

Article

Not peer-reviewed version

How Can ChatGPT Benefit Pharmacy: A Case Report on Review Writing

Yun Zhu , [Dan Han](#) , [Shaoging Chen](#) , [Feng Zeng](#) , [Cheng Wang](#) *

Posted Date: 20 February 2023

doi: 10.20944/preprints202302.0324.v1

Keywords: ChatGPT; pharmacy; review; artificial intelligence



Preprints.org is a free multidiscipline platform providing preprint service that is dedicated to making early versions of research outputs permanently available and citable. Preprints posted at Preprints.org appear in Web of Science, Crossref, Google Scholar, Scilit, Europe PMC.

Copyright: This is an open access article distributed under the Creative Commons Attribution License which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Article

How Can ChatGPT Benefit Pharmacy: A Case Report on Review Writing

Yun Zhu ^{a,1}, Dan Han ^{a,1}, Shaoqing Chen ^{c,1}, Feng Zeng ^d and Cheng Wang ^{b,*}

^a Department of Pharmacy, Nanjing Drum Tower Hospital, The Affiliated Hospital of Nanjing University Medical School, Nanjing, China

^b School of Pharmacy, Changzhou University, Changzhou 213164 Jiangsu, China

^c Second People's Hospital of Changzhou, Nanjing Medical University, Changzhou, Jiangsu, China

^d State Key Laboratory of Materials-Oriented Chemical Engineering, College of Chemical Engineering, Nanjing Tech University, Nanjing 211816, Jiangsu, China

¹ These authors have contributed equally to this work.

* Correspondence: wangc90@cczu.edu.cn

Abstract: Artificial Intelligence (AI) is a breakthrough technology that has been widely applied in many fields and its use in pharmacy is also gaining increasing attentions. Recently, ChatGPT, a newly developed virtual assistant and large language model, is showing strong ability in writing, which makes it a potential tool for review writing. Here in our study, we employ the public available ChatGPT and try to instruct it to generate a mini review on the topic of "lipid-based drug delivery systems" by conversation. Our results showed that ChatGPT can give reasonable outline for this topic and give seemingly sentences with concluding wording, which can give useful information to the readers. However, the accuracy and consistence of the review are not fully guaranteed and there is lack of reliable citations. Therefore, it is concluded that ChatGPT can only give general knowledge on the selected topic, but not capable of giving in-depth discussion. The generated review article can be a useful but occasionally unprecise electronic encyclopedia instead of rigorous scientific literature, which can give benefit for pharmaceutical education and interchange to some extent.

Keywords: ChatGPT; pharmacy; review; artificial intelligence

Introduction

Artificial Intelligence (AI) refers to the development of computer systems that can perform tasks that would typically require human intelligence, such as visual perception, speech recognition, decision-making, and natural language processing. ^[1–3] AI systems use techniques like machine learning, deep learning, and neural networks to process and analyze large amounts of data and identify patterns or trends. ^[4,5] The ultimate goal of AI is to create intelligent machines that can learn, reason, and perform complex tasks on their own, without the need for explicit programming, which makes it a powerful assistant to human. ^[6] The rapid development of AI technologies is giving continuous revolution on our knowledge. After AlphaGo dominated the game of Go, the unlimited potential of AI quickly led to its application in many different fields, such as computational diagnosis in medicine, ^[7] smart production in industry, ^[8] supply chain management in business, ^[9] etc.

Artificial intelligence is also gaining increasing attentions and wider applications in pharmacy ^[10] It was expected that AI can greatly accelerate drug discovery and development to reduce lifecycle of pharmaceutical products. ^[11] Therefore, introduction of AI into pharmacy holds great potential to accelerate the drug discovery and development process, reduce costs, and improve patient outcomes. ^[12] While most of the attention are paid on how to use AI for the experimental, clinical or industrial developments, it is also important to note that there are also increasing needs for education and interchange, which requires AI to have strong ability in writing and communication.

Recently, a virtual assistant and large language model called ChatGPT has been developed by OpenAI and made available to the public. ^[13] Benefit from machine learning technology, ChatGPT can autonomously learn from massive data set of text and improve its performance over time

without being explicitly programmed. ^[14] ChatGPT can produce sophisticated and seemingly intelligent writing after training and keep updating to recently provided information. ^[15] Due to the strong writing ability, ChatGPT has been shown to be capable of writing sophisticated and seemingly essays and talks, summarize literature and even generate computer code. ^[16] The use of ChatGPT also has been successfully practiced by scientist across the globe ^[17–19] and we believe that its widespread to all fields is unstoppable. Therefore, it is curious for the authors to know that how can ChatGPT benefit the field of pharmacy.

Review article is a type of academic article that provides an overview and evaluation of existing research on a particular topic. The purpose of a review article is to summarize the findings from multiple studies and to provide a comprehensive and critical analysis of the research in a specific field. It can be a useful tool for a beginner to quickly get familiar with a field and is perfectly suitable for education and interchange purposes. Considering the strong ability of ChatGPT in writing, we believe that review article is a good experiment subject to test its capability on benefiting pharmacy. ^[20] In this study, we used the public available ChatGPT as a tool to generate a review article on the topic of “lipid-based drug delivery systems” by conversation. The ChatGPT was firstly asked to give a concise outline on this topic, and then required to give more scientific information the subtitles based on the given outline.

2. Materials and methods

A review draft based on the topic of “lipid-based drug delivery systems” was generated using ChatGPT (<https://chat.openai.com/>, ChatGPT Feb 13 Version). The history of questions (raised by the author) and responses (produced by ChatGPT) were supplied as Supporting Information. The reliability of ChatGPT in writing review article was evaluated by comparing the ChatGPT-generated review to peer-reviewed research and review papers on the same topic.

3. Results and Discussion

In this study, ChatGPT was asked to write the paragraph based on our questions. As shown in the detailed conversation in the Supporting Information, in our first attempt, we tried to instruct ChatGPT to list a concise outline for a scientific mini review article relating on the topic “lipid-based drug delivery systems” and then write a corresponding scientific review article based on the above outline with detailed examples. As instructed, ChatGPT can give reasonable outline for the selected topic and write accordingly based on it. However, due to the length limitation of this ChatGPT version, the given words are restricted below 600 (also proved by the response in the question: “Please provide scientific information on “Applications of lipid-based drug delivery systems” based on the outline you give with detailed examples”), which makes it impossible to write a decent mini review article in a direct way. Therefore, in the following questions, we have to change another way by asking ChatGPT only one question related to one small subtitle in order to give full information.

As we analyzed the review draft given by ChatGPT, we can find two obvious characteristics: 1) the wording is conclusive and too general without specific samples adhere to the topic; 2) lack of citations. The first characteristic might due to the reason that ChatGPT can not fully understand the requirement of the author, which can be improved to some extent with step-by-step conversation until reaching a consensus. However, the second characteristic, or rather called error, is more fatal. As citation is the foundation of a review article, which is critical for readers to judge the accuracy and reliability of the article. It was suggested that due to rights preservation of many publishers, ChatGPT might not be able to freely access the content of many scientific papers, which makes it a shortage in writing scientific articles. In another attempt, we tried to instruct ChatGPT to give specific references based on the given information with the following questions: “Please list the references for the examples of chemotherapeutic agents that have been delivered using lipid nanoparticles for cancer treatment”, we received the following answer: “Certainly! Here are the references for the examples of chemotherapeutic agents that have been delivered using lipid nanoparticles for cancer treatment: 1. Kim, T. Y., Kim, D. W., Chung, J. Y., Shin, S. G., Kim, S. C., & Heo, D. S. (2004). Phase I and pharmacokinetic study of Genexol-PM, a cremophor-free, polymeric micelle-formulated paclitaxel,

in patients with advanced malignancies. *Clinical cancer research*, 10(11), 3708-3716. 2. Gradishar, W. J., Tjulandin, S., Davidson, N., Shaw, H., Desai, N., Bhar, P., ... & O'Shaughnessy, J. (2005). Phase III trial of nanoparticle albumin-bound paclitaxel compared with polyethylated castor oil-based paclitaxel in women with breast cancer. *Journal of clinical oncology*, 23(31), 7794-7803. 3. LoRusso, P., Krishnamurthi, S. S., Rinehart, J. J., Nabell, L. M., Malburg, L., Chapman, P. B., ... & Hamilton, A. (2010). Phase I clinical evaluation of CRLX101, a cyclodextrin-containing polymer-camptothecin conjugate, in patients with advanced solid tumors. *Clinical cancer research*, 16(4), 1257-1267. 4. Kim, T. Y., Kim, D. W., Kim, J. H., Kim, H. K., Heo, D. S., & Bang, Y. J. (2007). Phase I and pharmacokinetic study of NANO-paclitaxel, a novel Cremophor-free and albumin-free formulation of paclitaxel, in patients with advanced non-small-cell lung cancer. *Annals of Oncology*, 18(12), 2003-2009. I hope this helps! Let me know if you have any further question.” (data not shown). After double check the accuracy of the given references using Google Scholar, we can not identify reference 3 and 4, which means ChatGPT reach this answer without truly assessing to the article but merely relayed from other sources. Moreover, we can not rule out the possibilities that ChatGPT might fabricate the references by suturing different pieces of information, which deserves to be further evaluated by future studies. Moreover, the given samples in references 1 and 2 do not math the question, as the carriers for Genexol PM, albumin-bound paclitaxel and polyethylated castor oil-based paclitaxel are all out of the generally recognized scope of lipid carriers. [21]

Next, we performed more detailed evaluation on this review from two aspects: 1) structure of the outline and 2) the accuracy of the contents. In general, the given outline is acceptable as it is somehow reasonable. However, it was also noted that there are still some flaws. For example, in section II (Types of lipid-based drug delivery systems), liposomes, solid lipid nanoparticles (SLNs), nanostructured lipid carriers (NLCs) and lipid-based microemulsions as four most widely adopted kinds are involved, while lipid-drug conjugate, which represents another important specie of lipid-based drug delivery systems, are neglected. [22–24]. Moreover, in section IV (Applications of lipid-based drug delivery systems), cancer therapy, treatment of neurological disorders and delivery of vaccines are listed as equal subtitles. However, as far as we are concerned, cancer and neurological disorders are applications from the perspective of diseases while the delivery of vaccines are application from the perspective of drugs, which are not fully equivalent. The best solution is to divide this subtitle into two aspects as diseases and drug, and filled the corresponding applications with detailed examples.

As for the contents, due to the fact that ChatGPT prompt to give conclusive wording under the given conversation, we have to admit that most of the given information, although might be controversial in particular cases, are acceptable and applicable to this topic. However, after carefully checked the whole draft created by ChatGPT, we also found some fundamental mistakes which severely influence the reliability of the contents (Table 1).

Table 1. Comments of fundamental mistakes.

Contents provided by ChatGPT	Comments by authors
For example, a liposomal formulation of the anti-cancer drug irinotecan (Onivyde) has been developed, which can target cancer cells that overexpress the folate receptor.	Onivyde is a commercially available PEGlated liposome which does not have additional conjugation of targeting ligands. [25,26] It was reported by previous studies that Onivyde has shown little efficacy when administered alone. [27] Therefore, in clinical practice, Onivyde usually administered intravenously in combination with 5-fluorouracil and folic acid as for the treatment of metastatic pancreatic cancer. [28] Since folic acid is usually appear with Onivyde, ChatGPT might mistakenly think that Onivyde is modified with folic acid and finally give the wrong conclusion of

	its targeting ability towards cancer cells that overexpress the folate receptor.
For example, a liposomal formulation of the MRI contrast agent gadolinium (Gd-DO3A-BSA) has been developed, which can target the lymphatic system and improve lymph node imaging.	The corrected spelling for the word “Gd-DO3A-BSA” should be “Gd-DOTA-BSA”. [29,30]
Liposomal formulations of drugs such as doxorubicin (Doxil/Caelyx) and paclitaxel (Abraxane) have been approved for the treatment of several types of cancer, and other LBDDS are being developed for targeted delivery of chemotherapy agents and other cancer therapies.	Abraxane is albumin-bound particle form of paclitaxel, which does not fall in the scope of liposomal formulations. [31,32]
An example of the application of LBDDS in cancer therapy is the liposomal formulation of paclitaxel, known as Abraxane. Abraxane is designed to encapsulate paclitaxel in a liposomal carrier, which improves its solubility and bioavailability, as well as its pharmacokinetics and biodistribution.	Abraxane is albumin-bound particle form of paclitaxel, which does not fall in the scope of liposomal formulations. [31,32]

Moreover, there are also some improper uses of examples which are commented in Table 2.

Table 2. Comments of improper use of examples.

Contents provided by ChatGPT	Comments by authors
Additionally, LBDDS can improve drug absorption and bioavailability by increasing their residence time in the gastrointestinal tract, promoting their uptake by enterocytes, and bypassing efflux transporters. For example, a liposomal formulation of the anti-fungal drug amphotericin B (AmBisome) has been developed, which has higher efficacy and lower toxicity than the free drug. Vaccines: LBDDS have shown promise as delivery systems for vaccines, due to their ability to enhance the immune response and induce long-lasting immunity. Lipid-based carriers can encapsulate antigens and adjuvants, which can stimulate the immune system and enhance the efficacy of vaccines. Lipid-based adjuvants such as MF59 and AS03 have been approved for use in influenza vaccines, and other LBDDS are being developed for the delivery of vaccines against infectious diseases and cancer.	AmBisome is generally administered by intravenous injection, which makes it an improper example for description related to oral administration. [33–35] In the context, it says “LBDDS have shown promise as delivery systems for vaccines” which means LBDDS should be the carrier but not just adjuvants. Therefore, the authors believe that the example using MF80 and AS03 is not appropriate while the delivery of mRNA for the vaccination of COVID-19 is much more suitable. [36,37]

Finally, there are many inconsistencies among the draft. The authors have selected some representative examples in Table 3.

Table 3. Comments of inconsistencies.

Contents provided by ChatGPT	Comments by authors
In answer for the question: "Please provide a concise outline for a scientific mini review article relating to the topic "lipid-based drug delivery systems""	
...	
II. Types of lipid-based drug delivery systems	We can see that ChatGPT is not able to fully understand what is going on and keep track on the same topic. It seems that ChatGPT generates the answer after a series of complicated computations based on the current input without or give little attention to the previous existed information, as long as the given answer falls within the scope of the question. This is proved by the fact that if you ask ChatGPT the same question two times, you may receive different or sometimes even controversial, answers.
Liposomes	
Solid lipid nanoparticles (SLNs)	
Nanostructured lipid carriers (NLCs)	
Lipid-based microemulsions	
Comparison of the different types of systems in terms of drug loading, stability, and release	
...	
In answer for the question: "Please provide scientific information on "Types of lipid-based drug delivery systems" based on the outline you give above with detailed examples"	
Liposomes:	
Solid lipid nanoparticles (SLNs):	
Nanostructured lipid carriers (NLCs):	
Lipid-drug conjugates:	
In conclusion, lipid-based drug delivery systems (LBDDS) have emerged as a promising option for the delivery of a wide range of therapeutic agents, including small molecules, peptides, and nucleic acids. LBDDS offer several advantages over conventional drug delivery systems, including improved bioavailability, reduced toxicity, and the ability to encapsulate hydrophobic and hydrophilic drugs.	In the review draft provided by ChatGPT, no related information have been mentioned which makes it inconsistent with previous information.

4. Conclusion

In conclusion, here in our study, we employed the public available ChatGPT and tried to instruct it to generate a mini review on the topic of "lipid-based drug delivery systems" by conversation. ChatGPT can give a considerable amount of contents on this topic, but is unable to draft a complete scientific review due to the word restrictions. After carefully study the outline and contents of the review draft produced by ChatGPT, we found the following shortages: 1) Conclusive wording which is too general and not specific enough to the topic; 2) Lack of literature citations; 3) Existence of fundamental mistakes and even potential suturing of information for misleading; 4) Improper use of examples; 5) Inconsistence among the draft without strong logic. Based on the above reasons, we can conclude that it is insufficient for ChatGPT to write a rigorous scientific review but more suitable to be a useful tool as electronic encyclopedia, which can also give some benefit for pharmaceutical education and interchange.

References

- Collins G S, Moons K G M. Reporting of artificial intelligence prediction models[J]. *The Lancet*, 2019, 393(10181): 1577-9.
- Davenport T, Kalakota R. The potential for artificial intelligence in healthcare[J]. *Future healthcare journal*, 2019, 6(2): 94.

3. Zhang C, Lu Y. Study on artificial intelligence: The state of the art and future prospects[J]. *Journal of Industrial Information Integration*, 2021, 23: 100224.
4. Wu F, Lu C, Zhu M, Chen H, Zhu J, Yu K, Li L, Li M, Chen Q, Li X. Towards a new generation of artificial intelligence in China[J]. *Nature Machine Intelligence*, 2020, 2(6): 312-6.
5. Goralski M A, Tan T K. Artificial intelligence and sustainable development[J]. *The International Journal of Management Education*, 2020, 18(1): 100330.
6. Jeste D V, Graham S A, Nguyen T T, Depp C A, Lee E E, Kim H-C. Beyond artificial intelligence: exploring artificial wisdom[J]. *International psychogeriatrics*, 2020, 32(8): 993-1001.
7. Briganti G, Le Moine O. Artificial intelligence in medicine: today and tomorrow[J]. *Frontiers in medicine*, 2020, 7: 27.
8. Cioffi R, Travaglioni M, Piscitelli G, Petrillo A, De Felice F. Artificial intelligence and machine learning applications in smart production: Progress, trends, and directions[J]. *Sustainability*, 2020, 12(2): 492.
9. Pournader M, Ghaderi H, Hassanzadegan A, Fahimnia B. Artificial intelligence applications in supply chain management[J]. *International Journal of Production Economics*, 2021, 241: 108250.
10. Kolluri S, Lin J, Liu R, Zhang Y, Zhang W. Machine learning and artificial intelligence in pharmaceutical research and development: a review[J]. *The AAPS Journal*, 2022, 24: 1-10.
11. Paul D, Sanap G, Shenoy S, Kalyane D, Kalia K, Tekade R K. Artificial intelligence in drug discovery and development[J]. *Drug discovery today*, 2021, 26(1): 80.
12. Kiriiri G K, Njogu P M, Mwangi A N. Exploring different approaches to improve the success of drug discovery and development projects: a review[J]. *Future Journal of Pharmaceutical Sciences*, 2020, 6(1): 1-12.
13. Kung T H, Cheatham M, Medenilla A, Sillos C, De Leon L, Elepaño C, Madriaga M, Aggabao R, Diaz-Candido G, Maningo J. Performance of ChatGPT on USMLE: Potential for AI-assisted medical education using large language models[J]. *PLOS Digital Health*, 2023, 2(2): e0000198.
14. Pavlik J V. Collaborating With ChatGPT: Considering the Implications of Generative Artificial Intelligence for Journalism and Media Education[J]. *Journalism & Mass Communication Educator*, 2023: 10776958221149577.
15. Thorp H H. ChatGPT is fun, but not an author [M]. American Association for the Advancement of Science. 2023: 313-.
16. Van Dis E a M, Bollen J, Zuidema W, Van Rooij R, Bockting C L. ChatGPT: five priorities for research[J]. *Nature*, 2023, 614(7947): 224-6.
17. Rao A S, Kim J, Kamineni M, Pang M, Lie W, Succi M. Evaluating ChatGPT as an Adjunct for Radiologic Decision-Making[J]. *medRxiv*, 2023: 2023-02.
18. Alshurafat H. The Usefulness and Challenges of Chatbots for Accounting Professionals: Application On ChatGPT[J]. *Available at SSRN 4345921*, 2023.
19. Aydın Ö, Karaarslan E. OpenAI ChatGPT generated literature review: Digital twin in healthcare[J]. *Available at SSRN 4308687*, 2022.
20. Zhong Q, Tan X, Du R, Liu J, Liao L, Wang C, Sun R, Tang Z, Ren J, Mebrahtu C, Zeng F. Is ChatGPT a Reliable Source for Writing Review Articles in Catalysis Research? A Case Study on CO₂ Hydrogenation to Higher Alcohols. *Preprints 2023*, 2023020292 (doi: 10.20944/preprints202302.0292.v1).
21. Cho K, Wang X U, Nie S, Chen Z, Shin D M. Therapeutic nanoparticles for drug delivery in cancer[J]. *Clinical cancer research*, 2008, 14(5): 1310-6.
22. Neupane Y R, Sabir M D, Ahmad N, Ali M, Kohli K. Lipid drug conjugate nanoparticle as a novel lipid nanocarrier for the oral delivery of decitabine: ex vivo gut permeation studies[J]. *Nanotechnology*, 2013, 24(41): 415102.
23. Banerjee S, Kundu A. Lipid-drug conjugates: a potential nanocarrier system for oral drug delivery applications[J]. *DARU Journal of Pharmaceutical Sciences*, 2018, 26: 65-75.
24. Irby D, Du C, Li F. Lipid–drug conjugate for enhancing drug delivery[J]. *Molecular pharmaceuticals*, 2017, 14(5): 1325-38.
25. Passero Jr F C, Grapsa D, Syrigos K N, Saif M W. The safety and efficacy of Onivyde (irinotecan liposome injection) for the treatment of metastatic pancreatic cancer following gemcitabine-based therapy[J]. *Expert review of anticancer therapy*, 2016, 16(7): 697-703.
26. Zhang H, Wang T, He W, Wang J, Li X. Irinotecan-loaded ROS-responsive liposomes containing thioether phosphatidylcholine for improving anticancer activity[J]. *Journal of Drug Delivery Science and Technology*, 2022, 71: 103321.

27. Lamb Y N, Scott L J. Liposomal irinotecan: a review in metastatic pancreatic adenocarcinoma[J]. *Drugs*, 2017, 77: 785-92.
28. Taléns-Visconti R, Díez-Sales O, De Julián-Ortiz J V, Nácher A. Nanoliposomes in cancer therapy: marketed products and current clinical trials[J]. *International Journal of Molecular Sciences*, 2022, 23(8): 4249.
29. Lipinski M J, Frias J C, Amirbekian V, Briley-Saebo K C, Mani V, Samber D, Abbate A, Aguinaldo J G S, Massey D, Fuster V. Macrophage-specific lipid-based nanoparticles improve mri detection and characterization of human atherosclerosis[J]. *JACC Cardiovascular imaging*, 2009, 2(5): 637.
30. Pitchaimani A, Nguyen T D T, Wang H, Bossmann S H, Aryal S. Design and characterization of gadolinium infused theranostic liposomes[J]. *RSC advances*, 2016, 6(43): 36898-905.
31. Sahu T, Ratre Y K, Chauhan S, Bhaskar L, Nair M P, Verma H K. Nanotechnology based drug delivery system: Current strategies and emerging therapeutic potential for medical science[J]. *Journal of Drug Delivery Science and Technology*, 2021, 63: 102487.
32. Green M R, Manikhas G M, Orlov S, Afanasyev B, Makhson A M, Bhar P, Hawkins M J. Abraxane®, a novel Cremophor®-free, albumin-bound particle form of paclitaxel for the treatment of advanced non-small-cell lung cancer[J]. *Annals of oncology*, 2006, 17(8): 1263-8.
33. Yadav N K, Joshi S, Ratnapriya S, Sahasrabuddhe A A, Dube A. Combined immunotherapeutic effect of Leishmania-derived recombinant aldolase and Ambisome against experimental visceral leishmaniasis[J]. *Journal of Microbiology, Immunology and Infection*, 2023, 56(1): 163-71.
34. Meyerhoff A. US Food and Drug Administration approval of AmBisome (liposomal amphotericin B) for treatment of visceral leishmaniasis[J]. *Clinical Infectious Diseases*, 1999, 28(1): 42-8.
35. Adler-Moore J, Proffitt R T. AmBisome: liposomal formulation, structure, mechanism of action and pre-clinical experience[J]. *Journal of Antimicrobial Chemotherapy*, 2002, 49(suppl_1): 21-30.
36. Wilson B, Geetha K M. Lipid nanoparticles in the development of mRNA vaccines for COVID-19[J]. *Journal of Drug Delivery Science and Technology*, 2022, 74: 103553.
37. Kon E, Elia U, Peer D. Principles for designing an optimal mRNA lipid nanoparticle vaccine[J]. *Current opinion in Biotechnology*, 2022, 73: 329-36.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.