

Artificial intelligence in paediatrics: A checkup

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Key Points

- AI has demonstrated the ability to positively impact patient care across many broad areas of paediatrics, including imaging interpretation, diagnostics, disease prediction, and treatment decisions.
- While there has been considerable research into applying AI-methodologies in paediatric settings, this has not yet translated to widespread use of AI in clinical practice.
- The integration of AI into clinical practice is dependent on further development of such technologies and research into their ultimate effects on patient outcomes.

Artificial intelligence (AI) refers to a branch of computer science involved in the development of technologies capable of human-like cognitive processing. AI encompasses everything from humanoid robots designed to interact with the physical environment to the utilization of complex algorithms capable of 'learning' from existing data (a training dataset) and making increasingly accurate predictions. AI has many promising applications in medicine, including both direct clinical assistance – i.e. improving diagnostic accuracy and management plans – and facilitating novel discoveries in medical research. Commonly employed AI methodologies in the analysis of medical data include classical machine learning (notably support vector machines and artificial neural networks), deep learning, and natural language processing.¹

AI has many specific applications to the field of paediatrics. Pathology can sometimes be difficult to identify in the setting of normal underlying growth and development. This represents a unique opportunity for AI systems to improve diagnostic accuracy in paediatric-specific settings. Furthermore, the potential benefits of AI systems in improving diagnostic and treatment decisions are paramount in paediatrics, where early diagnoses and optimized treatment can have profound and positive impacts on patients for virtually their entire lives. A selection of recent examples outlining the potential use of AI technologies in various areas of paediatrics are highlighted below. These examples include the use of AI in paediatric radiology, monitoring patients in the critical care setting, as well as identifying and treating children with developmental

disorders. The application of AI in cancer research has also shown promise in elucidating complex disease mechanisms and facilitating the development of improved treatment options for common paediatric malignancies. While the use of AI methodologies has been expanding significantly in paediatrics research, the translation of these technologies from a research setting to clinical practice largely remains an important next step.

Paediatric Radiology

Paediatric radiology represents a field among the most amenable to assistance from AI technologies. Interpreting imaging in infants, children and adolescents carries unique challenges. It can often be difficult to identify true pathological findings in the context of normal growth and development. Examining skeletal age on hand radiographs is crucial in the routine assessment of children with growth disorders and various other chronic diseases, however this is a notoriously time-consuming endeavour which can be difficult to standardize.² As such, image analysis software can be used in clinical practice to assist radiologists in the assessment of bone age. Recently, the accuracy of a deep learning model for the assessment of bone age from hand radiographs was shown to be comparable to both existing image analysis technologies and expert radiologists.³ Since the accuracy of AI-based algorithms has been shown to increase with larger training datasets,³ continued development of such algorithms and the utilization of increasingly large training datasets can be expected to yield further improvements in accuracy. This use of AI shows promise in enhancing the current use of automation in image analysis and is, therefore, among the most likely applications of AI to have an impact on clinical practice in the foreseeable future.

The interpretation of brain imaging in children is another potential application of AI which has garnered substantial interest. Identifying pathological changes on brain magnetic resonance imaging (MRI) in children with neurodevelopmental disorders is particularly challenging, especially when such changes are present on a background of normal developmental changes.⁴ The use of machine learning in the interpretation of paediatric brain imaging is an active area of research. The use of such AI methods has the potential to not only improve diagnostic accuracy for certain neurodevelopmental disorders, but also to better characterize such conditions and identify novel imaging-based biomarkers.^{4,5} Indeed, machine learning was recently used to identify a novel association between inhibited cerebral development in preterm infants and genetic variability in *PPARG*.⁶ This enables further research into the possible therapeutic effects of agents which modulate *PPARG* signaling, which may ultimately lead to therapies that prevent the development of neurocognitive problems in preterm infants.

Deep learning methods have also demonstrated the ability to identify individuals with autism spectrum disorder (ASD) in large functional MRI databases while also defining specific areas of the brain that have the largest influence on differentiating patients with ASD from controls.⁷

Improved Diagnostic and Treatment Decisions

Outside of its potential applications in paediatric radiology, AI has demonstrated utility in improving diagnostic decisions in various areas of paediatrics. Motor impairments are included among possible associated symptoms in children with ASD, and a recent study employed a support vector machine approach to successfully identify preschool children with low-functioning ASD through motion analysis during a simple task.⁸ Machine learning has also been used to identify children with ASD based on their eye movement patterns during facial recognition.⁹ Further development and validation of such methods could lead to the use of novel technologies in the clinic to assist physicians in making conclusive diagnoses of ASD and other paediatric conditions. Such technology can also be utilized to monitor for the development of complications in children during the post-operative period. Analysis of facial expression using computer vision and machine learning algorithms has been shown to produce accurate assessments of post-operative pain in children after undergoing appendectomy surgery.¹⁰ The high incidence of post-operative pain and adverse outcomes associated with its under-identification highlight the potential usefulness of such technologies in the clinical setting.^{10,11}

Long-term monitoring of children with conditions characterized by recurrent events represents another suitable application for AI technologies. In children with epilepsy, monitoring technologies, including EEG, ECG, motion and electrodermal activity sensors, can be coupled with various machine learning algorithms to detect and predict seizures.¹² The accurate prediction of seizure activity through the integration of data from such systems could lead to the development of closed-loop systems which activate a corrective response when triggered. Such systems would provide constant monitoring and could exist as neuro-implantable seizure detection devices coupled with implantable neurostimulators capable of administering a corrective electrical response when seizure activity is identified by the detector.^{12,13} Such closed-loops systems would be expected to reduce the incidence of seizure-related comorbidities, including accidental injury and sudden unexpected death (SUDEP).

Closed-loop monitoring systems can also be used in an intensive care setting. Machine learning algorithms have shown potential utility in assisting with treatment decisions for neonates with late-onset sepsis in the neonatal intensive care unit.¹⁴ In the paediatric cardiac intensive care unit, there is interest in utilizing AI-based technologies to assist physicians with the early detection of clinical decompensation and cardiac arrest.¹⁵ Machine learning-based algorithms which integrate data from electronic health records (EHR) have also been developed to predict need for paediatric intensive care unit transfer in newly admitted patients with better sensitivity and specificity than available paediatric early warning scores.¹⁶ While the application of AI to critical care units has shown positive results in a research setting, further studies are necessary before such technologies are ready for prime-time use in clinical practice.

Paediatric Oncology

While the direct integration of many AI technologies into clinical practice will likely take some time, the utility of AI in identifying novel biomarkers and therapeutic targets promises to have more immediate impacts on patient care. In paediatric oncology, AI methodologies will become increasingly relevant as they possess the ability to examine the interaction between genomic factors and clinical responses to treatment in patients with cancer, particularly hematological malignancies.¹⁷ This should lead to more accurate selection of targeted therapies and lower the risk of adverse responses to treatment. AI has also been used to predict relapse in childhood acute lymphoblastic leukemia (ALL) based on the assessment of clinical data routinely obtained in affected patients.¹⁸ Applying AI technology in a way that leverages laboratory values and other data already obtained in accordance with best practice guidelines is likely to result in quicker uptake of these technologies into clinical practice. However, there is still a considerable amount of work to be done before AI technologies are widely adopted in clinical settings.

Limitations of AI

The use of AI-based systems must overcome several limitations of technology, privacy, and ethics before they can be widely implemented in clinical settings. While AI technologies have certainly demonstrated the potential to positively impact patient care, the benefits of AI-based technologies on patient outcomes need to be conclusively demonstrated using appropriately designed clinical trials. The benefits of AI must also be carefully weighed against the potential costs of implementing such technologies, especially within the context of the universal healthcare system in Canada. Furthermore, the ultimate success of AI systems in medicine is reliant on the continuous input of new data to improve performance parameters. This poses many potential issues, including the current lack of data sharing between institutions and the potential privacy concerns associated with widespread distribution of patient data.¹ An additional caveat to the widespread use of AI systems in medicine includes the need to educate physicians and other healthcare professional on the appropriate applications of such technologies, while also teaching the technical skills required to use them.¹⁹ Such initiatives represent huge undertakings, and while the majority of practicing paediatricians were likely not exposed to the use of AI systems during medical school, the integration of AI teachings into the curriculum for current medical trainees is necessary before the widespread use of AI in medicine is possible.

Issues of AI-associated medical errors will also need to be thoroughly investigated and addressed before such systems are put to widespread use. Indeed, biases in medical decision making could be perpetuated through the use of AI if human biases are prevalent in the datasets used to 'train' such systems.²⁰ While medical errors are likely inevitable, it will be necessary to safeguard against such systemic biases. This is particularly important in paediatrics, where a misdiagnosis can have severe and negative impacts on patients for the rest of their lives. Finally, the legal liabilities associated with AI-related medical error must be clearly outlined prior to such systems becoming extensively utilized in the clinical decision making process.²¹

Conclusion

It is clear that AI has the potential to positively impact many aspects of paediatric medicine. While various uses of AI-based systems continue to be investigated in research settings, such systems are not routinely used in paediatric care. The further translation of current AI technologies into clinical use in the coming years is largely dependent on further research and development. It is important to remember that, while AI is likely to have significant benefits on patient care, such technologies should not be viewed as independent clinical decision makers. Rather, AI should be viewed as a tool that paediatricians will be able to use, when applicable, to provide guidance when caring for patients. The ultimate success and acceptance of AI by paediatricians, patients, and caregivers will likely depend on the appropriate use of such technologies in conjunction with clinical expertise as well as patient and caregiver preferences.

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