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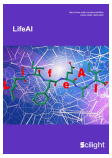

Commentary

Emergence of Artificial Intelligence Applications in Clinical Microbiology and Infectious Disease

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We read with interest the editorial published by Dmitrij Frishman on the revolution that artificial intelligence (AI) will bring to the study of various disciplines in life sciences, such as drug discovery, genomics, structural biology and clinical medicine [1]. For clinical microbiology and infectious disease, which deals with some of the most primitive forms of life that nonetheless could result in devastating epidemics and even pandemics, there is no exception: AI is already beginning to transform both the clinical and laboratory aspects of the discipline in a number of impactful ways [2].

In less than three years since its formal launch in November 2022 by OpenAI, ChatGPT has become a strong, globally recognized brand name for AI chatbot. Its wide application means that AI has been seamlessly integrated into our work in numerous and vastly different fields as well as our daily lives. ChatGPT creates a customizable and personalized experience for users, thanks to the large language model at its core, which enables users to tailor conversations to their preferences by adjusting the format, style, flow, extent of detail, length and language of the dialogue. Throughout a conversation, prompt engineering–crafting successive prompts and responses–is instrumental in shaping the context. This allows users to guide ChatGPT's replies to achieve the specific goals they have in mind, no matter whether they want to brainstorm new ideas, seek in-depth explanations, or get pointers on various possibilities, and so on. ChatGPT has rapidly gained widespread popularity, becoming one of the fastest-growing consumer software applications ever. It is hardly surprising that such success has prompted other tech companies to accelerate the development of rival products, such as Anthropic's Claude, Microsoft's Copilot, Google's Gemini and Perplexity AI's Perplexity, resulting in the ongoing unprecedented advancements in the AI field. In one of our recent studies, we have demonstrated the impressive performance of chatbots in answering not only factual recall questions but also clinical scenario analysis questions in clinical microbiology and infectious disease. The chatbots performed significantly better than final-year medical students, and were even comparable to clinical professors [3]. It was especially encouraging to see that the chatbots could match professors' effectiveness in clinical scenario analysis, as many of those questions demand interpretation of complex clinical histories of patients together with various data from hematological, biochemical, microbiological and immunological laboratories. Such capabilities have strong potential to support clinicians at the bedside. Clinicians regularly consult clinical microbiologists and infectious disease specialists in delivering patient care, on diverse issues from unexplained fevers to selecting and determining the duration of antimicrobials, as well as ordering the right microbiology tests and interpreting test results, etc. The role of clinical microbiologists and infectious disease specialists is broad in this respect as they work with clinicians from different specialties, such as intensive care unit physicians, surgeons and obstetricians and gynecologists, and those from subspecialties in internal medicine, such as hematologists, respiratory physicians and rheumatologists, etc. However, clinical microbiologists and infectious disease specialists may not always be available for consultations around the clock, even in many referral centers. In small hospitals and clinics, such services may even be unaffordable or not deemed cost-effective. Chatbots may well provide an alternative in such circumstances: when these specialists are unavailable, clinicians

may consider using chatbots that have demonstrated strong performance to get specific information relating to possible infections and patient management strategies. It can be envisaged that chatbot performance will continue to improve, following continuous advancements in databases, algorithms and computational power. Furthermore, in a recent study, when we compared the knowledge of the chatbots on *Aspergillus fumigatus*, a fungus of global importance, and *Talaromyces marneffei*, a thermally dimorphic fungus endemic in Southeast Asia, we found that the knowledge of the chatbots for both fungi were comparable [4]. This indicated that the chatbots seemed to be equally knowledgeable on both globally and regionally important microbes.

Similar to interpretation of radiographs and histological sections, the use of AI-based image recognition is another rapidly developing area that has been applied to laboratory diagnostics in clinical microbiology. Traditionally, many laboratory tests involved recognition of morphological characteristics of microbes, for example, the different sizes, shapes and characteristic features of the ova and cysts for parasites, and the lactobacillus and *Gardnerella vaginalis* morphotypes for diagnosis of bacterial vaginosis. For parasites, image detection and classification of various parasites based on deep learning is a rapidly emerging field of study [5]. As for bacterial vaginosis, instead of counting the number of different bacterial morphotypes under the microscope manually and determining the Nugent score and hence the likelihood of a patient suffering from bacterial vaginosis, AI-based image recognition software that treats each microscopic view as a picture has been developed in a number of studies [6,7]. Recently, we have explored the potential of AI in identifying *Aspergillus* species in a proof-of-concept study. We used three different convolutional neural networks with thousands of images of *A. fumigatus*, *A. flavus*, *A. niger* and *A. terreus*, which, among the *Aspergillus* species, are the most commonly associated with human infections, for training, validation and testing, respectively [8]. We assessed the performance and accuracy of automatic *Aspergillus* identification from colonial images, and the results indicated that AI-based image recognition using colonial images is a promising approach for identifying various *Aspergillus* species. These examples illustrated that AI-based image recognition for laboratory diagnosis of infectious disease is gaining prominence in clinical microbiology laboratories.

With similar development in other areas of laboratory science and clinical specialties, AI-based medicine is expected to result in saving cost and manpower for the healthcare profession in the future. Rising life expectancy and aging populations have led to higher demand for medical services and long-term care. The prevalence of chronic diseases such as cancer, chronic heart diseases and diabetes mellitus has also contributed to ongoing treatment costs. Additionally, advances in medical technology and pharmaceuticals, while improving care, often come with high price tags. As patient expectations grow and healthcare systems strive to offer more comprehensive services, budgets naturally have to expand to meet these increasing demands. As exemplified by the above-mentioned developments, it is foreseeable in the near future that some of the roles of infectious disease physicians, clinical microbiologists and other laboratory personnel would be partially or fully taken up by chatbots, AI-based image recognition software, etc. Similar developments have also been observed in other areas. For example, in radiology and pathology, AI-based image recognition software applications have been found to be extremely useful in interpreting radiographs and computerized tomography and magnetic resonance imaging results, as well as analyzing histological sections, replacing the work of radiologists and pathologists [9,10]. In essence, AI enables healthcare systems to do more with less resources–reducing dependency on a large workforce while improving accuracy, speed and efficiency across the board. These improvements not only cut costs but also allow professionals to focus more on areas where their expertise is most needed, paving the way for a more sustainable and effective healthcare system.

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Conflicts of Interest

The authors declare no conflict of interest.

Use of AI and AI-Assisted Technologies

No AI tools were utilized for this paper.

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