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# Running title: ChatGPT in Pathology

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**Possible Benefits, Challenges, Pitfalls, and Future Perspective of Using ChatGPT in Pathology**

**Abstract:**

The much hyped Artificial Intelligence (AI) model known as chat generative pre-trained transformer (**Chat GPT**), developed by Open AI can have far-reaching benefits for pathologists saving time so that they can devote their time to more meaningful work. Generative AI is a special class of AI model, that based on patterns and structures learned from existing data can create new data. However, certain hurdles have to be taken care of like integrating ChatGPT with image analysis which will revolutionize the field of pathology by providing assistance with diagnostic accuracy and precision. Generation of meaningful insights from the textual information provided by ChatGPT can be possible by the platform which should have the capability of processing different types of image data, such as medical images, and pathology slides. Due consideration should be given to ethical and legal issues including bias.

**Keywords:** Artificial Intelligence, ChatGPT, Chatbot, Machine Learning, pathology

**Abbreviations**

Artificial intelligence -AI

Machine learning -ML

Chat generative pre-trained transformer -Chat GPT

Optical character recognition - OCR

**Introduction:**

Significant advancements in artificial intelligence (AI) through machine learning (ML) including computer vision, image analysis, data processing and learning carry the potential to make important and permanent contributions in the field of health care, especially in diagnostic branches such as pathology and radiology. [1,2,3] In the year 1950 Englishman **Alan Mathison Turing** proposed the first machine that can learn and become artificially intelligent through the application of machine learning.[4]

Ever since the earliest concept, ML has been successfully used in numerous applications, like security services through face detection,[5,6] in social media platforms, increasing efficiency and decreasing risk in public transportation, [7,8] financial decisions, and recently in various aspects of healthcare and biotechnology.[9-14] This can spearhead major advancements in medicine.

In a recent global survey (487 pathologist-respondents practicing in 54 countries), overall around 80% of respondents predicted the introduction of AI technology in the pathology laboratory within the coming decade and about 75% showed interest or excitement in AI as a diagnostic tool to facilitate improvements in workflow efficiency and quality assurance in pathology.[15] In a study by Sinha et al. on the applicability of ChatGPT in assisting to solve higher order problems in pathology, ChatGPT solved the questions in an average of 45.31±7.14 seconds for each answer. They tested the applicability of the programme on a total of 100 questions.[16] In another study by Gilson et al., it was seen that ChatGPT has the ability to answer medical questions using natural language processing at a level similar to that of a third-year medical student in the United States. They observed that ChatGPT also has the ability to can provide informative context and reasoning in the majority of its responses.[17]

Various studies have shown that pathologists can save time with more accuracy by taking the aid of the computer.[18] In a study by Ehteshami and his team they noted that in the management of breast cancer, on a cohort of 70 patients, sensitivity for the detection of micrometastases rose from 83.3% (by a pathologist alone) to 91.2% (by a pathologist combined with a computer algorithm).[19] However, the application of AI and computational pathology at the current juncture faces multiple challenges, including problems in the integration of raw data from several different sources, processing of images to meaningful outputs, limited capacity of hardware processing and lack of specific working protocols and training programs. There are also issues of bias and ethics that are still solidifying.[20] The result of machine learning-based output is being increasingly applied for the management of patients in health care settings, although still there are lots of skcepticism regarding the practical application and interpretation of results. [21,22]

Since its introduction in late November 2022, the much hyped Artificial Intelligence (AI) model known as chat generative pre-trained transformer (**Chat GPT**), developed by Open AI (OpenAI, L.L.C., San Francisco, CA, USA) for generating human-like text has garnered substantial interest from professionals, media and the general public. Large language model 3.5 and more recently in mid-march its higher version GPT 4.0 is the powerhouse of ChatGPT. The ChatGPT has been built over its previous primitive model of generative pre-trained transformer 3 (GPT3), also an AI-trained model which was used to predict the next word in a sentence making use of the internet where a large collection of unstructured text is available. Since its introduction, Chat GPT has attracted the interest of social media users, policy-makers, film producers, engineers, authors, business owners, and students. With its capability of catering to a wide range of queries by generating human-like responses in a conversation, including chatbots, virtual assistants, and other conversational interfaces, ChatGPT is increasingly thought of as a revolutionary tool for healthcare applications. [23] The etymology of ChatGPT is related to being a chatbot (a program able to understand and generate responses using a text-based interface). [24,25] This offers new possibilities for improving accuracy, efficiency, and patient outcome.

# Although in medical practice, several important functions of ChatGPT have already been zeroed in including acting as a virtual assistant for telemedicine, remote patient monitoring, providing real-time support for the clinical decisions, medical record-keeping, creating symptom checkers and medical training.[26] A study by Hirosawa et al. demonstrated a high diagnostic accuracy (70.5%) of differential-diagnosis lists generated by ChatGPT-3 for clinical cases with common chief complaints. [27]

As professionals with a specialization in Pathology, it is very important to understand the potential impact of ChatGPT.[28] It has already started to raise crucial questions and will continue to in the coming time, about the impact of ChatGPT in the field of medicine, including pathology where we handle lots of tissue samples, numerical values and images.[16, 29] It is very preliminary to understand and derive a clear picture of the model and how it will unfurl and be helpful for pathologists in training, diagnostic practice and research. ChatGPT can assist pathologists in diagnosing diseases by providing recommendations based on previous cases and data from medical literature. It can also help identify rare or complex cases by analyzing data from multiple sources. [30]

To begin the review, we thought of asking ChatGPT itself a question **(** also in **Figure 1)** “Potential impact of ChatGPT in Pathology ”.

**Chat GPT gave the following answer:**

*“The potential impact of ChatGPT in pathology is significant, as it has the potential to improve patient outcomes and enhance the work of pathologists. Here are some potential impacts of ChatGPT in pathology”:*

1. *Improved accuracy: ChatGPT can assist pathologists in making more accurate diagnoses by providing insights and additional information. This can lead to better patient outcomes, as accurate diagnoses are essential for effective treatment.*
2. *Time-saving: ChatGPT can help pathologists save time by offering suggestions or narrowing down potential diagnoses. This can lead to faster diagnosis and treatment, which can be critical in urgent or emergency cases.*
3. *Learning and training: ChatGPT can be a valuable tool for medical students, residents, and practising pathologists to expand their knowledge and skills. This can help improve the quality of care for patients and enhance the overall expertise of pathologists.*
4. *Personalization: ChatGPT can be personalized to individual pathologists' needs, enabling more targeted support and learning. This can help pathologists address specific challenges or gaps in their knowledge and expertise.*
5. *Integration with other technologies: ChatGPT can be integrated with other technologies, such as image recognition software, to provide a more comprehensive analysis of tissue samples. This can help pathologists make more accurate diagnoses and treatment decisions.*
6. *Research: ChatGPT can be used to analyze large datasets and identify patterns and trends that may be difficult for humans to detect. This can lead to new insights and discoveries in the field of pathology, which could ultimately lead to the development of new treatments and therapies.*

*However, there are also potential negative impacts of ChatGPT in pathology, such as overreliance on technology and the potential for biases in the data. Therefore, it is important to carefully consider and address these potential pitfalls to ensure the safe and effective integration of ChatGPT into pathology practice. Overall, ChatGPT has the potential to enhance the work of pathologists and improve patient outcomes, but careful consideration and planning are essential to ensure its safe and effective use in the field.”*

It is exciting to know that the question we asked about pathology from ChatGPT was satisfactorily answered by ChatGPT itself. However since there is a worldwide discussion about ChatGPT and its impact on healthcare professionals and in healthcare setup, it is important to think and address crucial questions especially in the field of pathology and particularly in histopathology and cytopathology.  As pathologists, we have the opportunity to help guide and develop new ways to utilize this powerful tool. This can be best achieved by appreciating its power and its limitations. [31] One of the important benefits of AI in the form of ChatGPT is that it can aid in better time management by handling data and images which will help doctors and paramedical staff free up their time to prioritize other tasks. Integration with image recognition software, to provide a more comprehensive analysis of tissue samples is very important to harness the full benefit of ChatGPT in the near future. This seems to be possible due to deep learning algorithms and artificial intelligence (AI).

Further we asked ChatGPT, “What are the possible benefits, challenges, pitfalls, and future perspective of using ChatGPT in Pathology”. **Chat GPT gave the following answer** (also in **Figure 2**):

*“ChatGPT, as a language model, has the potential to offer several benefits to the field of pathology. Here are some possible benefits, challenges, pitfalls, and future perspectives of using ChatGPT in pathology”:*

*Benefits:*

1. *Assistance with diagnostic accuracy: ChatGPT could provide support to pathologists in diagnosing and classifying tissue samples by offering insights and additional information.*
2. *Time-saving: ChatGPT could help reduce the time pathologists spend on making diagnoses by offering suggestions or narrowing down potential diagnoses.*
3. *Learning and training: ChatGPT could be a valuable tool for medical students, residents, and practising pathologists to expand their knowledge and skills.*

*Challenges:*

1. *Technical challenges: Developing a chatbot that can understand and interpret medical terminology and concepts can be challenging.*
2. *Integration with existing systems: Incorporating ChatGPT into existing pathology systems could require significant modifications to the infrastructure.*
3. *Ethical and legal considerations: There may be ethical and legal considerations to consider when using ChatGPT in pathology, such as privacy, security, and liability.*

*Pitfalls:*

1. *Dependence on ChatGPT: Overreliance on ChatGPT could lead to a reduction in the critical thinking and decision-making abilities of pathologists.*
2. *Misinterpretation of information: ChatGPT may provide incorrect or inaccurate information that could lead to incorrect diagnoses and treatments.*
3. *Bias: ChatGPT could perpetuate biases in healthcare if it is trained on biased data.*

*Future perspectives:*

1. *Improving accuracy: ChatGPT could be trained to improve its accuracy and precision in identifying tissue abnormalities and classifying them into the correct categories.*
2. *Personalization: ChatGPT could be personalized to individual pathologists' needs, enabling more targeted support and learning.*
3. *Integration with other technologies: ChatGPT could be integrated with other technologies, such as image recognition software, to provide a more comprehensive analysis of tissue samples.*

*In conclusion, ChatGPT has the potential to revolutionize the field of pathology by providing assistance with diagnostic accuracy, saving time, and facilitating learning and training. However, it also poses challenges and potential pitfalls that need to be addressed to ensure its safe and effective integration into existing pathology systems. Additionally, future perspectives could focus on improving ChatGPT's accuracy, personalization, and integration with other technologies to provide more comprehensive and targeted support for pathologists. Despite the challenges and potential pitfalls, the use of ChatGPT in pathology could ultimately lead to improved patient outcomes and better healthcare overall.”*

# In Summary, ChatGPT replied that it will revolutionize the field of pathology by providing assistance with diagnostic accuracy, saving time, and facilitating learning and training. It alerted that there should be more focus on improving ChatGPT's accuracy, personalization, and integration with other technologies to provide more comprehensive and targeted support for pathologists. It suggested that caution should be taken as there might be misinterpretation of information and bias. It also pointed out important challenges ahead for ChatGPT including technical challenges of understanding medical terminology, challenges in integrating with existing systems like image analysis software, and very importantly ethical and legal considerations and challenges.

# It is important to remember that lack of accurate, systematic and meaningful data is a serious roadblock for AI platforms, which will pose difficulty to answer specific questions by machine learning platform. [32, 33] Even the slightest errors could pose serious health and safety risks. Hence annotated data as fodder for machine learning (ML) from the healthcare industry needs to be highly accurate. The training data for making reliable ML models should be objective as much as possible and well-structured so that the measured result remains well-structured over time. [34] One exciting aspect of ChatGPT is that it can be fine-tuned for specific applications and tasks, hence it can cater unique needs of medical professionals and researchers across various disciplines. [35]

Rapid digitization of histology slides has escalated interest in artificial intelligence (AI) applications for pathology.[36] Integrating ChatGPT with image analysis can help in a great way by aiding in the diagnosis, prognostication, staging and treatment of various diseases. [37, 38, 39] The accuracy and speed of analysis of pathological images can be improved by using integrated ChatGPT, which traditionally involves the manual examination of medical images under the microscope. However, the methodological integration of the Open AI language model, ChatGPT with image analysis software will be one of the important technical and scientific challenges in the near future, as in the present form it is more of a language model. [29] Developing a platform that can process large amounts of image data and textual information efficiently and meaningfully is one of the primary challenges of integrating ChatGPT with image analysis software.[40]

There are many image recognition software based on the science of enabling computers to interpret visual data such as images which can extract pixel features from an image, which are then labelled adequately to train the machine learning model so that it can repeatedly recognize images without making errors.[41, 42]

Generation of meaningful insights from the textual information provided by ChatGPT can be possible by the platform which should have the capability of processing different types of image data, such as medical images, pathology slides including hematoxylin and eosin slides, immunohistochemistry slides, and more like immunofluorescence and fluorescent in situ hybridization.[43] Also, it should be kept in mind that the integration of ChatGPT with image analysis software should not compromise the diagnostic accuracy of the image analysis, and the ChatGPT system should be trained on large datasets to ensure the diagnostic and prognostic reliability of the generated results.[44]

Optical character recognition or OCR involves recognizing and extracting text from an image, scanned document or video and converting it into a machine-readable format. i.e. it converts an image of text into a machine-readable text format. OCR has completely revolutionized the management of documents. The OCR technology can use machine learning algorithms to analyze the digitalized histology images and recognize patterns in the pixels to determine what characters are present.[45] The extracted text can then be fed as input to a language model like ChatGPT for further processing which can help in the analysis of pathology slides in a scientific and acceptable manner.

Deep learning algorithms can be utilized to analyze a large number of medical image data, such as histopathology and cytology slides, and identify varied patterns of tumor arrangement and individual cells that may indicate the presence of disease.[46,47] For example, these algorithms can detect malignant cells in cytology and histopathology samples with high accuracy, potentially reducing the risk of misdiagnosis.[48,49,50] By automating some of the more time-consuming and error-prone aspects of pathology analysis, deep learning algorithms can be of great help to pathologist’s work in a more efficient and effective

Modern algorithms are not only capable of predicting regions of cancer, but also driver mutations, metastatic origins, and patient prognosis.[51,52] Many algorithms rely only on the slide image and metadata, but others also require annotations of cells, tissues, and other entities within the slide.[36] This additional information helps connect histology images to their underlying biology and may improve the interpretability and generalizability of resulting algorithms.

**Ethical and legal issues**

Overall, the use of AI and ChatGPT in diagnostic pathology has the potential to improve the accuracy and efficiency of pathology practice, ultimately benefiting patients and healthcare providers alike. As in other medical field, ethical concerns are also important when using AI in diagnostic pathology, including issues of bias and privacy. Bias can occur if the algorithm is trained on biased data or if there is a lack of diversity in the dataset used to train the algorithm. Privacy concerns may arise if patient data is not properly protected or if the use of AI leads to the inappropriate sharing of patient data. [53] Although not entirely free of biases, ongoing efforts to minimize biases in training data is believed to provide more balanced and objective outputs for ChatGPT. [54]

It is important to note that AI technology can assist in decision-making processes, but it is not a substitute for human expertise and judgment in cases where subjective or ethical considerations are relevant. In these cases, it is crucial to seek the input of qualified human experts who have the training and experience to navigate these complex issues.[55] AI cannot think creatively, understand emotions, and exhibit ethical judgment, which are important skills for medical professionals.[56] Therefore, AI should always be used in conjunction with human expertise and judgment to ensure the best possible patient outcomes.[57] For example, while AI algorithms can analyze medical images and pathology reports to identify patterns and features that may indicate the presence of disease, they may not be able to make certain nuanced decisions or interpretations that require human judgment. [58,59,60,61] Additionally, AI algorithms may not be able to take into account a patient's emotional or psychological state, which may be important in making certain diagnoses or treatment decisions**.**[53]

The use of AI in the form of chatbots raises concerns about the lack of understanding and transparency of AI systems, which can lead to opaque decision-making. [62, 63] The lack of transparency and human oversight in black-box AI can lead to errors and biases that may negatively affect underrepresented or marginalized groups, and fail in clinical settings.[64,65,66,67]

Pathologists may also face challenges in validating a system they cannot fully understand, leaving them vulnerable to adversarial attacks and creating a clash between black-box medicine and the duty of care.[55,68,69] Bjerring and Busch in 2021 observed that black-box AI is not fundamentally different from opaque decision-making in non-AI-based medicine. However, the lack of expert knowledge to provide causal or mechanistic explanations of internal decision procedures in black-box medicine can limit informed decision-making. Moreover, black-box medicine may result in a loss of knowledge and explanation, which can hinder medical advances. Black-box AI can have a significant impact on the validity and potential harm it poses to patients. [70]

AI development requires access to vast amounts of data, including personal health information, which raises concerns about privacy and security.[2, 71,72] When data is collected and used for AI development, there is a risk that it can be accessed, or disclosed in a way that harms the individuals whose data is included.[71] Unauthorized access can lead to social stigma, negative career impacts, loss of health insurance, identity theft, and financial harm. In addition, AI systems can be vulnerable to attacks and breaches, which can lead to unauthorized access, modification, or destruction of data. Therefore, it is important to implement robust privacy and security measures when collecting, storing, and using health data for AI development. Such measures include data de-identification, encryption, access controls, and regular security audits. By ensuring the privacy and security of health data, we can reduce the risks of harm to individuals and promote trust in the use of AI in healthcare.[73] Security concerns and the potential of cyber-attacks with the spread of misinformation utilizing large language models (LLMs) like ChatGPT should also be considered.[74]

Breaches of databases containing personally identifiable health information are unfortunately all too common.[75] According to a report by Protenus and DataBreaches.net, there were 905 data breaches reported in the healthcare sector in 2021, up 19% from 758 reported in 2020, affecting over 50 million patient records. These breaches can occur due to various reasons, including human error, phishing attacks, and hacking.[76] The consequences of such breaches can be severe, with patients' sensitive health information falling into the wrong hands, leading to identity theft, fraud, and other forms of harm.[77,78] Additionally, the loss of trust and reputation for the organizations responsible for safeguarding this information can be damaging.[79].

Another concern is that Patients may be deprived of the ability to make informed decisions and exercise autonomy, which goes against the ethical requirement for informed consent. This type of medicine can also erode the patient-clinician trust relationship and may not align with patient-centred care. In addition, the lack of transparency and understanding of AI systems may deprive patients of the ability to make informed decisions and exercise autonomy, which goes against the ethical requirement for informed consent. This type of medicine can also erode the patient-clinician trust relationship and may not align with patient-centered care. [80]

**Conclusion:**

If proper research and direction are achieved ChatGPT can be of immense benefit for pathologists, helping them save time and be more confident in diagnosis. It is important that sufficient effort is made to integrate image data with ChatGPT interpretation for a meaningful output. Due consideration should be given to address legal, ethical and patient privacy issue. Open AI has further created ChatGPT based on GPT-4 architecture which has scaled up further deep learning. This higher version can accept both image and text inputs. It is a large multimodal language model. Human level performance has been demonstrated by GPT-4 at various professional and academic platforms, although it is still not as capable as humans, especially on emotional and reasoning fronts.

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**Legends to figure:**

**Figure 1:** Potential impact of ChatGPT in Pathology

**Figure 2:** Possible benefits, challenges, pitfalls, and future perspective of using ChatGPT in Pathology