degenerative changes of the spine with average accuracy rates >80% [8]. Predictive pain models can also be developed to use various types of data such as patient-specific demographic, genetic and disease characteristics to estimate the probability of having or developing a particular disease or specific outcome. These predictive models have been developed with research databases and need to be confirmed with larger population-based studies.

Another significant opportunity for AI in pain management is through pain prediction, planning and personalized treatment. Several studies report that data from electroencephalograms can help predict pain intensity, pain phenotypes (e.g., migraine phenotypes, neuropathic pain), and treatment response (e.g., responders vs nonresponders) with varying accuracies ranging from 65 to 100% [9]. These results suggest that AI has the potential to effectively predict pain outcomes, which may eventually be used to assist clinical care. Predictive algorithms may also be used to model the effectiveness of different interventions, for example to reduce the variability in currently tested stimulation settings for neuromodulation treatments [10]. These models could optimize neuromodulation therapies in a resource efficient manner by developing predictive and prognostic biomarkers [11]. Another example of the use of AI is personalized cognitive behavioral therapy [12]. Here, AI could utilize a patient's psychosocial profile and/or demographic information to develop patient selection biomarkers and make decisions tailored to the individual patient. These improved paradigms promise to increase

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treatment adherence and overall effectiveness. At last, recently-introduced large language models may improve patient education by translating medical terminology for patients and allowing them to better understand clinical terms and decisions [13]. The use of these tools provides opportunities for a more tailored patient training and treatment plan that integrates biologic, behavioral and biometric data.

Another potent opportunity for AI would be in the objective assessment of the functional interference associated with pain, using data from behavioral- and neurophysiology-based automated assessments to replace the current subjective evaluations [14,15]. By integrating many streams of data such as facial expressions, imaging or longer-term activity tracking, AI could help with pain assessment for vulnerable groups of patients such as children, geriatric patients or patients who are unconscious or have cognitive dysfunction. These opportunities can be further utilized in tandem with health equity efforts. Specifically for patients in disadvantaged communities or situations, semi-automated health care systems can provide affordable and easily accessible measures of pain diagnosis, management, or assessment. One of the potential strengths of AI is to be able to assess the multidimensional aspects of pain, using several data streams to come to a single output. This process may be abstract and conceptually challenging because of the extensive set of parameters and subjective conclusion. However, models like these can be used in many situations to take in sensory, biometric and behavioral data to come to a singular quantitative output.

2. Limitations & caution

Despite the many exciting opportunities for AI in the pain field, there are still several caveats, suggesting that a cautious approach is prudent. A significant limitation that impedes the development of accurate AI models at present is the scarcity of comprehensive datasets. Bias and errors may arise if data inputs are inaccurate, particularly concerning minority groups. Namely, if the training set is skewed towards certain demographics, then the entire model becomes biased and may lead to inaccurate results, health disparities and potential harm to some patients [6]. Another limitation of any AI model is that the input data must be very specific. The models are trained with a very structured input for an equally structured output, meaning they cannot have too broad of a use case. For example, AI models often cannot generalize across institutions and/or significant differences in the patient population (e.g., a model trained on pain in able-bodied individuals might fail if deployed on individuals with partial paralysis). Hence, it is vital that any model is not over-generalized, but used for specific situations. Many of the fundamental concepts to help improve pain management and develop new therapeutics, described in the Consensus Statement resulting from an National Institutes of Health (NIH) workshop [11], are equally applicable for the development and application of AI models.

While there may be considerable benefits in implementing AI models into pain practice, there are significant investments involved in the development and implementation of the model. Limited availability of data sets to develop these models cause a heavy investment on the data collection and curation front. There must also be an investment for the implementation of technology that is easily accessible, and training for the human input of data into the model. At last, even well-trained AI models can result in erroneous conclusions. Thus, regardless of how sophisticated the method is, there needs to be clinical safeguards to ensure that following the predictions does not harm patients.

Furthermore, bioethical concerns that include privacy and confidentiality, informed consent, the impact on the medical profession, and justice have been raised regarding implementation of AI models [2,16]. Is it ethical for a model to make a diagnosis completely autonomously? Is it ethical for thousands of electronic health records to be used for training for this model and does it present a security risk? At last, there are many disparities in health care currently that could be heightened if developed incorrectly. The potential unintended consequences of exacerbating treatment disparities along racial, ethnic and gender lines have been highlighted. The WHO has their own AI core principles that caution health care practitioners before using or developing an AI model for the good of any healthcare practice. At last, it is vital that communication is clear between engineers and clinical practitioners not only during the prediscussion, but throughout development of any technology. As interdisciplinary as a project like this would be, it is vital that discussion is happening throughout development, and not only in the initial stages.

3. Future considerations

The opportunities for AI in pain are immense, between pain diagnosis to management to assessment with many more applications. Future developments are likely to include augmented intelligence, which could enhance patient care and complement a physician's knowledge and skills. The development and implementation of any of these solutions, however, will require collaboration between stakeholders and proper checks and balances at

every stage of review. Prospective clinical data should be used to validate the model's efficacy, value and impact on patient-centered outcomes, such as pain, physical function and psychosocial improvement. In addition, healthcare providers must ensure that the application has safeguards in place, including meticulous governance, that would protect patient privacy [2,17]. Pain practitioners can contribute by collecting reliable data from diverse patient groups so that future innovations can be evidence-based and equitable. AI should be viewed as a complementary tool that does not replace clinicians but helps augment physician–patient relationship by automating routine tasks, and increasing time with patients [18].

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References

1. Chen M, Decary M. Artificial intelligence in healthcare: an essential guide for health leaders. Healthc Manage Forum. 2020;33(1):10–18. doi:10.1177/0840470419873123
2. Aung YYM, Wong DCS, Ting DSW. The promise of artificial intelligence: a review of the opportunities and challenges of artificial intelligence in healthcare. Brit Med Bulletin. 2021;139(1):4–15. doi:10.1093/bmb/ldab016
3. Xu Y, Jiang Z, Ting DSW, Kow AWC, et al. Medical education and physician training in the era of artificial intelligence. Singapore Med J. 2024;65(3):159–166. doi:10.4103/singaporemedj.SMJ-2023-203
4. Abd-Elsayed A, Robinson CL, Marshall Z, et al. Applications of artificial intelligence in pain medicine. Curr Pain Headache Rep. 2024;28(4):229–238. doi:10.1007/s11916-024-01224-8
5. Hagedorn JM, George TK, Aiyer R, et al. Artificial intelligence and pain medicine: an introduction. J Pain Res. 2024;17:509–518. doi:10.2147/JPR.S429594. eCollection 2024.
6. Nazer LH, Zatarah R, Waldrip S, et al. Bias in artificial intelligence algorithms and recommendations for mitigation. PLOS Digit Health. 2023;2(6):e0000278. doi:10.1371/journal.pdig.0000278. eCollection 2023 Jun.
7. Caruana A, Bandara M, Musial K, et al. Machine learning for administrative health records: A systematic review of techniques and applications. Artif Intell Med. 2023;144:102642. doi:10.1016/j.artmed.2023.102642
8. D'Antoni F, Russo F, Ambrosio L, et al. Artificial intelligence and computer aided diagnosis in chronic low back pain: a systematic review. Int J Environ Res Public Health. 2022;19(10):5971. doi:10.3390/ijerph19105971
9. Mari T, Henderson J, Maden M, et al. Systematic review of the effectiveness of machine learning algorithms for classifying pain intensity, phenotype or treatment outcomes using electroencephalogram data. J Pain. 2022;23(3):349–369. doi:10.1016/j.jpain.2021.07.011
10. Hariharan V, Harland TA, Young C, et al. Machine learning in spinal cord stimulation for chronic pain. Oper Neurosurg. 2023;25(2):112–116. doi:10.1227/ons.0000000000000774
11. Davis KD, Aghaeepour N, Ahn AH, et al. Discovery and validation of biomarkers to aid the development of safe and effective pain therapeutics: challenges and opportunities. Nat Rev Neurol. 2020;16(7):381–400. doi:10.1038/s41582-020-0362-2
12. Piette JD, Newman S, Krein SL, et al. Patient-centered pain care using artificial intelligence and mobile health tools: a randomized comparative effectiveness trial. JAMA Intern Med. 2022;182(9):975–983. doi:10.1001/jamainternmed.2022.3178
13. Oniani D, Sreekumar S, DeAlmeida R, et al. Toward improving health literacy in patient education materials with neural machine translation models. AMIA Jt Summits Transl Sci Proc. 2023;2023:418–426. eCollection 2023
14. Cascella M, Schiavo D, Cuomo A, et al. Artificial intelligence for automatic pain assessment: research methods and perspectives. Pain Res Manag. 2023;2023:6018736. doi:10.1155/2023/6018736
15. El-Tallawy SN, Pergolizzi JV, Vasiliu-Feltes I, et al. Incorporation of "artificial intelligence" for objective pain assessment: a comprehensive review. Pain Ther. 2024;13(3):293–317. doi:10.1007/s40122-024-00584-8
16. Manrique de Lara A, Peláez-Ballestas I. Big data and data processing in rheumatology: bioethical perspectives. Clin Rheumatol. 2020;39(4):1007–1014. doi:10.1007/s10067-020-04969-w
17. Murdoch B. Privacy and artificial intelligence: challenges for protecting health information in a new era. BMC Med Ethics. 2021;22(1):122. doi:10.1186/s12910-021-00687-3
18. Ahuja AS. The impact of artificial intelligence in medicine on the future role of the physician. Peer J. 2019;7:e7702. doi:10.7717/peerj.7702