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Drawing Connections: Artificial Intelligence to Address Complex Health Challenges

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ABSTRACT

Pattern recognition is a cornerstone of clinical care and public health practice. Historically, advances in medicine have relied on the ability of humans to detect patterns and make inferences. Modern healthcare challenges involve vast amounts of data and a level of complexity that requires additional support to understand. The advancement of Artificial Intelligence has expanded our capability to detect, understand, and address patterns that were previously beyond our grasp. We aim to charter a strategic path forward for innovative applications of Artificial Intelligence technology to understand and address pressing, complex health challenges. Artificial Intelligence is be-ginning to re-conceptualize our understanding of health and disease. Appropriate utilization of these new tools requires innovative thinking, critical appraisal, and tactful resource allocation to ensure issues are addressed in a timely and feasible manner.

Keywords: Artificial intelligence, Pattern recognition, Healthcare quality, Innovation, Complex health challenges

INTRODUCTION

Pattern recognition is a cornerstone of clinical care and public health practice. This recognition of the patterns or stigmata of disease underlies historical and modern diagnostic decision-making processes (Seitzinger et al. 2021). In the context of population health, pattern recognition involves finding epidemiological links among cases and risk factors of disease (Kalra et al. 2019). By seeing beyond individual clinical data points and drawing connections on a population level, clinicians and public health practitioners have made pivotal discoveries to mitigate illness and advance knowledge in the field (Seitzinger et al. 2021). However, to date, such 'hunches' occur on a haphazard basis and are rarely followed through on. Modern healthcare challenges involve vast amounts of data and a level of complexity that requires additional support to understand.

Artificial Intelligence (AI) is beginning to re-conceptualize our understanding of health and disease. The implementation of AI is pivotal in developing the modern era of medical practice and public health strategies. In an era of rapidly evolving technological advances, definitions of pattern recognition have expanded to include processes conducted by computer algorithms (Kalra et al. 2021). In the context of computer science, pattern recognition refers to the identification and classification of meaningful patterns of data input by computers based on the extraction and comparison of the characteristic properties or features of the data (Seitzinger et al. 2021). AI can be described as the process in which computers simulate processes and characteristics of humans to accomplish a task without being specifically programmed to do so. With the ever-increasing need for more accurate and precise healthcare delivery, the integration of AI presents a desirable solution for various data management and interpretation challenges. The integration of AI into the modern world has rapidly gained popularity, with much of the focus and funding being diverted towards AI in healthcare (Buch et al. 2018). Every day the potential benefits of AI are being realized in a growing number of medical fields and are playing an increasing role in tackling healthcare issues. The advancement of AI has the potential to expand our capability to detect, understand, and address patterns that were previously beyond our grasp.

CLINICAL APPLICATIONS OF ARTIFICIAL INTELLIGENCE

The capabilities of AI have shown promise in meeting the demands of any aspect of clinical care. Currently, AI systems are being introduced into clinical care at an unprecedented pace, with new applications arriving every day from health systems worldwide. These capabilities have been used to enhance the efficiency of documentation and detect disorders in various medical disciplines. AI systems have proven helpful in speech recognition with a vocabulary exceeding 300,00 words with an accuracy of 99%% (Schuman 2014). Given that the radiology field depends heavily on the visual identification of mass numbers of scans, AI systems can increase workflow without compromising the accurate identification of abnormalities (Paiva and Prevedello 2017). Using the recording of auscultation collected by electronic stethoscopes and ambulatory electrocardiograms, AI systems have been shown to perform at a level of board-certified cardiologists in detecting murmurs and arrhythmias (Hannun et al. 2019). In radiology, AI interpretations systems have been shown to expedite the treatment of intracranial bleeding, multiple sclerosis, traumatic brain injury, pulmonary embolisms, and wrist fractures. In Pediatrics, such computer-based interpretation systems have outperformed radiologists in performing bone age assessments with increased accuracy and decreased variability (Tajmir et al. 2019) and for ophthalmologists to detect prematurity of retinopathy (Wang et al. 2018). In genetics, AI systems have shown promise in detecting over 200 syndromes by assessing facial phenotypes through digital images with an accuracy of over 90% (Gurovich et al. 2019). These examples illustrate how the growing capabilities of AI are currently being used in individual medical disciplines.

Table 1. Accuracy of artificial intelligence in different medical disciplines.

Discipline	Capability	Data	Accuracy
Cardiology	Identifies common murmurs	Auscultation	88% accurate (Hannun et al. 2019)
Radiology	Detects Developmental Dysplasia of the Hip	Ultrasound	98% accurate (Tajmir et al. 2019)
Dermatology	Identifies skin lesions	Imaging of lesion	Sensitivity: 88.9% Specificity: 75.7% (Haenssle et al. 2018)
Ophthalmology	Detects Retinopathy of Prematurity	Imaging of retina	Sensitivity: 84.9% Specificity: 96.9% (Wang et al. 2018)
Genetics	Identifies over 200 syndromes	Imaging of face	91% accurate (Gurovich et al. 2019)
Clinical Decision Making	Diagnosing common pediatric presentations	Patient History	79-90% accurate (Liang et al. 2019)

The ability to serve as a copilot in clinical decision-making has long been a hope and need for helathcare providers interested in AI technology. For example, AI clinical decision support systems have been shown to diagnose common presentations of asthma, gastroenteritis, pneumonia, sinusitis, upper respiratory infections, encephalitis and psychiatric disorders with accuracies ranging from 70% to 90% (Liang et al. 2019). To provide context for these levels of accuracy, these systems currently outperform junior staff physicians (who have completed undergraduate studies, medical school and residency training) in clinical decision-making but remain inferior to the accuracy of more experienced staff physicians. Recent studies on the accuracy of AI systems in different medical disciplines are summarized in Table 1.

THE NEXT FRONTIER OF ARTIFICIAL INTELLIGENCE IN MEDICINE

AI has the capability to analyze otherwise insurmountable quantities of data to bring meaning and clarity to patterns that were previously deemed random or unintelligible. The modelling capabilities of AI have allowed for the simulation of potential viral mutations and the development of therapeutic agents. The predictive analyses provided by AIallow for a more holistic yet precise understanding of the ageing process and the progression of disease, thereby allowing the extent and timing of treatments to be optimized. Through AI, clinicians will be able to efficiently and accurately identify predictive clinical markers for educational and diagnostic purposes (Colling et al. 2019). The predictive capabilities of AI are showing promise in predicting conditions such as sepsis earlier, enabling clinicians to act more proactively rather than reactively (Goh et al. 2021). AI has the potential to inform the prevention,

treatment or management of existing or impending neurodegenerative diseases (Deng et al. 2020). It has brought a new lens to identify malignant cells and decode parts of the human genome previously labelled as sequences of unknown significance (Hie et al. 2021). Advancements in understanding the implications of differences in the human genome allow for treatments tailored to each patient, with a more comprehensive understanding of interactions among inherent susceptibilities, circumstances and proposed interventions. On a global scale, AI systems can be utilized to model trends and identify correlations (Cabitza and Banfi 2018). AI has given us the opportunity to better understand and anticipate the effects of climate change on health and predict the impacts of potential interventions (Cowls et al. 2021). AI systems have shown the potential to anticipate potential spillover events of zoonotic infectious diseases and guide disease control strategies (Plowright and Hudson 2021).

STRATEGIZING A PATH FORWARD

Navigating the transition to an AIassisted era of healthcare delivery will require an appreciation of the opportunities and limits of each technology. These tools have the potential to have transformative effects on screening, early diagnosis, and determining disease susceptibility and progression. For the first time in the development of modern medicine, we have the ability to recognize, understand, and address patterns that were previously deemed random or happenstance. AI alone cannot provide adequate care, and at the same time, lack of AI utilization will hinder the potential benefits that can be delivered to patients. As the demands for AI in healthcare increase, so must the capabilities of this technology. Advancing the AI system requires incorporating more than just numerical data when assessing patient outcomes or giving a diagnosis. Appropriate utilization of these new tools requires innovative thinking, critical appraisal, and tactful resource allocation to ensure issues are addressed in a timely and feasible manner.

CONCLUSION

Historically, advances in medicine have relied on the ability of humans to detect patterns and make inferences. Advancements in the field of AI have expanded our capabilities to recognize patterns and draw inferences. The modelling capabilities of AI have allowed for the simulation of potential viral mutations and the development of therapeutic agents. The predictive analyses provided by AI allow for a more holistic yet precise understanding of the ageing process and the progression of disease, thereby allowing the extent and timing of treatments to be optimized. It has brought a new lens through which to identify malignant cells on imaging and to decode parts of the human genome previously labelled as sequences of unknown significance. On a global scale, AI has given us the opportunity to better understand and anticipate the effects of climate change on health, including potential spillover and spread of zoonotic infectious diseases. Novel AI tools such

as these require further exploration to identify the wide range of potential applications and challenges.

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