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ChatGPT and mycosis– a new weapon in the knowledge battlefield

Yi Jin¹, Hua Liu², Bin Zhao^{3*} and Weihua Pan^{1*}

Abstract

As current trend for physician tools, ChatGPT can sift through massive amounts of information and solve problems through easy-to-understand conversations, ultimately improving efficiency. Mycosis is currently facing great challenges, including high fungal burdens, high mortality, limited choice of antifungal drugs and increasing drug resistance. To address these challenges, We asked ChatGPT for fungal infection scenario-based questions and assessed its appropriateness, consistency, and potential pitfalls. We concluded ChatGPT can provide compelling responses to most prompts, including diagnosis, recommendations for examination, treatment and rational drug use. Moreover, we summarized exciting future applications in mycosis, such as clinical work, scientific research, education and healthcare. However, the largest barriers to implementation are deficits in individual advice, timely literature updates, consistency, accuracy and data safety. To fully embrace the opportunity, we need to address these barriers and manage the risks. We expect that ChatGPT will become a new weapon in the battlefield of mycosis.

Keywords ChatGPT, Mycosis, Applications

Introduction

ChatGPT (Chat Generative Pre-trained Transformer) is a large language model (LLM) developed by OpenAI launched in November 2022. It mimics natural language and solves cognitive problems by reinforcing learning from online resources using human feedback. ChatGPT has medical licensing examination performance as an undergraduate third-year medical student, and has,

therefore, stimulated urgent discussions within medicine [1]. Text is actually a projection of the world, as well as of medicine and science. ChatGPT has rapidly become the current trend for the past months, because of its endless applications in medicine such as analysing vast amounts of medical data and as summarization tool, aiding in ‘standardized’ clinic letters and clinical trials, helping diagnosis and treatment, facilitating scientific research, improving medical education and communication with patients [2, 3]. In future, ChatGPT may also become a new weapon in the knowledge battlefield in mycosis.

Problems in mycosis: high burdens and high mortality

Despite the broad importance and socio-economic impact of medical mycology, research on fungal infections has lagged behind compared to other pathogens. The recent SARS-CoV-2 pandemic has highlighted the importance of fungal infections for morbidity and mortality [4]. In some studies, a two- to tenfold higher

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incidence of candidemia has been reported in patients with COVID-19 compared with patients without COVID-19 [5, 6]. *Candida auris* (*C. auris*) has become a global fungal public health threat. COVID-19-associated *C. auris* outbreaks have resulted in mortality rates ranging from 30% [7] to 83% [8] in those with candidemia. The incidence of mucormycosis has increased dramatically compared to pre-COVID-19. COVID-19-associated rhinoorbital mucormycosis (ROM) has mortality rates of 14% and higher [9], whereas pulmonary or disseminated mucormycosis has mortality rates in excess of 80% [10]. In the largest multicentre studies, COVID-19-associated pulmonary aspergillosis (CAPA) is an independent prognostic factor for mortality, with hazard ratios between 1.45 and 1.97 [11, 12]. CAPA has been consistently associated with COVID-19 mortality rates of more than 50% [13–16]. New hosts contributing to new therapies for malignant and autoimmune disease have increased [17, 18]; and new patterns, including aspergillosis in pulmonary tuberculosis (PTB) and chronic obstructive pulmonary disease (COPD), are emerging [19, 20]. High fungal burdens, high mortality, limited choice of antifungal drugs and increasing drug resistance caused a huge impact on public health, which underscore the urgent need for increasing awareness of fungal infection,

building prompt and accurate diagnostic and therapeutic capacity, and solving multidrug resistance. ChatGPT, as a tool for doctors, can be used to improve efficiency and reduce workload, and applied to clinical work, scientific research, education and healthcare in mycosis.

Conversation with ChatGPT regarding mycosis

We asked ChatGPT for fungal infection scenario-based questions, then assessed the appropriateness, consistency, pitfalls of the AI (artificial intelligence) tool.

First, we had a conversation with ChatGPT about drug interaction of itraconazole and asked suggestions for rational drug use (Fig. 1). We found general advice is provided rather than specific guidance on rational use of drugs, and there was no clear time window for drug prohibition.

Second, We used ChatGPT to input examinations such as lung shadow and GM test weak positive, and it was able to analyse the data and provide a probable diagnosis and a rational list of recommendations for further examination for the specific condition (Fig. 2).

Third, we had a conversation about a patient with cryptococcal meningitis who was intolerant to amphotericin twice. For the first time, ChatGPT provided correct suggestions for alternatives for induction therapy. However,

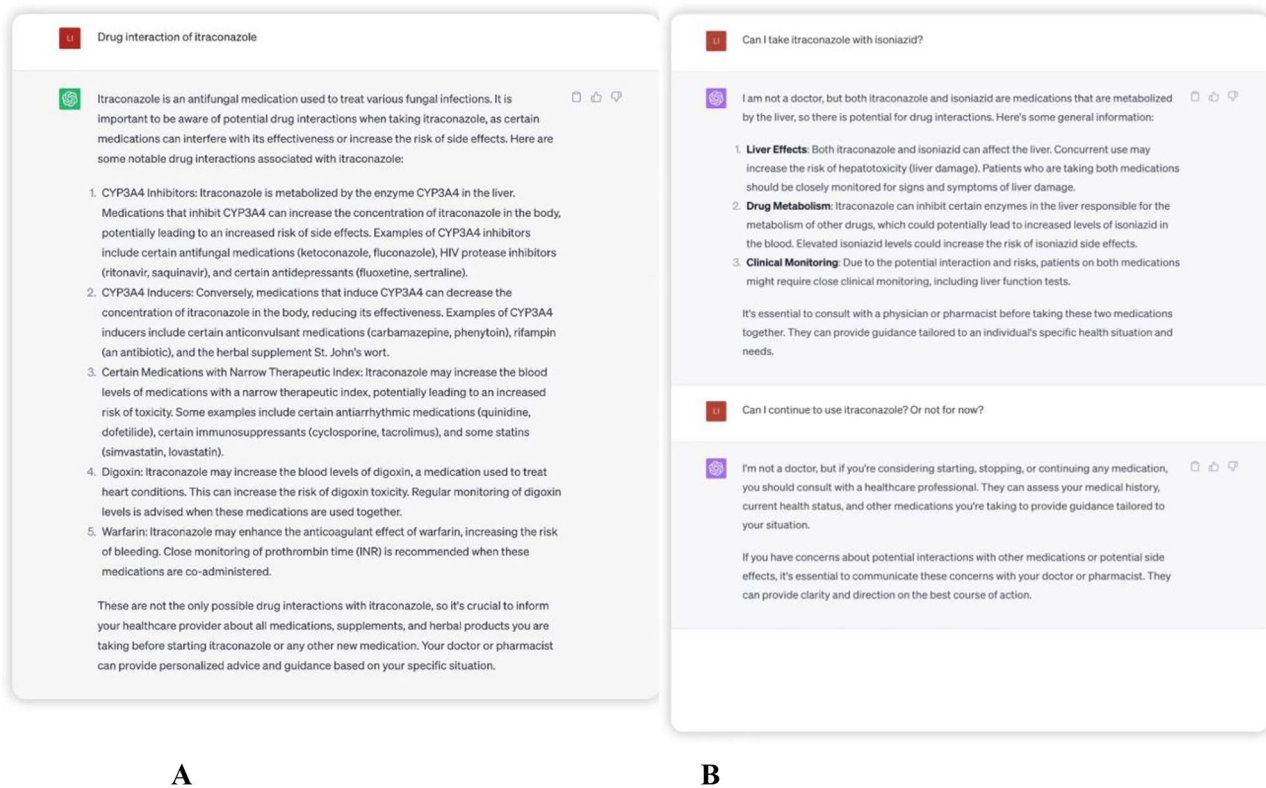
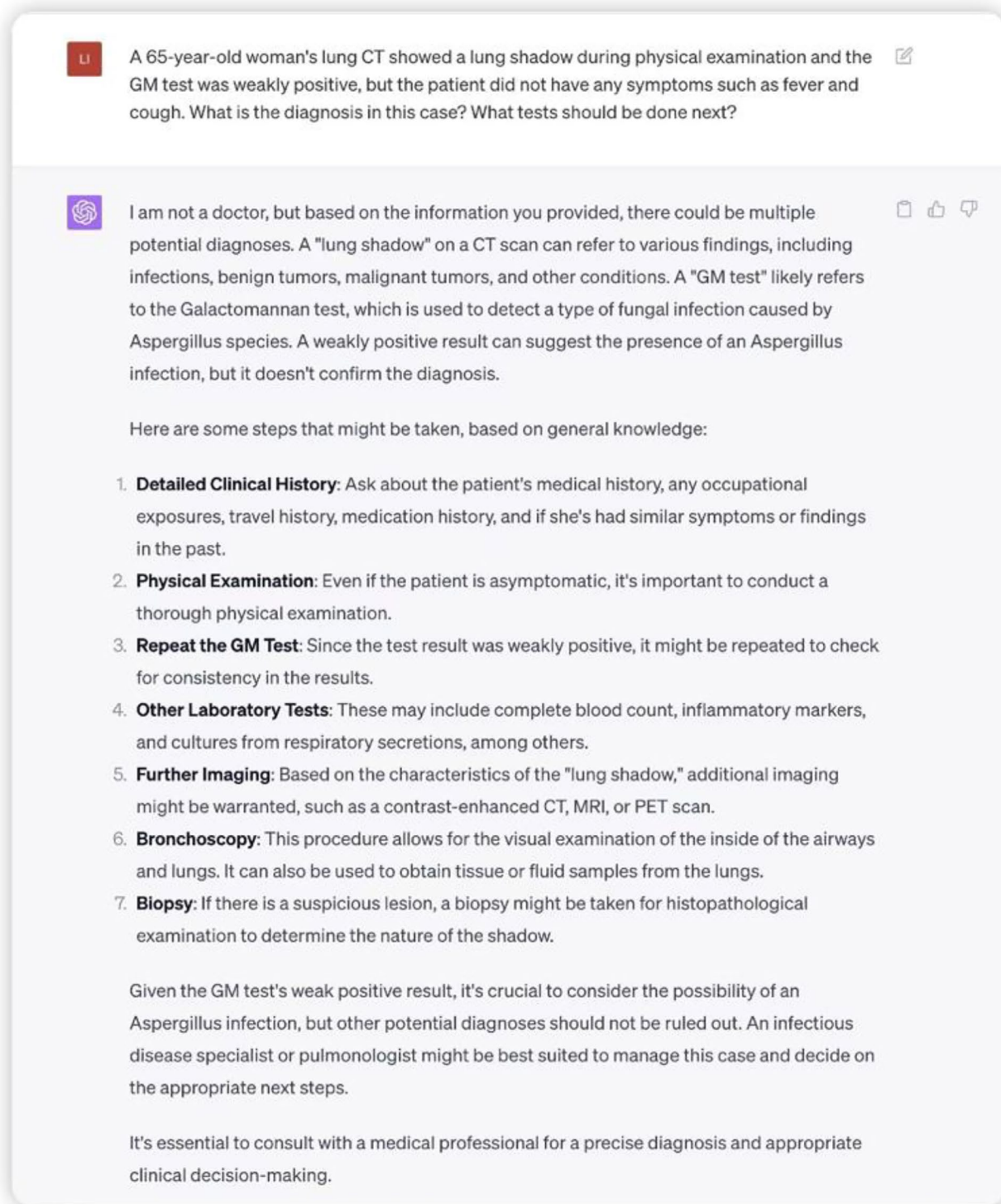


Fig. 1 Screenshots examples of tasks ChatGPT completed. **A.** Conversation with ChatGPT about drug interaction of itraconazole. **B.** Suggestions of ChatGPT for rational drug use. General advice is provided rather than specific guidance on rational use of drugs, and there is no clear time window for drug prohibition



A 65-year-old woman's lung CT showed a lung shadow during physical examination and the GM test was weakly positive, but the patient did not have any symptoms such as fever and cough. What is the diagnosis in this case? What tests should be done next?

I am not a doctor, but based on the information you provided, there could be multiple potential diagnoses. A "lung shadow" on a CT scan can refer to various findings, including infections, benign tumors, malignant tumors, and other conditions. A "GM test" likely refers to the Galactomannan test, which is used to detect a type of fungal infection caused by *Aspergillus* species. A weakly positive result can suggest the presence of an *Aspergillus* infection, but it doesn't confirm the diagnosis.

Here are some steps that might be taken, based on general knowledge:

- Detailed Clinical History:** Ask about the patient's medical history, any occupational exposures, travel history, medication history, and if she's had similar symptoms or findings in the past.
- Physical Examination:** Even if the patient is asymptomatic, it's important to conduct a thorough physical examination.
- Repeat the GM Test:** Since the test result was weakly positive, it might be repeated to check for consistency in the results.
- Other Laboratory Tests:** These may include complete blood count, inflammatory markers, and cultures from respiratory secretions, among others.
- Further Imaging:** Based on the characteristics of the "lung shadow," additional imaging might be warranted, such as a contrast-enhanced CT, MRI, or PET scan.
- Bronchoscopy:** This procedure allows for the visual examination of the inside of the airways and lungs. It can also be used to obtain tissue or fluid samples from the lungs.
- Biopsy:** If there is a suspicious lesion, a biopsy might be taken for histopathological examination to determine the nature of the shadow.

Given the GM test's weak positive result, it's crucial to consider the possibility of an *Aspergillus* infection, but other potential diagnoses should not be ruled out. An infectious disease specialist or pulmonologist might be best suited to manage this case and decide on the appropriate next steps.

It's essential to consult with a medical professional for a precise diagnosis and appropriate clinical decision-making.

Fig. 2 Regarding a case of lung shadow and GM test weak positive, the diagnosis and recommendations for further examination are appropriately described

for the second time, ChatGPT did not mention Liposomal Amphotericin B for alternative therapy. Furthermore, ChatGPT lacked literature updates on voriconazole. We found that, for complex clinical questions, the answers of ChatGPT lacked consistency and coherence, and the literature could not be updated in time (Fig. 3).

We conclude ChatGPT provides compelling responses to most prompts, including diagnosis, recommendations for further examination, appropriate treatment and suggestions for rational drug use. The largest barriers to the implementation of ChatGPT in clinical practice are deficits in situational awareness, inference, and consistency. These limitations have the potential to compromise patient safety. While ChatGPT can provide general directions, it lacks the ability to offer individualized medication recommendations. Hence, it is imperative to recognize and uphold the indispensable role of doctors in patient treatment—a responsibility that cannot be replaced by AI. As LLMs evolve rapidly and incorporate more information, it is crucial that clinicians become familiar with and apply the new technology in mycosis (Fig. 4), thus driving the progress of mycology.

Applications of ChatGPT in mycosis and future direction

We summarized exciting future applications and concerns in mycosis (Figure 5). The strength of ChatGPT is the ability to sift through massive amounts of information

and produce responses in a manner that is conversational and easy to understand [21]. ChatGPT provides a basis for more flexible and efficient fungal epidemiological research. Indeed, epidemiological research also relies on efficient and reliable data collection, recording and analysis. ChatGPT not only solves the difficulty of remote inquiries, but also helps to reduce labour requirements to complete the work [22]. Besides, ChatGPT is usually more accurate and faster than manual statistics and records. It can be seen that computation can help practitioners save time and do more research.

Due to the lack of available antifungal drugs, increasing drug resistance and high mortality, it is urgent to explore the pathogenesis of mycosis and develop new drugs. ChatGPT may serve as a new tool for discovering potential drug targets. ChatGPT can be applied to the 'language' of DNA or protein sequences, derive the right relationships between molecules on its own, and predict new proteins which might make good drug targets. Hence, ChatGPT is arguably a more direct line to drug discovery and drug development [23]. The competition and workload in academia increases. ChatGPT provides opportunities to complete tasks quickly. Therefore, results can be published faster, freeing academics up to focus on new experimental designs [24, 25]. This could significantly accelerate innovation and potentially lead to breakthroughs in mycosis.

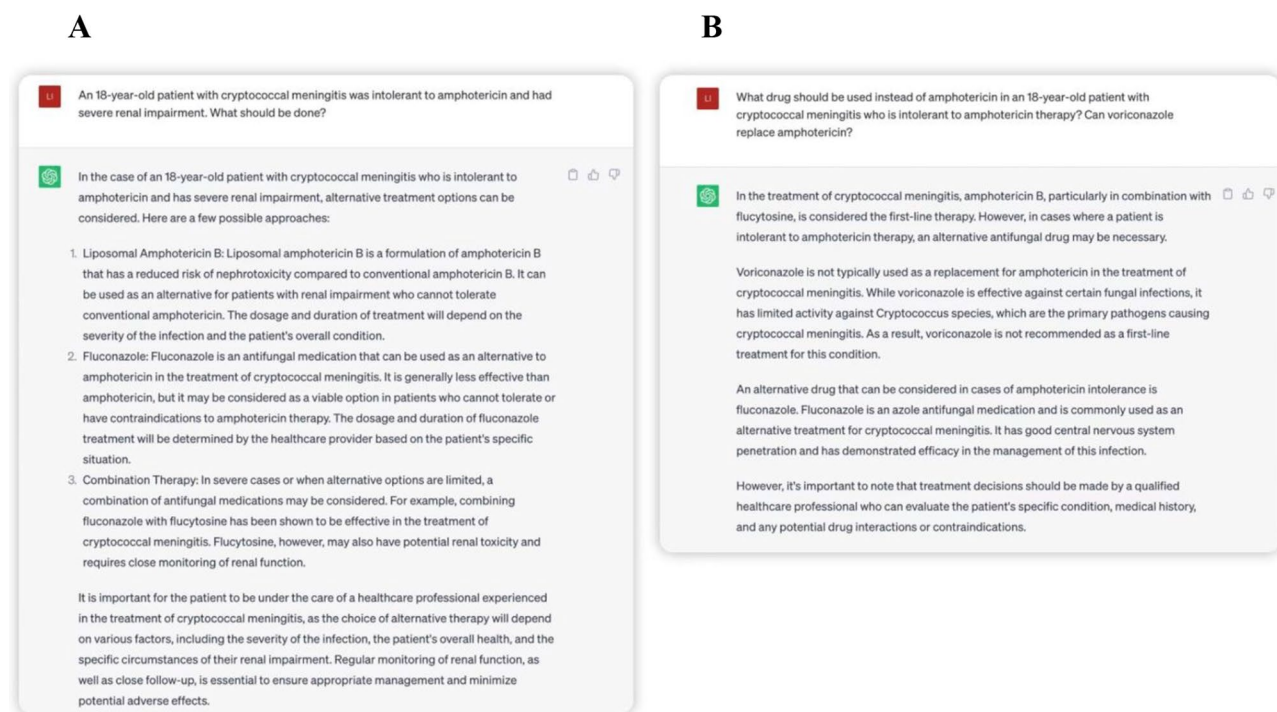


Fig. 3 Conversation about a patient with cryptococcal meningitis who is intolerant to amphotericin. (A) ChatGPT provides correct suggestions for alternatives for induction therapy. (B) ChatGPT did not mention Liposomal Amphotericin B for alternative therapy and lack of updating literature of voriconazole. For complex clinical questions, the literature cannot be updated in time, and the answers are not consistent

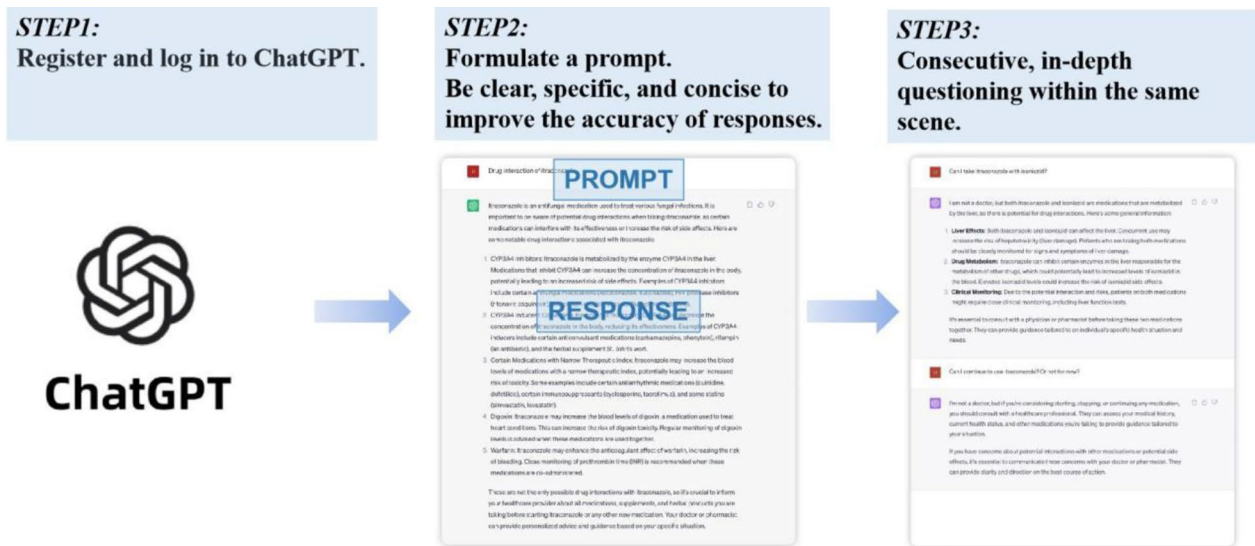


Fig. 4 Step-by-step workflow diagram for applying GPT. Step1 is to register and log in to GPT. Step2 is to formulate a prompt. Please note that for ensuring accurate and high-quality responses, instructions should be clear and specific, and concise. Step3 allows for continuous and in-depth questioning on the same topic to ensure completeness and depth of the responses

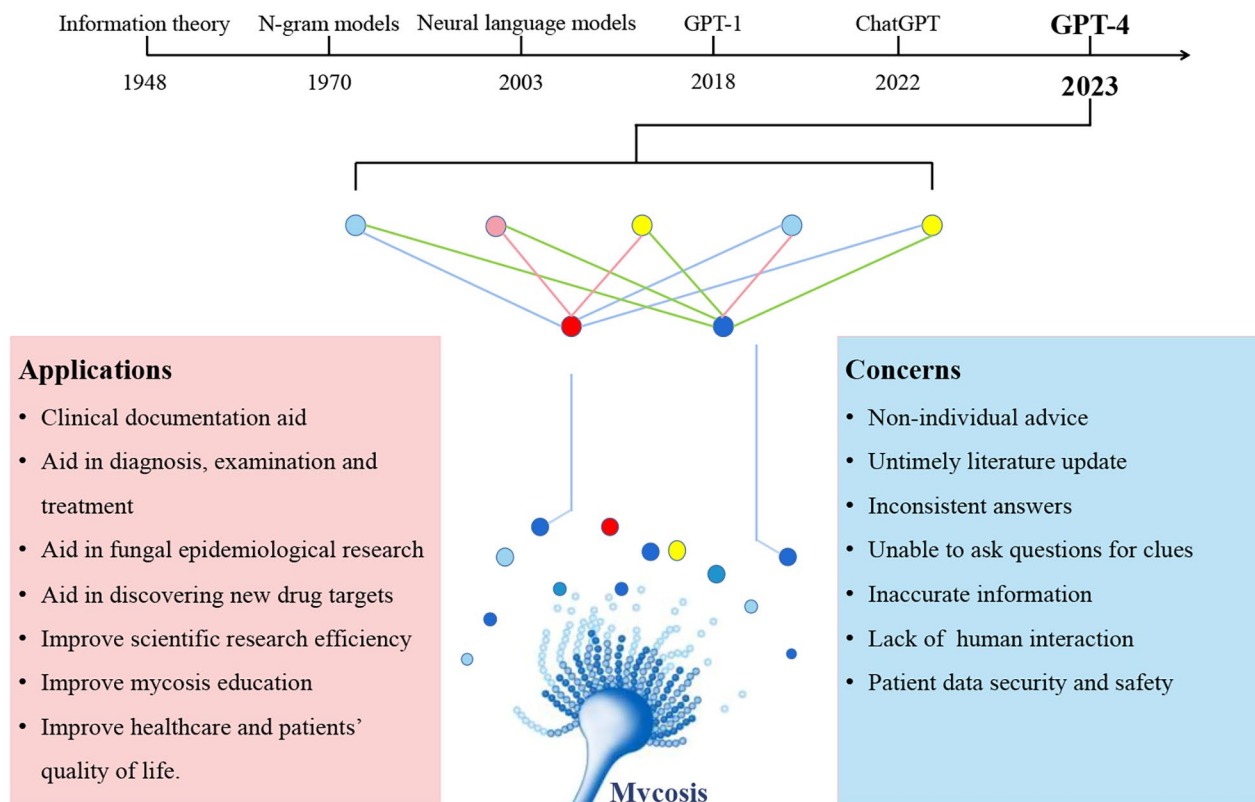


Fig. 5 History of large language model, applications and concerns of GPT4

The high mortality of invasive mycosis is also associated with a lack of awareness of mycosis among clinicians, therefore, strengthening training and education is critical. Learning is best when a knowledgeable and inspiring teacher works with the trainee, enabling them to learn at their own pace and style. ChatGPT, if used correctly, can make processes such as curriculum design, knowledge test and continuing medical education more dynamic than they are currently [26]. This use will help popularize fungal knowledge, enable learners to increase awareness of mycosis, facilitate learning and reflecting.

To popularize the knowledge of mycosis to patients is the key to reduce the incidence of mycosis, improve the compliance of patients and ensure the success of treatment. ChatGPT may be able to enhance healthcare delivery and patients' quality of life. In fact, patients are often not aware of resources to obtain accurate and personalized information about their condition. A survey reported that around one-third of the US adults sought medical advice on the internet for self-diagnoses, with only around half of these respondents subsequently consulting a physician about the web-based results [27]. People tend to more naturally trust something that mimics human behaviors and responses, such as the responses generated by ChatGPT. The conversational dialogue is more comprehensible than professional guidelines or primary literature. Compared to web surfing, ChatGPT allows you to quickly receive well-tailored answers to the desired questions and receive AI-based medical decision making based on the latest research and guidelines. Even without reviewing the guidelines and papers one by one, you can easily check the information summarized and extracted by AI [28]. Within a constructive and alert regulatory environment, ChatGPT could have a transformative impact in healthcare, augmenting rather than replacing human expertise, and ultimately improving quality of life for many patients.

ChatGPT is not foolproof. Our concerns and urgent problems are as follows: ChatGPT can provide general advice rather than individual suggestions. It cannot ask questions to seek further clues, and sometimes could provide dangerous advice about the anti-microbial contraindications and often miss clinical patient safety cues [29]. Besides, lack of timely updating of literature and human supervision, can output inaccurate and inconsistent information. Furthermore, currently, ChatGPT may not always respect copyright, which is a notable issue to consider. Despite these limitations, ChatGPT's utilization value can be very high due to its ability to provide personalized interaction and quick response time. To improve the validity and reliability of ChatGPT, it is essential to utilize ChatGPT under the supervision of qualified healthcare professionals. Careful scrutiny and revision of the initial drafts provided by ChatGPT are imperative.

Furthermore, selectively select a clinical mycosis data source and feed that information into a ChatGPT conversation frequently, will bridge the case-specific and machine-specific gap, thereby enriching ChatGPT's knowledge with more customized data. Continual efforts must be made to advance and optimize the capabilities of ChatGPT to ensure its responsible application in the field of mycology. It is crucial to strike a balance between AI integration and clinical judgment, acknowledging the limitations and potential risks associated with overreliance on ChatGPT. Researchers must know how to use the technology judiciously. Therefore, The successful utilization of AI technologies, such as ChatGPT, holds substantial promise for propelling advancements in mycology.

Summary

ChatGPT plays an important role, but as a tool for the people posing the hypotheses, designing the experiments, and making sense of the results. Ultimately the product must come from—and be expressed by—the wonderful computer in our heads [30]. In the field of mycosis, the focus should be on embracing the opportunity and managing the risks. As ChatGPT evolves and incorporates more information rapidly, rather than AI replacing humans (clinicians), we see it as “clinicians using AI” replacing “clinicians who do not use AI” in the coming years. We expect that ChatGPT will become a new weapon in the battlefield of mycosis. We should begin to utilize and anticipate the possible misuse of this new technology. We are confident that ChatGPT will support and promote scientific progress, achieving curiosity, imagination, and discovery.

Authors' contributions

All authors contributed to the writing of the final manuscript. Yi Jin analyzed data and wrote the main manuscript text. Hua Liu wrote the main manuscript and prepared Figs. Bin Zhao wrote the manuscript and revised the manuscript. Weihua Pan revised the manuscript text.

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Data Availability

The datasets analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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