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Editorial

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Artificial Hallucinations in ChatGPT: Implications in Scientific Writing

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Abstract

While still in its infancy, ChatGPT (Generative Pretrained Transformer), introduced in November 2022, is bound to hugely impact many industries, including healthcare, medical education, biomedical research, and scientific writing. Implications of ChatGPT, that new chatbot introduced by OpenAI on academic writing, is largely unknown. In response to the Journal of Medical Science (Cureus) Turing Test - call for case reports written with the assistance of ChatGPT, we present two cases one of homocystinuria-associated osteoporosis, and the other is on late-onset Pompe disease (LOPD), a rare metabolic disorder. We tested ChatGPT to write about the pathogenesis of these conditions. We documented the positive, negative, and rather troubling aspects of our newly introduced chatbot's performance.

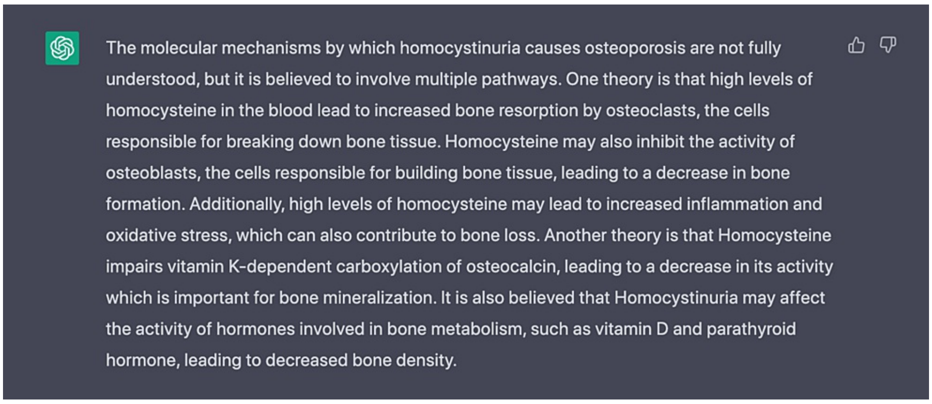
Categories: Endocrinology/Diabetes/Metabolism, Internal Medicine, Healthcare Technology
Keywords: artificial intelligence and writing, artificial intelligence and education, chatgpt, chatbot, artificial intelligence in medicine

Editorial

Although large language models such as ChatGPT can produce increasingly realistic text, the accuracy and integrity of using these models in scientific writing are unknown. In this paper, we present the case of ChatGPT, a new chatbot introduced by OpenAI as a natural language generator (NLG) yet able to produce artificial hallucinations. We hoped to investigate ChatGPT's ability to generate factually correct scientific writing by asking it to provide short paragraphs on specific medical and non-medical topics and evaluating the generated text.

By the time Cureus Medical Journal called for reports written with the assistance of ChatGPT, we were working on several projects, one on pathophysiological mechanisms of homocysteine and another on liver involvement in late-onset Pompe disease (LOPD).

We asked ChatGPT to provide a short paragraph on the mechanism of homocysteine-induced osteoporosis. It was a stunning moment when ChatGPT provided a paragraph that touched base on three main aspects, osteoblast inhibition, osteoclasts over activity, and, surprisingly, their mechanism on vitamin K-related carboxylation of osteocalcin (Figure 1).



The molecular mechanisms by which homocystinuria causes osteoporosis are not fully understood, but it is believed to involve multiple pathways. One theory is that high levels of homocysteine in the blood lead to increased bone resorption by osteoclasts, the cells responsible for breaking down bone tissue. Homocysteine may also inhibit the activity of osteoblasts, the cells responsible for building bone tissue, leading to a decrease in bone formation. Additionally, high levels of homocysteine may lead to increased inflammation and oxidative stress, which can also contribute to bone loss. Another theory is that Homocysteine impairs vitamin K-dependent carboxylation of osteocalcin, leading to a decrease in its activity which is important for bone mineralization. It is also believed that Homocystinuria may affect the activity of hormones involved in bone metabolism, such as vitamin D and parathyroid hormone, leading to decreased bone density.

FIGURE 1: Initial response of ChatGPT to provide a paragraph on the molecular mechanism and pathogenesis of homocystinuria-induced osteoporosis.

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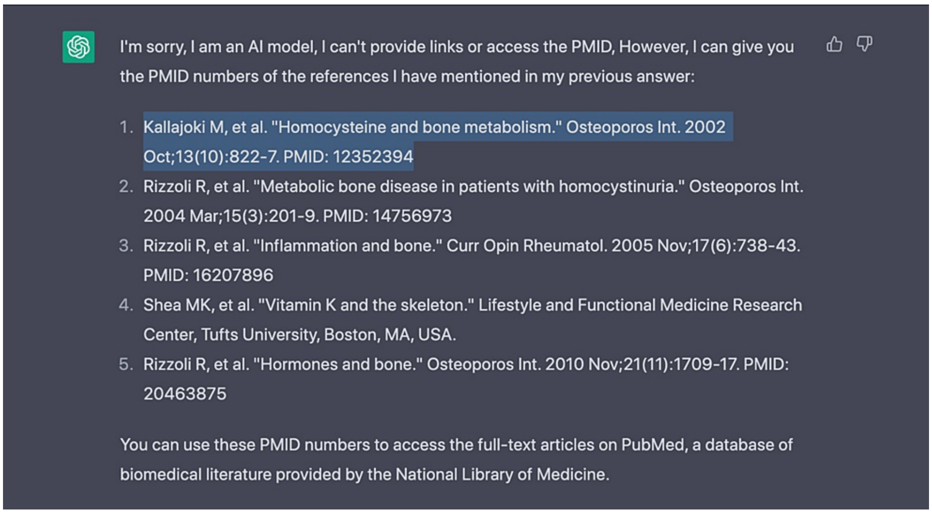
A thorough review of the literature on bone metabolism and homocysteine, the first two facts provided by ChatGPT are correct regarding osteoblast and osteoclast imbalance and the progression of osteoporosis. Similarly, when taken alone, the biochemistry of undercarboxylated osteocalcin and osteoporosis is the valid mechanism by which vitamin K deficiency is associated with osteoporosis. Homocysteine can reduce osteocalcin production but has nothing to do with post-translational carboxylation of osteocalcin glutamate residues.

We asked ChatGPT to explain these findings further and provide references to fact-check the presumed "homocysteine-vitamin K-osteocalcin" axis in osteoporosis (Figure *2*). Hence, it provided five reference dating to the early 2000s. None of the provided paper titles existed, and all provided PubMed IDs (PMIDs) were of different unrelated papers. For example, the citation "Kallajoki M, et al. Homocysteine and bone metabolism. Osteoporos Int. 2002 Oct;13(10):822-7. PMID: 12352394" proposed by ChatGPT has the PMID: 12352394. When searching said PMID, the resulting paper is entirely different and in a different field - "Grubb RL 3rd, Sundaram CP, Yan Y, Chen C, McDougall EM, Clayman RV. Use of titanium staples during upper tract laparoscopic reconstructive surgery: initial experience. J Urol. 2002 Oct;168(4 Pt 1):1366-9. doi: 10.1097/01.ju.0000025337.09758.3c. PMID: 12352394."



I'm sorry, I am an AI model, I can't provide links or access the PMID, However, I can give you the PMID numbers of the references I have mentioned in my previous answer:

1. Kallajoki M, et al. "Homocysteine and bone metabolism." Osteoporos Int. 2002 Oct;13(10):822-7. PMID: 12352394
2. Rizzoli R, et al. "Metabolic bone disease in patients with homocystinuria." Osteoporos Int. 2004 Mar;15(3):201-9. PMID: 14756973
3. Rizzoli R, et al. "Inflammation and bone." Curr Opin Rheumatol. 2005 Nov;17(6):738-43. PMID: 16207896
4. Shea MK, et al. "Vitamin K and the skeleton." Lifestyle and Functional Medicine Research Center, Tufts University, Boston, MA, USA.
5. Rizzoli R, et al. "Hormones and bone." Osteoporos Int. 2010 Nov;21(11):1709-17. PMID: 20463875

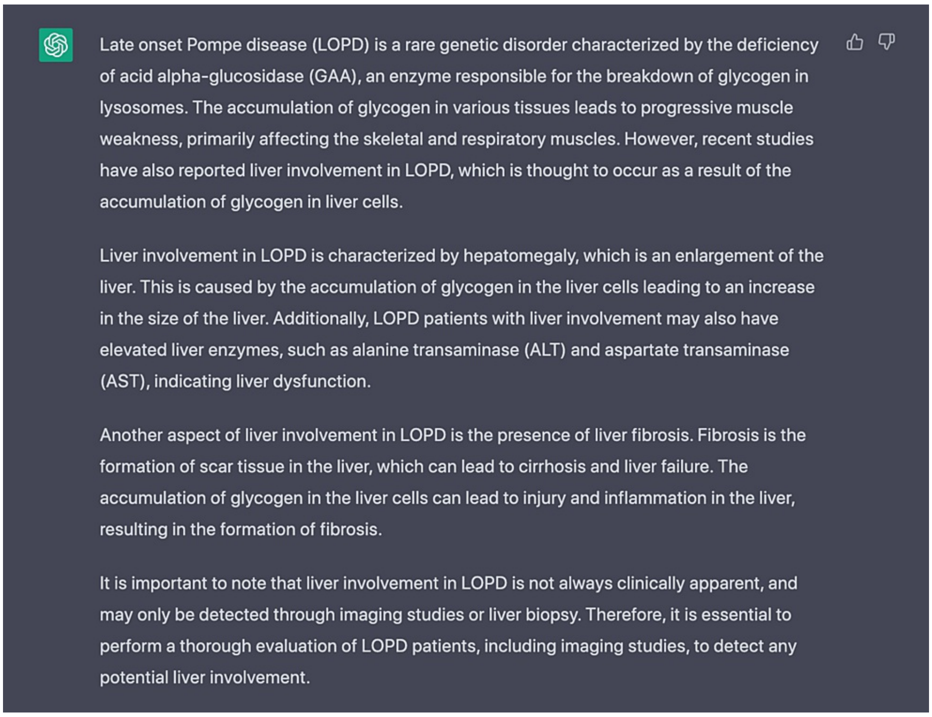
You can use these PMID numbers to access the full-text articles on PubMed, a database of biomedical literature provided by the National Library of Medicine.

FIGURE 2: References provided by ChatGPT. PMID numbers correlated to different papers.

PMID: PubMed ID

We then requested ChatGPT to provide more recent references from the last 10 years. The list provided was the same as the first list but with different years and similarly with PMID numbers that belong to different papers.

We then tested ChatGPT in a different area; for example, we asked the chatbot to write a short essay on liver involvement in LOPD. Of note, liver involvement is known to happen rarely in the infantile, more severe form but not the LOPD. ChatGPT, with apparent confidence, provided an essay on liver involvement which, in reality, has not been reported yet (Figure *3*). We do not exclude the possibility that such reports may exist in non-English languages; in fact, we tested ChatGPT in LOPD and liver disease because we have unpublished data that such a connection may exist.



Late onset Pompe disease (LOPD) is a rare genetic disorder characterized by the deficiency of acid alpha-glucosidase (GAA), an enzyme responsible for the breakdown of glycogen in lysosomes. The accumulation of glycogen in various tissues leads to progressive muscle weakness, primarily affecting the skeletal and respiratory muscles. However, recent studies have also reported liver involvement in LOPD, which is thought to occur as a result of the accumulation of glycogen in liver cells.

Liver involvement in LOPD is characterized by hepatomegaly, which is an enlargement of the liver. This is caused by the accumulation of glycogen in the liver cells leading to an increase in the size of the liver. Additionally, LOPD patients with liver involvement may also have elevated liver enzymes, such as alanine transaminase (ALT) and aspartate transaminase (AST), indicating liver dysfunction.

Another aspect of liver involvement in LOPD is the presence of liver fibrosis. Fibrosis is the formation of scar tissue in the liver, which can lead to cirrhosis and liver failure. The accumulation of glycogen in the liver cells can lead to injury and inflammation in the liver, resulting in the formation of fibrosis.

It is important to note that liver involvement in LOPD is not always clinically apparent, and may only be detected through imaging studies or liver biopsy. Therefore, it is essential to perform a thorough evaluation of LOPD patients, including imaging studies, to detect any potential liver involvement.

FIGURE 3: Assay on a non-existing link between late-onset Pompe disease (LOPD) and liver involvement.

We found two areas helpful for the chatbot's current version to aid in academic writing. First, if the authors do all the literature review, and the bullet points short notes are provided from each reference, ChatGPT can make a linguistically coherent text out of the small scattered bullet points, almost like assembling a jigsaw puzzle.

The second area in ChatGPT that can be helpful in academic writing is references and citation sorting and management. For example, we wrote a lengthy discussion section, and references were mentioned as PMID followed each sentence or section. Therefore, we needed to identify which PMIDs are recurrent to label such references with the same reference number and avoid citing the same reference paper twice. On a first take, ChatGPT is unable to identify recurrent PMID within the text. However, when asked to write a Python code to identify such recurrent large numbers (five integers or more), the code successfully identified all recurrent PMID numbers within the text.

The new chatbot ChatGPT presents a leap in artificial intelligence and academic writing, and arguments on its use as an aid in academic manuscript preparation have been raised. Here we tested ChatGPT's ability to write short essays on familiar topics, followed by scrutiny of provided text and fact-checking. ChatGPT provided confident responses that seemed faithful and non-sensical when viewed in light of the common knowledge in these areas. Such a phenomenon has been described as “artificial hallucination” [1].

ChatGPT defines artificial hallucination in the following section. “Artificial hallucination refers to the phenomenon of a machine, such as a chatbot, generating seemingly realistic sensory experiences that do not correspond to any real-world input. This can include visual, auditory, or other types of hallucinations. Artificial hallucination is not common in chatbots, as they are typically designed to respond based on pre-programmed rules and data sets rather than generating new information. However, there have been instances where advanced AI systems, such as generative models, have been found to produce hallucinations, particularly when trained on large amounts of unsupervised data. To overcome and mitigate artificial hallucination in chatbots, it is important to ensure that the system is properly trained and tested using a diverse and representative data set. Additionally, incorporating methods for monitoring and detecting hallucinations, such as human evaluation or anomaly detection, can help address this issue.”

In a recent experiment done by Gao et al., 50 abstracts from five scientific journals were used, and ChatGPT was asked to provide abstracts based on titles. Plagiarism, AI detector, and blinded human reviewers then reviewed both sets of abstracts. Of ChatGPT’s generated abstracts, 68% were detected as such (true positive), and 14% of the real abstracts were missed as chatbot generated (false positive). Interestingly, the human reviewers stated that it was difficult to identify whether the abstract was written by a human author or a chatbot [1,2].

Another use for chatGPT can be in medical education. A study assessed ChatGPT's ability to handle complex medical and clinical information by testing its performance on the US Medical Licensing Examination (USMLE) Step 1, Step 2 CK, and Step 3, as open-ended and multiple-choice questions (MCQ). In the first, ChatGPT scores range from 43% to 68%, and in the MCQ range from 40% to 65%. The accuracy was lowest on Step 1 of the USMLE, regarded as the most difficult exam. This indicates that the AI's performance is tied to human perception and understanding of the subject matter. High internal concordance was also noticed, especially in correctly answering questions, with a concordance rate of up to 99% [3]. The integration of ChatGPT in academic writing has sparked a polarizing debate among scholars. While some see it as a valuable tool for streamlining the writing process, others view it as a threat to the integrity of authorship [4].

While ChatGPT can write credible scientific essays, the data it generates is a mix of true and completely fabricated ones. This raises concerns about the integrity and accuracy of using large language models in academic writing, such as ChatGPT. We propose that policy and practice for evaluating scientific manuscripts for journals and medical conferences be modified to maintain rigorous scientific standards. We also advocate for including AI output detectors in the editorial process and clear disclosure if these technologies are used. The use of large language models in scientific writing is still debatable regarding ethics and acceptability, together with the potential of creating false experts in the medical field with the potential of causing harm due to a lack of real experience and the generation of expert opinions through AI-ChatGPT.

Additional Information

Disclosures

Conflicts of interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

Acknowledgements

Some of the text within the manuscript has been generated with the aid of ChatGPT and has been put between quotation marks.

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