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Abstract

Background: Artificial intelligence models like ChatGPT have advanced significantly, with GPT-4o offering improved accuracy and contextual understanding. In healthcare, ChatGPT provides accessible explanations of complex medical concepts, aiding patient education and reducing clinician workload. It is particularly effective in simplifying medical jargon, addressing patient questions, and fostering engagement. However, limitations include misinformation risks, outdated data, and potential biases. For lung cancer, the leading cause of cancer-related deaths globally, patients require reliable, comprehensive, and accessible educational tools, particularly for complex treatments like radiotherapy. ChatGPT offers potential as a supplementary resource to meet these needs, though careful oversight is required to address its shortcomings.

Objective: This study aims to evaluate the educational capabilities and limitations of GPT-4 for patients undergoing radiotherapy for lung cancer, focusing on clinician-led assessments of relevance, accuracy, and completeness, patient-led evaluations of educational content, and a readability analysis to assess response accessibility.

Methods: Eight questions related to lung cancer radiotherapy were posed to GPT-4 (July 2024) via OpenAI's web interface. Responses were assessed for readability using the Modified Flesch Reading Ease (FRE) Formula and the 4th Vienna Formula (WSTF). Six clinicians (two radiation oncologists, two medical oncologists, and two thoracic surgeons) experienced in the treatment of lung cancer rated relevance, correctness, and completeness on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree). Patients evaluated comprehensibility, accuracy, relevance, trustworthiness, and willingness to use ChatGPT for future medical questions during post-radiotherapy follow-up. Data were analyzed using descriptive statistics (median, mean, standard deviation) in Microsoft Excel (version 2410). Figures were created in Python (version 3.8) using Matplotlib, with data structured in Pandas DataFrames for analysis and visualization.

Results: ChatGPT's responses were classified as "very difficult" or "difficult to read" in the readability analysis using the Modified Flesch Reading Ease (FRE) and the 4th Vienna Formula (WSTF) (FRE: 23.36 ± 11.16 , WSTF: 13.81 ± 2.01). Clinicians rated relevance (3.7–4.3), correctness (3.5–4.3), and completeness (3.5–4.2), with ChatGPT's response to the question "What follow-up care is required after radiotherapy for lung cancer?" scoring highest across all dimensions. Thirty consecutive patients (48 – 87 years, median: 66 years) who received radiotherapy for lung cancer rated clarity highly ("easy to understand": 4.4 ± 0.61), but trustworthiness and usability scored lower ("confidence in information": 4.0 ± 0.84). These results highlight

ChatGPT's strengths in accessibility and relevance, with room for improvement in trustworthiness and usability.

Conclusions: ChatGPT shows promise as a supplementary tool for patient education in radiation oncology, offering clear and relevant information. However, limitations in completeness and trustworthiness necessitate careful review and supplementation by healthcare professionals. Further advancements and standardized evaluation criteria are essential for its effective integration into clinical practice.

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Original Manuscript

Original Paper

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Keywords: AI, Artificial Intelligence, Patient Education, ChatGPT, Lung Cancer, NSCLC, Radiotherapy

Purpose: This study aims to evaluate the educational capabilities and limitations of GPT-4 for patients undergoing radiotherapy for lung cancer, focusing on clinician-led assessments of relevance, accuracy, and completeness, patient-led evaluations of educational content, and a readability analysis to assess response accessibility.

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Conclusion: ChatGPT shows promise as a supplementary tool for patient education in radiation oncology, offering clear and relevant information. However, limitations in completeness and trustworthiness necessitate careful review and supplementation by healthcare professionals. Further advancements and standardized evaluation criteria are essential for its effective integration into clinical practice.

Background

Artificial intelligence (AI) has made remarkable progress in recent years, with models like ChatGPT, launched by OpenAI in November 2022, emerging as critical tools in natural language processing.

Built on the GPT architecture, ChatGPT has evolved from GPT-1 (2018) to GPT-4o (May 2024), with each iteration improving accuracy, contextual understanding, and versatility, particularly in generating human-like texts. In addition to ChatGPT, other notable large language models (LLMs) include Google's Bard, which excels in generating creative content and integrating real-time data, Meta's LLAMA, tailored for research and non-commercial applications and Anthropic's Claude, which prioritizes safety and ethical AI interactions.

ChatGPT, in its current form, offers notable advantages in the medical field, especially in patient education and communication [1, 2]. It can provide clear explanations of complex medical concepts, answer patient queries, and assist clinicians in creating educational materials [3, 4]. ChatGPT is a powerful tool for enhancing patient understanding and engagement in treatment plans, leveraging its ability to process and generate text from vast datasets.

In healthcare, ChatGPT has found diverse applications [5]. It is particularly effective for patient education, simplifying complex medical jargon into accessible language, and offering support beyond clinical hours. Patients often have follow-up questions about treatment processes, side effects, safety, and treatment design and delivery [6].

These queries can significantly increase staff workload, potentially exacerbating physician burnout and negatively affecting care quality [7]. LLM chatbots like ChatGPT offer a promising solution to mitigate this burden by answering routine patient inquiries and reducing the workload on healthcare professionals. Furthermore, its ability to simulate conversations enables interactive patient education, improving comprehension and fostering a more informed and empowered patient community [4, 8, 9].

However, ChatGPT has limitations. It lacks critical thinking and contextual judgment, which can lead to misinformation or factually inaccurate responses, commonly referred to as "hallucinations" [10, 11]. Other concerns include the risk of providing incorrect medical information, breaches of patient privacy, generating falsified documents or images, overdependence on AI in medical education, and reinforcing existing biases [12]. Additionally, the current version relies on data up to 2021, limiting its ability to provide up-to-date medical information [13].

Lung cancer, one of the most prevalent cancers and the leading cause of cancer-related deaths worldwide, presents a significant need for patient education [14]. Given the critical implications of this diagnosis with its complex treatment modalities, such as radiotherapy, patients often seek comprehensive, reliable, and easily accessible information online [15].

This study aims to evaluate the educational capabilities and limitations of GPT-4 for patients undergoing radiotherapy for lung cancer. This includes a clinician-led evaluation of response relevance, accuracy, and completeness and a patient-led review of its performance in providing educational content. Additionally, a readability analysis was conducted to assess the accessibility of the generated responses.

Methods

We designed eight questions about radiotherapy for lung cancer, drawing from our clinical experience and frequently asked questions by patients during consultations. These questions covered general information about lung cancer, treatment options, radiotherapy, side effects, quality of life, preparations before treatment, and follow-up care. The questions were presented to GPT-4 (version

as of July 2024) via OpenAI's web interface, using the prompt: "I am a lung cancer patient looking for answers to the following questions:" Table 1 displays the questions and ChatGPT's responses. The questions and answers were originally in German and translated for this publication. To ensure consistency, each question was posed to ChatGPT five times using the same prompt. A comparison revealed no relevant differences in the responses.

Table1: Questions and responses from ChatGPT-4

<p>Q1: What is lung cancer?</p> <p>ChatGPT: Lung carcinoma, also known as lung cancer, is a malignant neoplasm in the lung tissue. It develops when cells in the lungs grow uncontrollably and form tumors. There are two main types of lung cancer:</p> <ol style="list-style-type: none"> 1. non-small cell lung carcinoma (NSCLC): This is the most common type and accounts for about 85% of cases. It includes various subtypes such as adenocarcinoma, squamous cell carcinoma and large cell carcinoma. 2. small cell lung carcinoma (SCLC): This type is more aggressive and grows faster than non-small cell lung carcinoma. It is less common and accounts for about 15% of cases. <p>The main causes of lung cancer are tobacco smoking, inhalation of second-hand smoke, environmental and workplace exposure to certain pollutants and genetic factors. Symptoms can include chronic cough, chest pain, weight loss and shortness of breath. Diagnosis is usually made by imaging (e.g. X-ray, CT scan) and biopsies. Treatment may include surgery, radiotherapy, chemotherapy and targeted therapies, depending on the type and stage of the cancer.</p>	<p>Q2: How can lung cancer be treated?</p> <p>ChatGPT: The treatment of lung cancer depends on the type (non-small cell or small cell) and the stage of the disease:</p> <ul style="list-style-type: none"> - Surgery: removal of the tumor and surrounding lung tissue, often for early stages of non-small cell lung cancer. - Radiotherapy: High-energy radiation destroys cancer cells, useful for inoperable tumors or for follow-up treatment. - Chemotherapy: Drug treatment to kill or inhibit the growth of cancer cells, used before or after surgery and in advanced stages. - Targeted therapy: Drugs that attack specific molecular targets on cancer cells, particularly effective for certain genetic mutations. - Immunotherapy: Stimulates the immune system to fight cancer cells, especially in advanced non-small cell lung cancer. - Palliative therapy: Alleviates symptoms and improves quality of life in advanced cancer. <p>Treatment is often customized and may include a combination of these methods.</p>
<p>Q3: What are the advantages of radiotherapy over other treatment options?</p> <p>ChatGPT: Radiotherapy offers several advantages in the treatment of lung cancer:</p> <ul style="list-style-type: none"> - Targeted treatment: precise radiation attacks the tumor directly, sparing the surrounding healthy tissue. - Non-invasive: No surgical intervention required, ideal for patients who cannot undergo surgery. - Complementary to other therapies: Effective in combination with chemotherapy to improve outcomes. - Applicability for inoperability: Useful for tumors that cannot be surgically removed. - Pain relief: Relieves symptoms and improves quality of life in advanced cancer. - Preservation of organ function: Preserves lung function better than complete removal of a lung section. - Outpatient treatment: Often available as an outpatient therapy, minimizing hospitalization. <p>These benefits make radiotherapy a valuable treatment option for various stages of lung cancer.</p>	<p>Q4: How is radiotherapy carried out for lung cancer?</p> <p>ChatGPT: Radiotherapy for lung cancer is carried out in several stages:</p> <ol style="list-style-type: none"> 1. planning: imaging techniques such as CT or MRI create detailed images of the tumor. A radiotherapist plans the exact dose and position of the radiation. 2. simulation: The patient is placed on a couch in the treatment position, often with special cushions or masks for stabilization. Markings on the skin or special tattoos help with precise alignment. 3. treatment: The actual radiotherapy takes place over several sessions (fractions), typically daily over several weeks. High-energy beams are directed at the tumor from different angles to achieve maximum effect and spare healthy tissue. 4. monitoring: regular reviews and imaging during the treatment phase to adjust therapy and monitor progress. <p>The treatment is painless and is performed on an outpatient basis, with each session lasting only a few minutes.</p>
<p>Q5: What are the possible side effects of radiotherapy for lung cancer?</p> <p>ChatGPT: Radiotherapy for lung cancer can have several side effects, depending on the radiation dose and the area treated:</p> <p>Acute side effects:</p> <ul style="list-style-type: none"> - Fatigue: frequent feeling of exhaustion. - Skin reactions: Redness, irritation or dryness in the irradiated area. Cough and breathing difficulties: 	<p>Q6: What precautions or preparations are necessary before the radiation treatment?</p> <p>ChatGPT: Several precautions and preparations are necessary before radiotherapy for lung cancer:</p> <ul style="list-style-type: none"> - Consultation and planning: a detailed consultation with the radiotherapist to discuss the treatment plan, possible side effects and the expected course. - Detailed imaging (CT, MRI) for precise localization of the tumor.

<p>Intensification of existing symptoms. Late side effects:</p> <ul style="list-style-type: none"> - Scarring: In the lungs can lead to long-term breathing problems. Pneumonia: Radiation pneumonitis, an inflammation of the lung tissue. - Esophagitis: Inflammation and pain in the esophagus, making swallowing difficult. <p>Rare side effects:</p> <ul style="list-style-type: none"> - Heart problems: With radiation near the heart. - Secondary tumors: Increased risk of other types of cancer in the irradiated area. <p>Side effects vary from person to person and can be mitigated by supportive measures and medication. Close monitoring by the treatment team helps to identify and treat side effects at an early stage.</p>	<ul style="list-style-type: none"> - Medical preparation: review and adjustment of current medications, as some may affect the radiation effect. - Assessment of general health and lung function tests. - Physical preparation: Making markings or tattoos on the skin for exact alignment during radiation. - Possibly creation of custom-made splints or masks to stabilize the treatment position. - Nutrition and lifestyle advice: Advice on nutrition to strengthen the body. - Advice to stop smoking and avoid alcohol to promote healing. - Psychological support: access to counseling and support to manage anxiety and stress before treatment. <p>These preparations help to make the treatment more effective and safer.</p>
<p>Q7: How does radiation affect the patient's quality of life during and after treatment?</p> <p>ChatGPT: Radiotherapy can affect the patient's quality of life in various ways both during and after treatment:</p> <p>During treatment:</p> <ul style="list-style-type: none"> - Fatigue: frequent fatigue may limit daily activities. - Skin reactions: Redness and irritation may cause discomfort. - Breathing problems and coughing: Exacerbation of existing symptoms that interfere with everyday life. <p>After treatment:</p> <ul style="list-style-type: none"> - Recovery phase: fatigue may last a few weeks, return to normality often takes longer. - Long-term effects: Scarring and radiation pneumonitis can cause breathing difficulties. - Emotional distress: Fear of relapse and coping with physical changes. <p>Positive effects:</p> <ul style="list-style-type: none"> - Symptom relief: reduction of tumor pain and improvement in breathing can increase quality of life. - Cancer control: Effective tumor control or reduction increases well-being and confidence. <p>Close cooperation with the medical team, supportive measures and a healthy lifestyle help to improve quality of life during and after radiotherapy.</p>	<p>Q8: What follow-up care is required after radiotherapy for lung cancer?</p> <p>ChatGPT: After radiotherapy for lung cancer, careful aftercare is crucial. This includes regular check-ups to monitor the response to treatment and detect possible relapses at an early stage. These usually include imaging such as CT or PET scans, blood tests and lung function tests. It is also important to monitor and treat side effects of radiotherapy, such as pneumonia (radiation pneumonitis) or pulmonary fibrosis. Rehabilitation measures can help to improve lung function and increase quality of life. Psychosocial support is also an essential part of aftercare to provide emotional support for patients and their families.</p>

Evaluation of readability

A readability analysis was conducted using the Modified Flesch Reading Ease (FRE) Formula for German. A well-established readability metric for the English language is the Flesch Reading Ease Scale (FRE) [16]. The FRE measures the readability of a text in terms of its average sentence length (ASL) and the average number of syllables per word (ASW). It relies on the fact that short words or sentences are usually easier to understand than longer ones. For this analysis, we have used the modified FRE for the German language by Toni Amstad [17]: $FRE(\text{German}) = 180 - ASL - (58.5 \times ASW)$.

Also, the 4th Vienna Formula (WSTF) was utilized. Unlike the FRE, the Vienna Formula (WSTF) has not been adapted for the German language. Instead, it is based on the work of Bamberger and Vanacek [18], who analyzed German textual material. They derived at least five versions of the Vienna Formula for prose and non-fiction texts. Typically, the fourth WSTF is used for text analysis. This metric is also based on average sentence length (ASL) and the proportion of words with three or more syllables (MS): $WSTF = 0.2656 \times ASL + 0.2744 \times MS - 1.6939$.

Table 2: Interpretation of readability scores: Modified Flesch Reading Ease (FRE) for German, 4th Vienna Formula (WSTF)

Description	FRE	WSTF
Very difficult to read	0-29	> 14
Difficult to read	30-49	13-14
Fairly difficult to read	50-59	10-13
Average readability	60-69	8-10
Fairly easy to read	70-79	7-8
Easy to read	80-89	5-7
Very easy to read	90-100	4-5


Clinician Evaluation

Following the readability analysis, the eight responses were independently evaluated by six clinicians experienced in lung cancer treatment, two radiation oncologists, two medical oncologists, and two thoracic surgeons with 5-12 years of experience working in specialized cancer centers. Each response was scored for relevance, correctness, and completeness using an ordinal five-point Likert scale, with 1 indicating disagreement and 5 indicating complete agreement with the statements that the responses were relevant, correct, and complete, respectively. Respondents were also allowed to add additional comments to their responses.

Patient evaluation

Finally, the question-answer pairs were presented to lung cancer patients during their first follow-up appointment after completing radiotherapy. Patients evaluated ChatGPT's performance on comprehensibility, accuracy, relevance, and trustworthiness using a five-point Likert scale (Figure 1). Additionally, they were asked whether the information made them feel better informed and if they would consider using ChatGPT for future medical questions.

Please rate your agreement with the following statements regarding information:



	Do not agree at all	Rather disagree	Neutral	Agree	Fully and completely agree
1. The information provided by ChatGPT was easy to understand.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2. The information provided by ChatGPT was consistent with my experience	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3. The information provided by ChatGPT was clear and did not contain medical terminology that was difficult to understand.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4. The information provided by ChatGPT was accurate and relevant to the topic of radiotherapy for lung cancer.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5. The information provided by ChatGPT would have helped me to become better informed about radiotherapy for lung cancer in advance.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6. I have confidence in the information I received from ChatGPT.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7. I would also use the ChatGPT search for future medical questions.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Figure 1: Example of a five-point Likert scale presented to patients to rate ChatGPT's responses

Ethical approval

The local Ethics Committee of Ludwig-Maximilians-University Munich (LMU) approved the study protocol in August 2023 (approval number of the University of Munich 23-0742). It was conducted in accordance with the Declaration of Helsinki, and all patients gave signed written consent to participate.

Statistical analysis

Data are reported using descriptive statistics, including median, mean, and standard deviation. Statistical analyses were performed using Microsoft Office Excel (version 2410). Figures were generated using Python (version 3.8) with the Matplotlib library. Data extracted from tables was structured in Pandas DataFrames for analysis and plotting.

Results

Evaluation of Readability

The FRE scores ranged from 6.3 to 42.3, with a mean of 23.4 ± 11.2 , classifying most responses as "very difficult to read." Similarly, the WSTF scores ranged from 10.6 to 16.8, with a mean of 13.8 ± 2.1 . Most responses were in the "very difficult to read" category, with some being "difficult" or "fairly difficult" (Table 3, Figure 2).

Table 3: Readability scores of ChatGPT's Responses to Questions 1-8: Modified Flesch Reading Ease (FRE) and 4th Vienna Formula (WSTF), displaying individual scores of Answers 1-8, Mean \pm Standard Deviation (SD) and Minimum – Maximum.

Readability analysis of questions presented to ChatGPT				
Answer	FRE	FRE Interpretation	WSTF	WSTF Interpretation
A1	42.3	Difficult to read	10.6	Fairly difficult to read
A2	12.6	Very difficult to read	16.8	Very difficult to read
A3	23.9	Very difficult to read	14.4	Very difficult to read
A4	35.8	Difficult to read	10.8	Fairly difficult to

				read
A5	21.1	Very read difficult to	13.6	Difficult to read
A6	28.2	Very read difficult to	14.1	Very difficult to read
A7	16.6	Very read difficult to	14.7	Very difficult to read
A8	6.3	Very read difficult to	15.	Very difficult to read
Min. Max.	6.3 - 42.3	-	10.6 - 16.8	-
Mean \pm SD	23.4 \pm 11.2	-	13.8 \pm 2.1	-

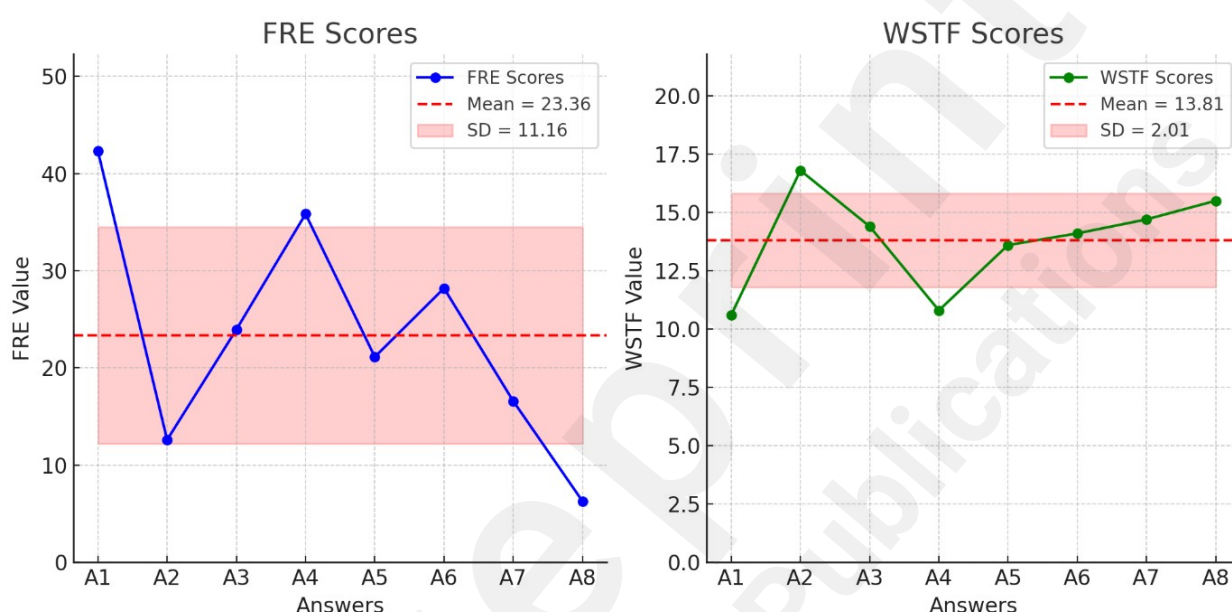


Figure 2: Individual values of the readability analysis of the ChatGPT Answers (A1-A8) to the presented questions (Q1-8) along with the Mean \pm Standard Deviation (SD). Modified Flesch Reading Ease (FRE) and 4th Vienna Formula (WSTF) Scores: The blue (FRE) and green (WSTF) lines represent the FRE / WSTF values for each answer (A1-A8). The red dashed line indicates the mean score, and the shaded area represents the SD.

Clinician evaluation

Figure 2 and Table 3 present the evaluation of ChatGPT's responses by six clinicians experienced in treating lung cancer: two radiation oncologists, two medical oncologists, and two thoracic surgeons. The mean scores for relevance ranged from 3.7 ± 0.94 (Responses 2 (treatment) and 3 (advantages of radiotherapy)) to 4.3 ± 0.75 (Response 8 (follow-up)). Correctness scores varied between 3.5 ± 0.50 (Response 7 (quality of life)) and 4.3 ± 0.75 (Response 8 (follow-up)). Completeness ratings ranged from 3.5 ± 0.50 (Responses 2 (treatment), 5 (side effects), and 7 (quality of life)) to 4.2 ± 0.69 (Response 8 (follow up)). Overall, responses showed variability in performance, with relevance and correctness achieving higher mean scores than completeness. Notably, Response 8 (follow up) scored the highest across all three dimensions (Relevance: 4.3 ± 0.75 , Correctness: 4.3 ± 0.75 , Completeness: 4.2 ± 0.69), while Response 7 (quality of life) scored the lowest for correctness (3.5 ± 0.50). The results are summarized in Figure 2, illustrating the mean score distribution across all evaluated response criteria.

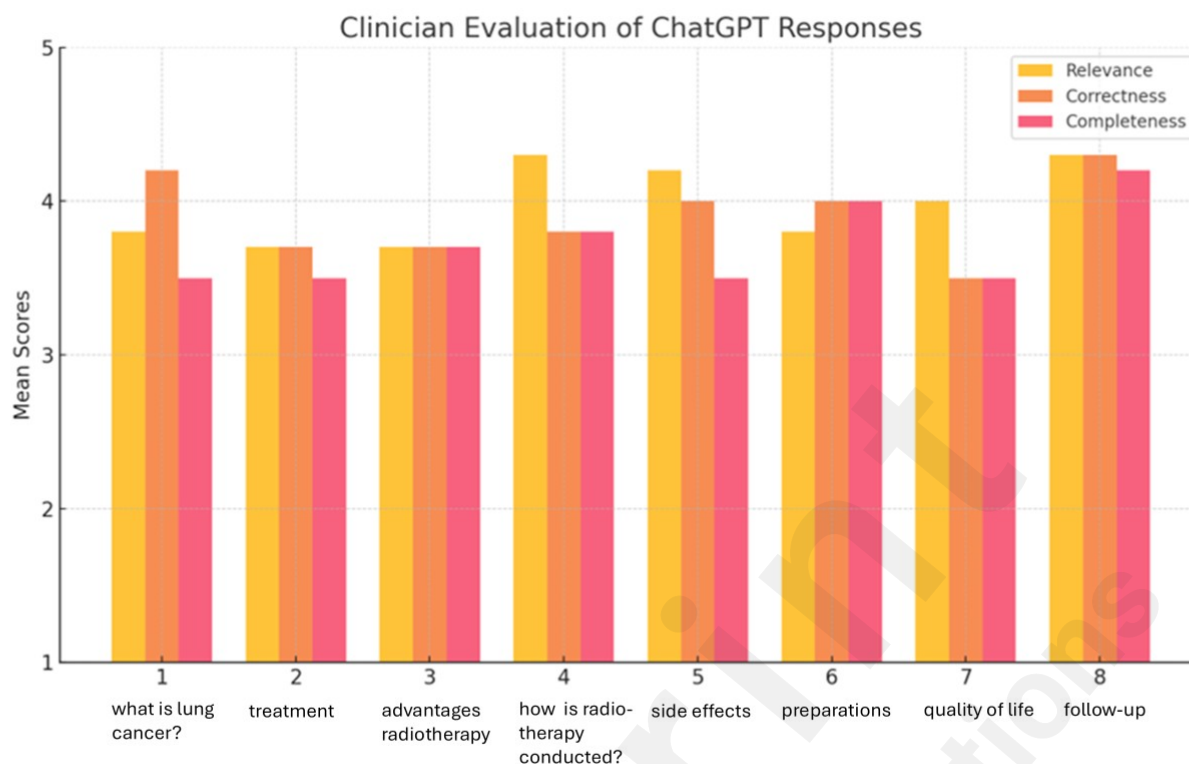


Figure 2: Mean clinician ratings of ChatGPT's responses (1–8) for relevance, correctness, and completeness. Scores are based on a 5-point Likert scale, where 1 represents the lowest and 5 the highest score. Relevance, correctness, and completeness were evaluated for each response, providing an overview of ChatGPT's performance across these dimensions.

A thoracic surgeon commented that ChatGPT did not discuss chances of treatment success and recurrence rates. A medical oncologist commented that the role of multidisciplinary tumor boards should have been mentioned. A radiation oncologist commented that there was no differentiation between radiotherapy modalities.

Table 3: Clinician ratings of ChatGPT's responses (1–8) for relevance, correctness, and completeness. Scores are based on a 5-point Likert scale, where 1 represents the lowest and 5 the highest score.

Response to questions	Mean (SD)	Ratings on Likert Scale, (%)				
		1	2	3	4	5
Response 1						
Relevance	3.8 (1.07)	0%	17%	17%	33%	33%
Correctness	4.2 (0.37)	0%	0%	0%	83%	17%
Completeness	3.5 (0.76)	0%	17%	17%	67%	0%
Response 2						
Relevance	3.7 (0.94)	0%	17%	17%	50%	17%
Correctness	3.7 (0.75)	0%	0%	50%	33%	17%
Completeness	3.5 (0.50)	0%	0%	50%	50%	0%
Response 3						
Relevance	3.7 (0.94)	0%	17%	17%	50%	17%
Correctness	3.7 (0.75)	0%	0%	50%	33%	17%
Completeness	3.7 (0.47)	0%	0%	33%	67%	0%

Response 4						
Relevance	4.3 (0.47)	0%	0%	0%	67%	33%
Correctness	3.8 (0.37)	0%	0%	17%	83%	0%
Completeness	3.8 (0.37)	0%	0%	17%	83%	0%
Response 5						
Relevance	4.2 (0.90)	0%	0%	33%	17%	50%
Correctness	4.0 (0.58)	0%	0%	17%	67%	17%
Completeness	3,5 (0.50)	0%	0%	50%	50%	0%
Response 6						
Relevance	3.8 (0.90)	0%	0%	50%	17%	33%
Correctness	4.0 (0.00)	0%	0%	0%	100%	0%
Completeness	4.0 (0.00)	0%	0%	0%	100%	0%
Response 7						
Relevance:	4.0 (0.82)	0%	0%	33%	33%	33%
Correctness:	3.5 (0.50)	0%	0%	50%	50%	0%
Completeness:	3.5 (0.50)	0%	0%	50%	50%	0%
Response 8						
Relevance:	4.3 (0.75)	0%	0%	17%	33%	50%
Correctness:	4.3 (0.75)	0%	0%	17%	33%	50%
Completeness:	4.2 (0.69)	0%	0%	17%	50%	33%

Patient evaluation

The responses generated by ChatGPT were evaluated by 30 consecutive patients who underwent radiation therapy for lung cancer between 06/2024 – 10/2024 at the University Hospital LMU Munich during their first follow-up examination six weeks after treatment completion. The median age of the nineteen male and eleven female patients was 66 years (48 – 87 years). Twenty-six of those patients had non-small cell lung cancer (NSCLC), while four patients had small cell lung cancer (SCLC). Twelve patients received concomitant chemotherapy, and ten patients received stereotactic body radiotherapy (SBRT). Five patients were treated using magnetic resonance-guided radiotherapy (MRgRT).

The evaluation was based on seven statements about the provided information's clarity, accuracy, relevance, and usability. Each statement was rated on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree), and the results are summarized in Table 4. The highest-rated statement was "The information provided by ChatGPT was easy to understand," with a mean score of 4.4 ± 0.61 , where 94% of patients rated it as "agree" or "strongly agree." Similarly, the statement "The information provided by ChatGPT was accurate and relevant to radiotherapy for lung cancer" received a high mean score of 4.2 ± 0.83 , with 87% of patients rating it positively. The statement "The information provided by ChatGPT was consistent with my experience" achieved a mean score of 4.1 ± 0.63 , reflecting alignment with patient expectations. Similarly, the statement "The information provided by ChatGPT was clear and did not contain medical terminology that was difficult to understand" received a mean score of 4.1 ± 0.81 , with 80% of patients giving positive feedback. This highlights ChatGPT's strength in delivering accessible and jargon-free information.

In contrast, statements related to usability and trustworthiness received slightly lower ratings. "The information provided by ChatGPT would have helped me to become better informed about radiotherapy for lung cancer in advance" and "I would also use ChatGPT for future medical questions" both scored a mean of 3.9 ± 0.94 . Additionally, the statement "I have confidence in the information I received from ChatGPT" scored 4.0 ± 0.84 .

Table 4: Patients' ratings of statements 1-7. Scores are based on a 5-point Likert scale, where 1 represents the lowest and 5 the highest score (1 = strongly disagree, 5 = strongly agree).

Statement		Mean (SD)	Ratings on Likert Scale, % (n)				
			1	2	3	4	5
1.	The information provided by ChatGPT was easy to understand.	4.4 (0.61)	0% (0)	0% (0)	7% (2)	47% (14)	47% (14)
2.	The information provided by ChatGPT was consistent with my experience.	4.1 (0.63)	0% (0)	0% (0)	17% (5)	60% (18)	23% (7)
3.	The information provided by ChatGPT was clear and did not contain medical terminology that was difficult to understand.	4.1 (0.81)	0% (0)	3% (1)	17% (5)	43% (13)	37% (11)
4.	The information provided by ChatGPT was accurate and relevant to the topic of radiotherapy for lung cancer.	4.2 (0.83)	0% (0)	7% (2)	7% (2)	47% (14)	40% (12)
5.	The information provided by ChatGPT would have helped me to become better informed about radiotherapy for lung cancer in advance.	3.9 (0.94)	0% (0)	10% (3)	20% (6)	40% (12)	30% (9)
6.	I have confidence in the information I received from ChatGPT.	4.0 (0.84)	0% (0)	3% (1)	27% (8)	40% (12)	30% (9)
7.	I would also use the ChatGPT search for future medical questions.	3.9 (0.94)	0% (0)	10% (3)	20% (6)	40% (12)	30% (9)

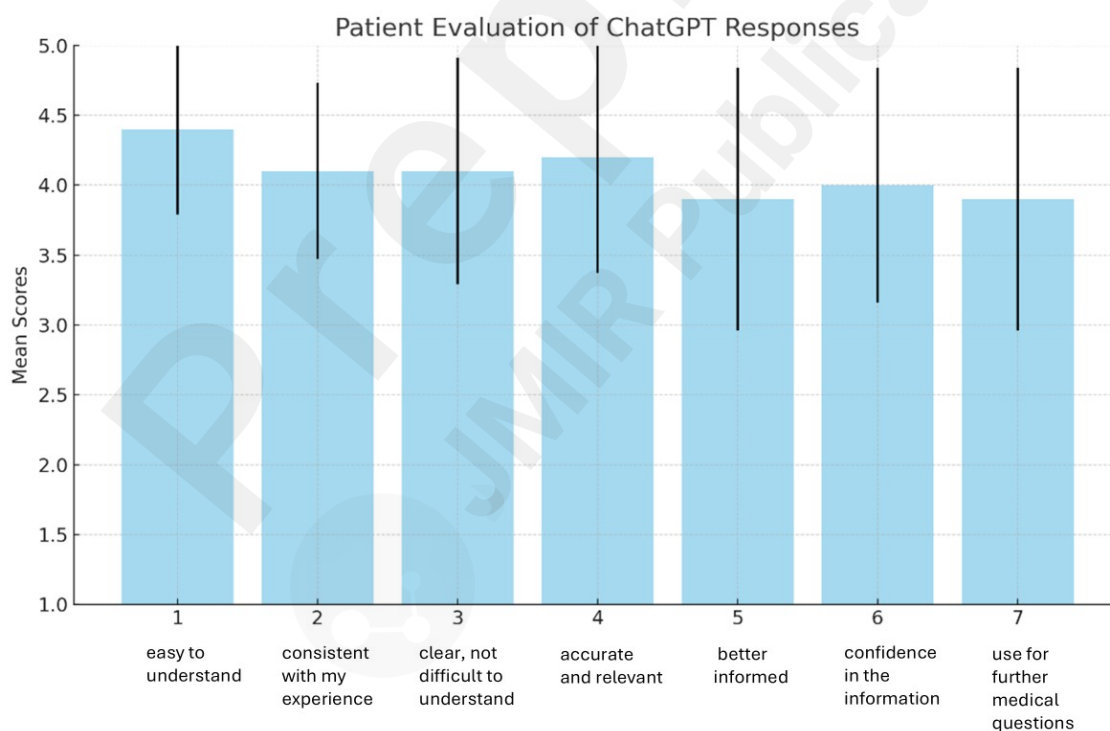


Figure 3: Mean patient ratings with standard deviations (SD) of ChatGPT's responses to seven statements, evaluated using a 5-point Likert scale. Statements assessed the answers' clarity, relevance, accuracy, and usefulness. Error bars indicate standard deviations, reflecting variability in patient responses.

Discussion

This study evaluated the benefits and risks of using ChatGPT to educate patients undergoing radiotherapy for lung cancer. Research has shown that cancer patients obtain information from

sources other than their healthcare providers, with the Internet being a primary resource[19]. Existing online resources often fail to address specific patient queries in radiation oncology adequately and frequently exceed recommended complexity levels [20, 21].

The readability analysis of ChatGPT's responses revealed that the FRE and WSTF scores classified most responses as "very difficult to read" or "difficult to read," which may limit accessibility, particularly for individuals with lower health literacy. These findings align with studies indicating that cancer-related information on the Internet is generally not well-tailored to patient's needs [22]. Despite this, the patient evaluation showed that ChatGPT's responses were perceived as easy to understand (mean score: 4.4 ± 0.61), possibly because the survey was conducted post-therapy when patients were already familiar with relevant topics and terminology.

The clinician evaluation of ChatGPT highlighted its strengths in relevance and correctness but noted limitations in completeness. Response 8, for example, performed best across all dimensions (Relevance: 4.3 ± 0.75 , Correctness: 4.3 ± 0.75 , Completeness: 4.2 ± 0.69), while Response 7 demonstrated inconsistencies, scoring the lowest for correctness (3.5 ± 0.50). These findings align with other studies assessing ChatGPT's accuracy in answering questions about lung cancer [23, 24] and other queries in radiotherapy [25, 26]. Interestingly, another study found that ChatGPT achieved high qualitative ratings for factual accuracy, conciseness, and completeness, closely mirroring expert responses [27].

Patients rated ChatGPT highly for clarity and relevance, but usability and trust received comparatively lower scores. Statements like "I would also use ChatGPT for future medical questions" (3.9 ± 0.94) and "I have confidence in the information I received from ChatGPT" (4.0 ± 0.84) highlight areas where trust and reliability could be improved.

LLMs like ChatGPT are often approached cautiously in healthcare due to concerns about trust, security, privacy, and ethics [28, 29].

While ChatGPT is sometimes criticized for lacking a human touch and empathy [30], studies have found its responses to be more empathetic than those of clinicians in specific scenarios [31], especially for sensitive health topics where patients may feel uncomfortable consulting clinicians, non-sentient LLM chatbot can be valuable [27].

Despite concerns about "hallucinations," where LLMs generate plausible but incorrect answers [10, 11], no potential harm was identified in ChatGPT's responses in this study. OpenAI, the developer of ChatGPT, acknowledges the possibility of inaccurate outputs [32], likely contributing to healthcare providers' reluctance to adopt LLM chatbots for patient communication and education [32]. However, other studies have shown that ChatGPT can provide highly accurate and complete responses comparable to virtual patient-clinician communication in radiation oncology [27].

This study has several limitations. The questions were formulated by the study team rather than actual patients, potentially limiting the diversity of clinical scenarios and the representativeness of the findings. Additionally, the study was conducted in German, which could affect the generalizability of results, as ChatGPT's performance may vary across languages. Furthermore, this study used GPT-4o, released by OpenAI in May 2024, a paid subscription model with superior accuracy and coherence compared to the free GPT-3.5 version. The lack of standardized criteria to assess AI-generated responses also poses challenges for consistent evaluation.

Finally, while our study focused on ChatGPT, the most popular and earliest publicly released conversational LLM [33], Other models, such as Bard (Google), LLAMA (Meta), and Claude (Anthropic), show promise in addressing oncology queries. Each offers unique strengths [34]. We selected ChatGPT because it is the most utilized LLM and has superior response quality compared to other LLMs [35, 36].

In conclusion, ChatGPT demonstrates significant potential as a supplementary tool for patient

education in radiation oncology, particularly for patients undergoing radiotherapy for lung cancer. Its ability to provide clear and relevant information highlights its value in enhancing patient understanding and engagement in their treatment journey. However, completeness, accuracy, and trust limitations underscore the need for careful review and supplementation by healthcare professionals. Further advancements in LLM technology, alongside the development of standardized evaluation criteria, are crucial to optimizing the integration of AI tools like ChatGPT into clinical practice. With continued research and refinement, ChatGPT and similar technologies have the potential to revolutionize patient education, supporting healthcare providers in delivering accurate, accessible, and personalized care.

Acknowledgments

CRedit authorship contribution statement

Cedric Richlitzki: Data curation, Conceptualization, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing – original draft. **Sina Mansoorian:** Methodology, Validation, Data curation, Writing – review & editing. **Lukas Käsmann:** Methodology, Validation, Data curation, Writing – review & editing. **Mircea Gabriel Stoleriu:** Methodology, Validation, Data curation, Writing – review & editing. **Julia Kovacs:** Methodology, Validation, Data curation, Writing – review & editing. **Wulf Sienel:** Methodology, Validation, Data curation, Writing – review & editing. **Diego Kauffmann-Guerrero:** Methodology, Validation, Data curation, Writing – review & editing. **Thomas Duell:** Methodology, Validation, Data curation, Writing – review & editing. **Nina Sophie Schmidt-Hegemann:** Methodology, Validation, Data curation, Writing – review & editing. **Claus Belka:** Conceptualization, Resources, Investigation, Formal analysis, Methodology, Project administration, Supervision, Validation, Writing – review & editing. **Stefanie Corradini:** Conceptualization, Resources, Investigation, Methodology, Formal analysis, Project administration, Supervision, Validation, Writing – review & editing. **Chukwuka Eze:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – review & editing.

Conflicts of Interest

No funding was received to conduct this study. The authors have no competing interests to declare relevant to this article's content.

Abbreviations

AI	artificial intelligence
ASL	average Sentence Length
ChatGPT	Chat Generative Pre-Trained Transformer
FRE	Modified Flesch Reading Ease
GPT	Generative Pre-trained Transformer
LLM	large language model
LMU	Ludwig-Maximilians-University Munich
MRgRT	magnetic resonance-guided radiotherapy
NLP	natural language processing
NSCLC	non-small cell lung cancer
RI	readability Index

SBRT	stereotactic body radiotherapy
SCLC	small cell lung cancer
SD	standard deviation
WSTF	4th Vienna Formula

Data availability Statement

Clinical study reports, detailed data tables, and programming code are available on request: Cedric Richlitzki, Department of Radiation Oncology, LMU University Hospital, LMU Munich, Marchioninistrasse 15, 81377 Munich, Germany. E-mail address: Cedric.Richlitzki@med.uni-muenchen.de.

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Supplementary Files

Clinician ratings of ChatGPT's responses (1–8) for relevance, correctness, and completeness. Scores are based on a 5-point Likert scale, where 1 represents the lowest and 5 the highest score.

URL: <http://asset.jmir.pub/assets/724489038f6002074c609ce70915a543.docx>

Interpretation of readability scores: Modified Flesch Reading Ease (FRE) for German, 4th Vienna Formula (WSTF).

URL: <http://asset.jmir.pub/assets/d79bb540654e801e689f08a018372a15.docx>

Patients' ratings of statements 1-7. Scores are based on a 5-point Likert scale, where 1 represents the lowest and 5 the highest score (1 = strongly disagree, 5 = strongly agree).

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Questions and responses from ChatGPT-4.

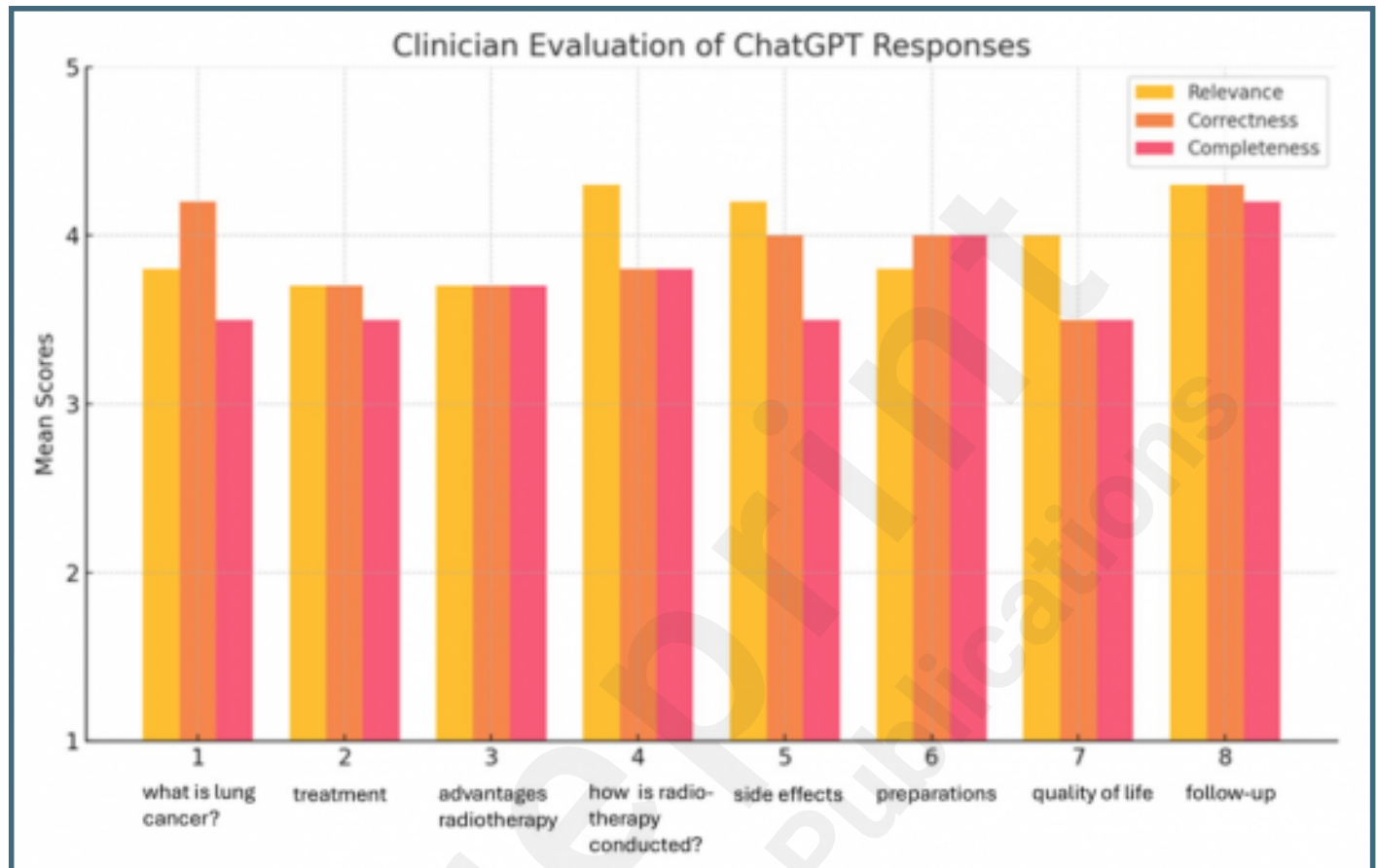
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Readability scores of ChatGPT's Responses to Questions 1-8: Modified Flesch Reading Ease (FRE) and 4th Vienna Formula (WSTF), displaying individual scores of Answers 1-8, Mean \pm Standard Deviation (SD) and Minimum – Maximum.

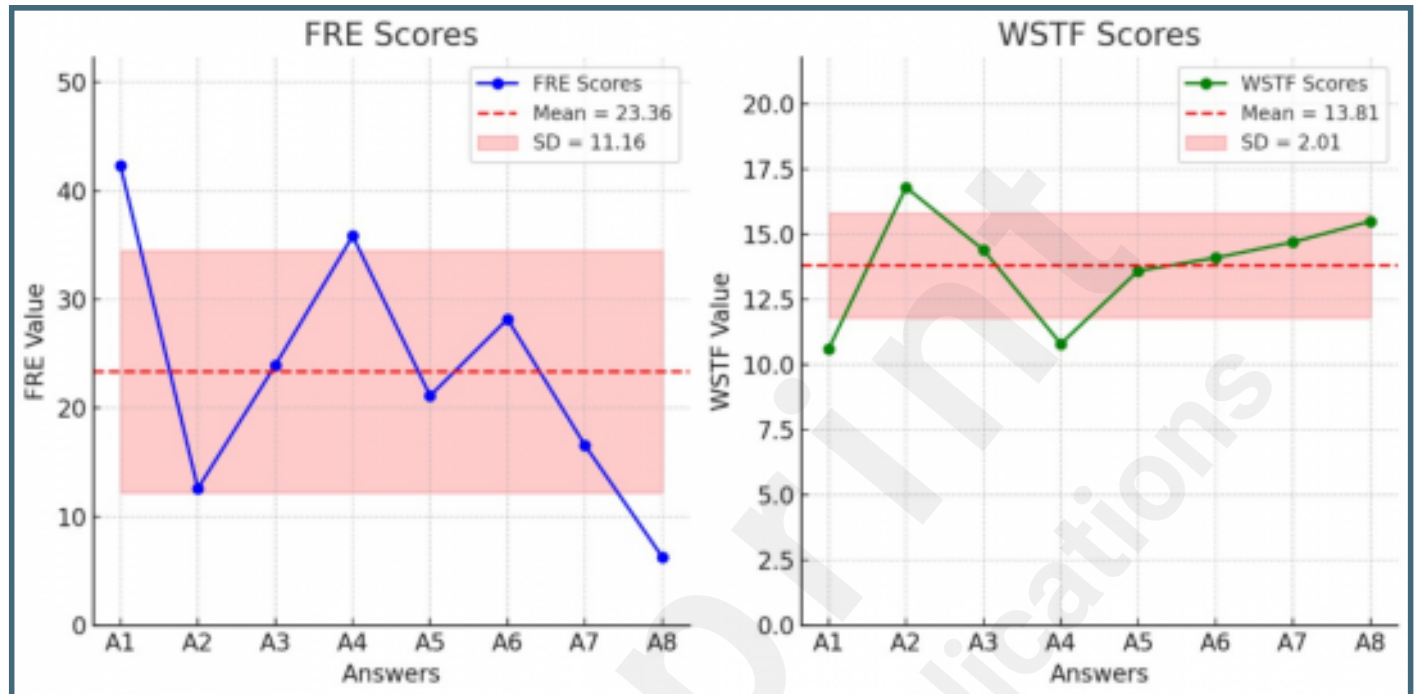
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Figures

Mean clinician ratings of ChatGPT's responses (1–8) for relevance, correctness, and completeness. Scores are based on a 5-point Likert scale, where 1 represents the lowest and 5 the highest score. Relevance, correctness, and completeness were evaluated for each response, providing an overview of ChatGPT's performance across these dimensions.








Individual values of the readability analysis of the ChatGPT Answers (A1-A8) to the presented questions (Q1-8) along with the Mean \pm Standard Deviation (SD). Modified Flesch Reading Ease (FRE) and 4th Vienna Formula (WSTF) Scores: The blue (FRE) and green (WSTF) lines represent the FRE / WSTF values for each answer (A1-A8). The red dashed line indicates the mean score, and the shaded area represents the SD.



Example of a five-point Likert scale presented to patients to rate ChatGPT's responses.

Please rate your agreement with the following statements regarding information:

	Do not agree at all	Rather disagree	Neutral	Agree	Fully and completely agree
1. The information provided by ChatGPT was easy to understand.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2. The information provided by ChatGPT was consistent with my experience	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3. The information provided by ChatGPT was clear and did not contain medical terminology that was difficult to understand.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4. The information provided by ChatGPT was accurate and relevant to the topic of radiotherapy for lung cancer.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5. The information provided by ChatGPT would have helped me to become better informed about radiotherapy for lung cancer in advance.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6. I have confidence in the information I received from ChatGPT.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7. I would also use the ChatGPT search for future medical questions.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Mean patient ratings with standard deviations (SD) of ChatGPT's responses to seven statements, evaluated using a 5-point Likert scale. Statements assessed the answers' clarity, relevance, accuracy, and usefulness. Error bars indicate standard deviations, reflecting variability in patient responses.

