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You can't spell pain without AI: How Artificial Intelligence will change Pain Medicine

Elliot Revell[1]

Correspondence: Dr Elliot Revell, Department of Anaesthesia, Barnsley Hospital NHS Foundation Trust, Gawber Road, Barnsley, UK S75 2EP
Email: elliotrevell@doctors.org.uk

[1]*Barnsley Hospital NHS Foundation Trust*

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The Ratio Club was a private dining group formed in 1949 to discuss cybernetics, an emerging discipline concerned with control and communication in animals and machines[1,2]. Early correspondence from its founders stressed the importance of conviviality to facilitate discussion, with meetings ranging from the structure of nerve fibres to the education of digital computers[3]. By explicitly drawing parallels between the nervous system and early computing, the group helped shape the intellectual foundations of modern artificial intelligence (AI)[4].

It is therefore unsurprising that a technology inspired by neurobiology has such potential relevance for pain, a noxious stimulus of the nervous system itself. Broadly, AI systems can be divided into deterministic and probabilistic approaches. Deterministic systems apply machine learning to structured data to generate reproducible predictions, whereas probabilistic systems, including neural networks, estimate the most likely outputs and may generate novel responses[5]. Both approaches have potential utility across the spectrum of pain prevention, diagnosis, and management.

At its most upstream, AI may reduce exposure to pain-inducing events. In transport, deep learning models embedded in advanced driver assistance systems and autonomous vehicles have demonstrated potential to improve safety and reduce traumatic injury[6]. In sports medicine, machine learning has been applied to training load and physiological data to predict injury risk, supporting preventative interventions[7]. Similar approaches are being explored in labour-intensive workplaces, where wearable sensors can analyse kinematic data to identify high-risk movements and suggest ergonomic adjustments[8]. These concepts could extend to the wider population, particularly frail and older adults, using smart wearables to capture biomechanical and physiological data and deliver real-time personalised guidance to reduce musculoskeletal pain and repetitive strain injury.

Where pain cannot be prevented, deterministic AI may assist diagnosis and prognosis by integrating clinical assessment with electronic health record data, including demographics, medical history, laboratory results, and imaging reports[9]. The full potential of this approach lies in the integration of high-volume, heterogeneous data streams such as smartphone use, wearable sensors, audio, and video. By better capturing biological, psychological, and social contributors to pain, these systems may accelerate diagnosis and inform more targeted analgesic strategies.

Pharmacological management represents another area of opportunity. AI-enabled prescribing support tools have been proposed to assist clinicians in optimising analgesic choice, dosing, and safety, particularly in complex or high-risk patients[10]. Improved pharmacovigilance may be achieved through models capable of identifying non-adherence or patterns suggestive of opioid misuse[11]. At a more fundamental level, advances in deep learning have transformed drug discovery. AlphaFold demonstrated that protein three-dimensional structure can be predicted from amino acid sequence with high

accuracy[12], accelerating therapeutic development and raising the prospect of more personalised analgesic compounds informed by individual biology.

Clear communication remains central to effective pain care. Language barriers and health literacy continue to limit access to services and patient understanding. Probabilistic large language models offer an opportunity to support translation, patient education, and information delivery across hospital and community settings, provided appropriate safeguards are in place. These systems may assist with appointment information, treatment summaries, and frequently asked questions, potentially improving engagement for underserved groups.

Rapid progress is not without risk, and governance frameworks have struggled to keep pace with deployment. Poorly supervised systems have demonstrated the capacity to deliver misleading or harmful information. The potential for therapeutic misconception is particularly concerning if boundaries between clinicians and automated systems are unclear. For these reasons, clinical leadership is essential. AI systems should augment, not replace, professional judgement, with robust safeguards around confidentiality, transparency, and accountability. Care must also be taken to ensure that efficiency gains do not come at the cost of dehumanised clinical encounters, particularly in pain medicine, where trust and empathy remain fundamental.

Despite these challenges, the pace of progress since the Ratio Club first convened is striking. What began as a speculative discussion over dinner has produced technologies with the capacity to reshape medical practice. Although predictions about the future role of AI in pain medicine remain uncertain, one conclusion is clear: it will be analytics and algorithms, rather than beer and buffets, that drive the next phase of innovation.

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