Journal of Hand Surgery Global Online 7 (2025) 37–40

Contents lists available at ScienceDirect

Journal of Hand Surgery Global Online

journal homepage: www.JHSGO.org

Original Research

Leveraging ChatGPT to Produce Patient Education Materials for Common Hand Conditions

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ARTICLE INFO

Article history:
Received for publication September 3, 2024
Accepted in revised form October 1, 2024
Available online November 8, 2024

Key words:
Artificial intelligence
Hand
Patient education materials

Purpose: Many adults in the United States possess basic or below basic health literacy skills, making it essential for patient education materials (PEMs) to be presented at or below a sixth-grade reading level. We evaluate the readability of PEMs generated by ChatGPT 3.5 and 4.0 for common hand conditions.
Methods: We used Chat Generative Pre-Trained Transformer (ChatGPT) 3.5 and 4.0 to generate PEMs for 50 common hand pathologies. Two consistent questions were asked to minimize variability: 1. "Please explain [Condition] to a patient at a sixth-grade reading level, including details on anatomy, symptoms, doctors' examination, and treatment (both surgical and nonsurgical)." 2. "Create a detailed patient information sheet for the general patient population at a sixth-grade reading level explaining [Condition], including points such as anatomy, symptoms, physical examination, and treatment (both surgical and nonsurgical)." Before asking the second question, a priming phase was conducted where ChatGPT 3.5 and 4.0 were presented with a text sample written at a sixth-grade reading level and informed that this was the desired output level. Multiple readability tests were used to evaluate the output, with a consensus reading level created from the results of all eight readability scores. Statistical analyses were performed using SAS 9.4.
Results: ChatGPT 4.0 successfully produced 28% of its responses at the appropriate reading level following the priming phase, compared to none by ChatGPT 3.5. ChatGPT 4.0 showed superior performance across all readability metrics.
Conclusions: ChatGPT 4.0 is a more effective tool than ChatGPT 3.5 for generating PEMs at a sixth-grade reading level for common hand conditions.
Clinical relevance: The results suggest that Artificial Intelligence could significantly enhance patient education and health literacy with further refinement.

In the rapidly evolving health care landscape, the emergence of large language models like Chat Generative Pre-Trained Transformer (ChatGPT) has presented both opportunities and challenges. One promising application of this technology is its potential to assist in creating patient education materials (PEMs). ChatGPT's ability to generate coherent and human-like text can be leveraged to craft educational content that is not just comprehensible, but also engaging for patients.[1] Furthermore, ChatGPT's ability to analyze large-scale medical data and generate personalized content could be instrumental in developing tailored educational resources that address individual patients' unique needs and concerns.[1]

An early illustration of ChatGPT's integration in educational environments is a pilot study conducted by Khan Academy. In this study, the model, known as Khanmigo, analyzed student responses and provided guidance and encouragement to facilitate more efficient and effective learning.[2] This demonstrates the potential for large language models to become interactive medical education tools capable of supporting individual patients' understanding of complex health information.

In total, 36% of adults in the United States have basic or below basic health literacy skills.[3] One study reported that 43% of patients who presented to an urban academic hospital-based hand surgeon

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https://doi.org/10.1016/j.jhsg.2024.10.002

Table 1
Descriptions and Formulas of Readability Scores

Readability Measure	Description	Formula
Flesch Reading Ease	This rates text on a 100-point scale. A higher score is associated with easier readability.	$206.835 - 1.015 * (\frac{\text{total \# of words}}{\text{total \# of sentences}}) - 84.6 * (\frac{\text{total \# of syllables}}{\text{total \# of words}})$
Flesch Kincaid Grade Level	This score returns the US grade level required to comprehend the text.	$0.39 * (\frac{\text{total \# of words}}{\text{total \# of sentences}}) + 11.8 * (\frac{\text{total \# of syllables}}{\text{total \# of words}}) - 15.59$
Gunning Fog Score	This score returns an index estimating the number of years of formal education required to comprehend the text.	$0.40 * (\frac{\text{total \# of words}}{\text{total \# of sentences}}) + 100 * (\frac{\text{total \# of words with} > 3 \text{ syllables}}{\text{total \# of words}})$
Coleman Liau Index	This returns the US grade level to comprehend the text using the number of characters.	$0.40 * (\frac{\text{total \# of words}}{\text{total \# of sentences}}) + 100 * (\frac{\text{total \# of words with} > 3 \text{ syllables}}{\text{total \# of words}})$
Automated Readability Index	This index returns the US grade level required to comprehend the text using the number of characters and words per sentence.	$4.71 * (\frac{\text{characters}}{\text{total words}}) + 0.5 * (\frac{\text{total words}}{\text{total sentences}}) - 21.43$
Simple Measure of Gobbledygook (SMOG Index)	This index, using polysyllabic words, estimates the number of years of formal education required to comprehend the text.	$1.043 * \sqrt{\text{total polysyllables} * \frac{30}{\text{total sentences}}} + 3.1291$
Linsear Write Formula	This formula defines easy words as words with two or fewer syllables and difficult words as three or more syllables and returns an approximate US grade level required for comprehension.	$\frac{(\text{easy words}) * 1 + (\text{difficult words}) * 3}{\text{total number of sentences}}$
Dale Chall Readability Score	This index defines difficult words as those not included in the Chall Word List, a list of 3,000 words that are known among 80% of US fourth-grade students and returns an approximate US grade level required for comprehension.	$0.1579 * (\frac{\text{total \# of difficult words}}{\text{total \# of words}} * 100) + 0.0496 * (\frac{\text{total \# of words}}{\text{total \# of sentences}})$

had limited health literacy.[4] Therefore, multiple strategies have been employed to provide widely accessible health care information that is medically accurate and easily understandable, regardless of educational background. Current guidelines recommend presenting PEMs at or below a sixth-grade reading level.[5,6]

Although the prospects for ChatGPT in patient education are promising, addressing the notable concerns related to these models' vulnerabilities is crucial, such as the risk of generating inaccurate information.[1] Before integrating ChatGPT into health care settings, a comprehensive clinical validation is imperative to ensure its reliability and safety.[1] Therefore, this study aims to evaluate the readability of ChatGPT 3.5 and 4.0 responses when prompted to explain 50 common hand conditions.

Materials and Methods

Institutional review board approval was not required for this study. Fifty common hand pathologies were included in this study. This list was developed by analyzing the highest-ranking search queries on Google, obtaining information from the American Academy of Orthopaedic Surgeons OrthoInfo PEM webpages, and incorporating insights from our fellowship-trained hand and upper-extremity surgeon. The list of the 50 examined hand conditions is shown in Appendix A (available online on the *Journal*'s website at https://www.jhsgo.org). In order to analyze the quality of information generated by popular, publicly available artificial intelligence platforms, ChatGPT versions 3.5 and 4.0 were employed. A separate application programming interface call was employed for every hand condition examined to minimize any residual influence a prior prompt could have.

Additionally, two templated questions were created and used for all conditions to minimize variability across prompts. Question 1 was "Please explain [CONDITION] to me, and include points such as anatomy, symptoms, doctors' examination, and treatment (both surgical and nonsurgical)." Before question 2 was prompted, ChatGPT was primed with an example of a text excerpt and informed that the text was written at a sixth-grade reading level based on Flesch Kincaid readability tests. Question 2 was "Create a detailed patient information sheet for the general patient explaining [CONDITION], and include points such as anatomy, symptoms, physical examination, and treatment (both surgical and nonsurgical). Please provide this information at a 6th-grade reading level."

Responses were generated sequentially through a series of application programming interface calls to ChatGPT servers. Readability scores were calculated using the Python library TextStat. Multiple readability test scores were generated, including Flesch Reading Ease scores, Flesh Kincaid grades, Gunning Fog scores, Coleman Liau indices, Automated Readability indices, Simple Measure of Gobbledygook (SMOG) indices, Linsear Write Formula scores, and Dale Chall scores. For all readability scores, except for the Flesch Reading Ease score, a lower value correlates with a better (or lower reading level) readability score. These scores analyze various factors within a text excerpt, including the number of words, syllables, and sentences, and examine sentence structure. For all of the examined readability metrics, except for Flesch Reading Ease scores, the generated scores correlate with the reading grade level associated with the text (eg, a score of six equates to a sixth-grade reading level). The formulas for these scores are shown in Table 1.

Given that the data were available in a non-normal distribution, a nonparametric test was used, namely, the Wilcoxon rank-sum test. Categorical or dichotomous variables were compared using chi-squared tests or Fisher exact tests. *P* values less than .05 were considered statistically significant.

Results

Table 2 compares the readability scores of PEMs generated by two versions of ChatGPT, version 3.5 and version 4.0, using various readability formulas for 50 common hand conditions. For question 1, ChatGPT 3.5 and 4.0 could not provide any PEMs at or below the sixth-grade reading level. However, ChatGPT 4.0 outperformed ChatGPT 3.5 based on readability scores (Automated Readability Index: 8.99 vs 10.02, $P < .05$; Coleman Liau Index: 7.22 vs 9.48, $P < .001$; Dale Chall Score: 6.82 vs 7.82, $P < .001$; Flesch Kincaid Grade: 6.58 vs 8.07, $P < .001$; Flesch Reading Ease: 82.22 vs 69.06, $P < .001$; Gunning Fog: 8.59 vs

Table 2
Readability Scores of ChatGPT PEMs for Common Hand Conditions

Reading Score	Question 1			Question 2			Comparing ChatGPT 3.5 Question 1 and Question 2	Comparing ChatGPT 4 Question 1 and Question 2
	ChatGPT 3.5	ChatGPT 4.0	*P* Value	ChatGPT 3.5	ChatGPT 4.0	*P* Value		
Automated Readability	10.02 (1.76)	8.99 (1.10)	<.05*	15.02 (3.51)	8.17 (1.63)	<.001*	<.0001*	.0035*
Coleman Liau Index	9.48 (1.65)	7.22 (0.72)	<.001*	12.77 (1.26)	7.49 (0.81)	<.001*	<.0001*	.0388*
Dale Chall Score	7.82 (0.64)	6.82 (0.32)	<.001*	8.82 (0.57)	6.55 (0.31)	<.001*	<.0001*	<.0001*
Flesch Kincaid Grade	8.07 (1.37)	6.58 (0.93)	<.001*	12.20 (2.81)	5.49 (1.46)	<.001*	<.0001*	<.0001*
Flesch Reading Ease	69.06 (8.22)	82.22 (4.55)	<.001*	48.17 (9.83)	83.31 (6.02)	<.001*	<.0001*	.2138
Gunning Fog	9.19 (1.18)	8.59 (0.83)	<.05*	12.72 (2.81)	7.15 (1.35)	<.001*	<.0001*	<.0001*
Linsear Write Formula	8.37 (1.63)	8.04 (1.96)	.136	9.35 (2.70)	6.40 (1.35)	<.001*	0.017*	<.0001*
SMOG Index	9.76 (1.49)	8.10 (0.69)	<.001*	13.40 (1.74)	7.89 (0.92)	<.001*	<.0001*	.15

ChatGPT, Chat Generative Pre-Trained Transformer.
Descriptive statistics reported as mean (SD).
* Indicates statistical significance.

9.19, $P < .05$; and SMOG Index: 8.10 vs 9.76, $P < .001$). However, no statistically significant differences were observed for the Linsear Write Formula scores (8.04 vs. 8.37, $P = .136$).

Regarding question 2, ChatGPT 3.5 did not produce any PEMs at or below the sixth-grade reading level, while ChatGPT 4.0 was able to produce PEMs that were at or below the sixth-grade reading level in 28% of the generated responses ($P < .001$). ChatGPT 4.0 outperformed ChatGPT 3.5 in all readability scores (Automated Readability Index: 8.17 vs 15.02, $P < .001$; Coleman Liau Index: 7.49 vs 12.77, $P < .001$; Dale Chall Score: 6.55 vs 8.82, $P < .001$; Flesch Kincaid Grade: 5.49 vs 12.20, $P < .001$; Flesch Reading Ease: 83.31 vs 48.17, $P < .001$; Gunning Fog: 7.15 vs 12.72, $P < .05$; Linsear Write Formula scores 6.40 vs 9.35, $P < .001$; and SMOG Index: 7.89 vs 13.40, $P < .001$).

When primed with an example text at a sixth-grade reading level, ChatGPT 3.5's performance declined when producing responses to question 2. When comparing question 1 to question 2, the Automated Readability Index (10.02 vs 15.02, $P < .0001$), Coleman Liau Index (9.48 vs 12.77, $P < .0001$), Dale Chall Score (7.82 vs 8.82, $P < .0001$), Flesch Kincaid Grade (8.07 vs 12.20, $P < .0001$), Gunning Fog (9.19 vs 12.72, $P < .0001$), Linsear Write Formula (8.37 vs 9.35, $P = .017$), and SMOG Index (9.76 vs 13.40, $P < .0001$) all increased, indicating the content generated by ChatGPT 3.5 was more difficult to comprehend. The Flesch Reading Ease score decreased when comparing ChatGPT's responses to question 1 and question 2 (69.06 vs 48.17, $P < .0001$), indicating that the content generated by ChatGPT 3.5 was more difficult to comprehend.

Conversely, ChatGPT 4.0's performance significantly improved when primed with an example text at a sixth-grade reading level. When comparing question 1 to question 2, the Automated Readability (8.99 vs 8.17, $P = .0035$), Dale Chall Score (6.82 vs 6.55, $P < .0001$), Flesch Kincaid Grade (6.58 vs 5.49, $P < .0001$), Gunning Fog (8.59 vs 7.15, $P < .0001$), and Linsear Write Formula (8.04 vs 6.40, $P < .0001$) decreased, indicating that the content generated by ChatGPT 4.0 was easier to comprehend. When comparing ChatGPT 4.0's responses between question 1 and question 2, the Coleman Liau Index score increased (7.22 vs 7.49, $P = .0388$), indicating that the PEMs generated by ChatGPT 4.0 for question 2 were more difficult to comprehend. The performance of ChatGPT 4.0 did not significantly change from question 1 to question 2 when analyzing the Flesch Reading Ease index (82.22 vs 83.31, $P = .2138$).

Discussion

PEMs are important tools in health care delivery as they allow patients to be thoroughly informed about their medical conditions. This ensures effective communication between patients and health care providers and sufficient consent for medical and surgical interventions. To the best of our knowledge, this study represents one of the first to comprehensively evaluate the quality of information produced by ChatGPT versions 3.5 and 4.0 for common hand conditions.

Our study shows neither ChatGPT 3.5 nor 4.0 could produce responses at the recommended sixth-grade reading level. However, after a priming phase, in which ChatGPT was given an example of text at the sixth-grade reading level, ChatGPT 4.0 showed a significant improvement. Following the priming phase, ChatGPT 4.0 generated 28% of its responses at or below the sixth-grade reading level, a stark contrast to ChatGPT 3.5, which did not produce any PEMs at this level. ChatGPT 4.0 outperformed ChatGPT 3.5 across all readability scores, indicating that the newer version is more capable of producing PEMs that are easier to read and understand.

However, neither version generated more than 50% of responses at an acceptable reading level, regardless of a priming phase beforehand. This indicates that clinicians should remain the primary source of patient education. Consequently, health care leaders have voiced apprehension that artificial intelligence is a tool to help improve the quality of patient care, but should not be a substitute for interactive patient education, medical decision-making, or human interaction.[7]

Low health literacy is associated with poorer baseline patient-reported outcome measures, higher prevalence of high health-risk behaviors, and increased mortality.[8–10] A multitude of factors impact an individual's health literacy. Sun et al[11] identified that health literacy is potentially impacted by age, educational background, socioeconomic status, and prior health-related conditions. Other reported factors associated with low health literacy in patients seeking hand care include housing issues, recent changes in living situations, unemployment, limited English proficiency, smoking, and marital status.[12] However, these are not stagnant metrics, as an individual's health literacy can be improved. Dinh and Bonner[13] advised that improving health literacy is critical in managing chronic disease. They found that improved communication strategies and increased health care provider support are strongly associated with improved health literacy.[13] Some have recommended that artificial intelligence can help augment the physician-patient relationship, building effective communication and educational strategies.[14]

Health literacy has been shown to impact many medical and surgical intervention metrics. Those with limited health literacy can be limited to consent for intervention.[15] Additionally, investigators have identified that lower health literacy is associated with increased hospital stays and readmissions.[16,17] Moreover, a systematic review found strong evidence that poorer health literacy is

associated with worse patient-level outcomes following various surgical interventions.[18]

Readability is just one aspect of health literacy and only covers part of the scope of patient understanding. When a patient struggles with text readability, it can hinder their ability to advocate for themselves and make informed health care decisions, thus impacting their health literacy. Readability formulas, such as those used in this study, evaluate the structural complexity of a text. However, many other factors influence a patient's comprehension, such as text layout, font size, images, medical jargon not caught by readability formulas, and the patient's self-efficacy and motivation.[19,20] Therefore, studies assessing the correlation between readability scores and health literacy are warranted.

Although this study's results demonstrated that ChatGPT could not reliably provide PEMs at an appropriate level, this does not negate its ability to be a powerful tool for patient education. This is identified in comparisons between artificial intelligence and publicly available online content. Published content is a popular source for patients to engage with and learn about their health. However, the shortcomings of provider-written online content are highlighted in a study conducted by Cook et al,[21] who found that the average readability score for written online educational resources for hand surgery provided by academic institutions was at the 11.92-grade reading level, which is five grade levels above the American Medical Association and National Institutes of Health recommendations.[21]

Herein lies the advantages of language model artificial intelligence that can rapidly adjust generated material to the needs of the prompter. Shah et al[22] demonstrated that ChatGPT could adjust its readability material with prompt-specific criteria. Furthermore, ChatGPT 4.0 allows prompters to request images, figures, graphs, and charts tailored to individual needs. New artificial intelligence technology has shown remarkable promise in creating videos and audio content. Content can be tailored to fit the needs of specific individuals, including those who may be visually or aurally impaired.

Additionally, these programs can recommend outside resources that aid with comprehension and allow for a more thorough understanding. This engaging, continually evolving interaction can facilitate understanding of challenging topics. Some have suggested using artificial intelligence (AI) machine learning to improve health literacy and combat misinformation.[23] Improved health literacy can prevent future health problems and better protect and manage issues as they arise.[24] These interventions can have far-reaching effects and offset the immense public burden associated with health care costs.[25]

This study has limitations. Proposed prompts primarily influence the quality of responses associated with language model AI software. Additionally, including 50 hand conditions may limit the scope of analysis performed in this study. Furthermore, newer language AI platforms, including Google Gemini, Grok, and many others, are continually being developed. Therefore, future studies should investigate more specific subsets of hand complaints and employ comparative analyses identifying the strengths and weaknesses of different AI software. This will allow for more precise and individualized recommendations addressing health literacy limitations. However, this study sets a stable framework for a comprehensive evaluation of the readability of AI-generated responses to common hand complaints.

In conclusion, this study reveals that ChatGPT 4.0 is superior to ChatGPT 3.5, producing more comprehensible PEMs for 50 common hand conditions. However, neither version could reliably and consistently generate PEMs at the recommended sixth-grade reading level. Furthermore, although ChatGPT 4.0 could adjust some of its content with a priming phase, ChatGPT 3.5 declined in performance. This underscores concerns that ChatGPT should be more than a standalone resource for PEMs; instead, health care providers should be chiefly responsible for educating their patients. Enhancing the archive of medical information and readability of ChatGPT will allow it to be more integrated with clinical practice and patient education. This connection empowers patients, allows for more informed decision-making, and improves health-related outcomes.

Conflicts of Interest

No benefits in any form have been received or will be received related directly to this article.

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