ChatGPT in Nutrition: Trends, Challenges and Future Directions

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ABSTRACT

A healthy and balanced diet is of paramount importance to the physical and psychological well-being of an individual, since unhealthy dietary choices have been linked with the occurrence of non-communicable diseases. Recent technological advances has led to the development of large language models, such as ChatGPT that has been widely adopted as a convenient tool for creating meal plans and obtaining nutritional information. This work aims to provide a thorough review of the scientific work performed so far regarding the use of ChatGPT in the field of nutrition. In this survey, the advantages and limitations of ChatGPT in different aspects of nutrition are pinpointed, while the challenges from the use of ChatGPT in nutrition are identified and discussed. Future research directions are also proposed to assist researchers towards the development of more effective nutrition recommendation systems.

CCS CONCEPTS

• **Applied computing** → **Health care information systems**; **Consumer health**; • **Information systems** → *Information retrieval*.

KEYWORDS

ChatGPT, nutrition, diet

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1 INTRODUCTION

Nutrition plays an important role in a human's overall health and well-being since food is not only a primary energy provider for the human body but also the necessary fuel for the organs to operate effectively [10]. However, the knowledge of humans on which diets are beneficial to them is limited, leading them to adopt unbalanced diets that can be detrimental to their health. The high prevalence of Non-communicable Diseases (NCDs), such as obesity and Type 2 Diabetes, is highly correlated with the adoption of unhealthy diets [3]. On the other hand, individuals with adequate knowledge in nutrition demonstrate the capacity to understand nutritional guidelines and appropriate portion sizes [7]. Due to the positive association between nutrition knowledge and dietary intake, these individuals tend to make more informed and healthier dietary choices [15].

The construction of healthy and balanced diets is traditionally performed by nutrition and healthcare professionals with deep knowledge of nutritional guidelines and dietary principles. With the rise of AI, Large Language Models (LLMs), such as ChatGPT [1], have been widely employed by users for information acquisition. Developed by OpenAI, ChatGPT is capable of understanding and generating human-like text responses and engage in conversations on various topics. Lately, ChatGPT has been also employed in nutrition to effectively formulate meal plans and adapt its meals according to the individual's requirements. However, questions have been raised on the effectiveness of ChatGPT in its ability to provide accurate and personalized dietary advice [11].

The aim of this survey is to perform a literature review of the works that employ ChatGPT in nutrition. Through the analysis of these works, the ability of ChatGPT to provide useful dietary advice is assessed and the main advantages and drawbacks of this technology are identified. In addition, this review aims to identify current and future directions of the usage of ChatGPT in nutrition and assess the improvements that should be made and the challenges that should be overcome for ChatGPT to be successfully employed as an efficient and effective nutrition recommendation system. More specifically, the objectives of this review can be summarized as follows:

- A comprehensive study on the use of ChatGPT in the field of nutrition, as well as a categorization of the relevant research work is performed.
- The advantages and limitations of ChatGPT in nutrition are explored and discussed.
- Possible future directions and challenges in the development of LLMs as efficient and effective nutrition recommendation systems are identified and reported.

2 LITERATURE SEARCH

Following the PRISMA guidelines [8], a systematic literature search was performed. The articles were extracted on February 7, 2024 from three academic databases, namely Scopus (https://www.scopus.com/home.uri), Science Direct (https://www.sciencedirect.com) and IEEEXplore (https://ieeexplore.ieee.org/Xplore/home.jsp). Since this article deals with ChatGPT in the field of nutrition, the search condition was the following:

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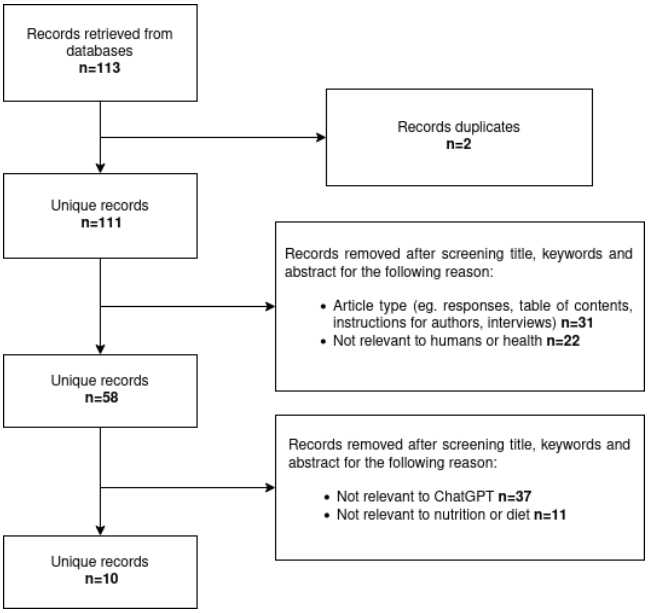

Figure 1: Flowchart illustrating the systematic literature search process.

TITLE-ABS-KEY (ChatGPT AND (diet OR nutrition)) AND PUBLISH YEAR > 2022

The aforementioned search criteria pertain to the presence of the words ChatGPT and diet or nutrition within the title, abstract, or keywords of the literature works. Furthermore, the search is conducted specifically for papers published after 2022, the year that coincides with the appearance of ChatGPT. As a result, this review aims to present all works that have been published so far in the literature and evaluate the use of ChatGPT in the fields of diet or nutrition.

The number of records obtained from the three databases is 113. Out of this number, 2 duplicate records were eliminated, resulting in 111 unique records. Following a thorough screening of titles, keywords, abstracts, and, finally, full texts using specific criteria to exclude irrelevant entries, 10 records met the inclusion criteria and form the content of this review. The selection process is illustrated in Fig. 1.

3 LITERATURE REVIEW

ChatGPT, among other LLMs, has found extensive usage lately in the field of nutrition and has prompted researchers to evaluate the model in several nutrition-related tasks. In literature, ChatGPT has been employed for extracting meal plans and recommending foods for both healthy individuals and patients with specific medical conditions, such as NCDs [10, 11, 14], as well as for checking nutritional content and addressing common nutrition questions [5, 6].

An important aspect of a healthy diet is the appropriateness of the foods consumed by individuals having specific medical conditions or diseases. Qarajeh et al. in [12] conducted a study to assess the efficacy of various AI models, including ChatGPT 3.5 and 4, Bard AI, and Bing Chat, in identifying potassium and phosphorus content in foods. The evaluation involved 240 food items, extracted from the Mayo Clinic Renal Diet Handbook for Chronic Kidney Disease (CKD) patients. These items were differentiated based on their potassium (149 items) and phosphorus (91 items) content levels. Each model was tasked with categorizing the items into high or low potassium and high phosphorus content, and the results were compared with recommendations from the Mayo Clinic Renal Diet Handbook. Additionally, the study checked the consistency of the models across repeated sessions to test their reliability. Similarly, Aiumtrakul et al. in [2] focused on the reliability of chatbots in categorizing foods based on their oxalate content level. They evaluated the accuracy of ChatGPT-3.5, ChatGPT-4, Bard AI, and Bing Chat in classifying dietary oxalate content per serving into low (<5 mg), moderate (5–8 mg), and high (>8 mg) oxalate content. A total of 539 food items were analyzed by each chatbot and the oxalate content classification results were compared among the chatbots.

In diet planning, Niszczota et al. explored the safety and precision of 56 diets proposed by ChatGPT for hypothetical individuals with food allergies [9]. Different conditions, such as the existence of a single or two allergies and the need for a low-calorie diet, were formulated and the ability of ChatGPT to provide credible diets under these conditions was assessed. In a similar fashion, the ability of ChatGPT to generate appropriate meal plans for patients with NCDs was evaluated in [17]. The authors developed an AI-based nutritionist program that combines human language and image recognition models. The effectiveness of the program for individuals with type 2 diabetes mellitus (T2DM) was assessed through a multi-step process. Initially, a survey was conducted among T2DM patients and endocrinologists to identify any gap in dietary knowledge. Subsequently, different ChatGPT versions were subjected to the Chinese Registered Dietitian Examination to test their ability in giving evidence-based dietary advice. Finally, the food recommendations generated by ChatGPT were compared against the responses received from professional dietitians. A deep learning-based image recognition model was also developed for ingredient identification in foods, and its performance was compared with existing models.

A more thorough evaluation of the ability of ChatGPT to generate daily and weekly meal plans for healthy people, as well as patients suffering from NCDs, was performed in [10]. Using a knowledge-based diet recommendation system as a benchmark and a large database of meals, the authors assessed the meal plans generated by ChatGPT 3.5 and ChatGPT 4 with respect to nutritional content (i.e., calorie intake and macronutrients) and meal diversity. The comparison between ChatGPT recommendations and knowledge-driven dietary advice for 3000 virtual user profiles that describe healthy young and older adults, athletes, obese people and people with cardiovascular diseases and T2DM revealed important advantages and limitations of LLMs in the field of nutrition. On the other hand, Haman et al. in [5] explored the ability of ChatGPT to construct meal plans with high nutrient precision for dietary planning and weight management. The authors took the reference values provided by the United States Department of Agriculture

(USDA) Food Data Central for each of the five nutrients, namely carbohydrates, energy, protein, lipids, and water, computed upper and lower bounds as percentages of the reference values and assessed whether the nutritional content of the meals generated by ChatGPT falls within the bounds.

Other works have evaluated ChatGPT's capacity on answering nutrition-related questions and providing nutritional guidance and education. In [14], the authors directed ChatGPT to respond to questions related to diabetes self-management. They presented ChatGPT with typical inquiries across four domains of diabetes self-management education, specifically diet and exercise, hypoglycemia and hyperglycemia education, insulin storage and insulin administration. They replicated the interaction in an unstructured manner to emulate authentic real-world patient communication, and different ChatGPT versions were scrutinized for consistency and reliability. Chatelan et al. in [4] requested from ChatGPT to define the ideal diet for a person with T2DM and an individual undergoing hemodialysis. Additionally, they presented ChatGPT with a case study of a patient with Type 1 diabetes, typically used for educational purposes in nutrition and dietetics and asked ChatGPT to generate nutritional diagnoses based on the Nutrition Care Process Terminology.

In a similar fashion, Ponzo et al. performed a thorough evaluation of ChatGPT as a tool for providing nutritional guidance, especially to different NCDs [11]. The study compared the dietary advice given by ChatGPT against established guideline recommendations and assessed the ability of the model to handle a complex individual case with multiple diseases. Additionally, a panel of nutrition experts was employed to evaluate ChatGPT's responses. Analogously, Kirk et al. in [6] examined ChatGPT's ability in responding to typical nutrition inquiries. Firstly, dietitians were asked to share their frequently asked nutrition-related questions along with their own answers. Then, these questions were inputed to ChatGPT and both sets of answers were given to other dietitians or experts in the relevant domain of each question for evaluation based on scientific accuracy, practicability, and clarity. The assessments were averaged to generate an overall score, and the group means of responses to each question were compared using permutation tests.

After a comprehensive analysis of the aforementioned literature works, five overlapping categories of evaluation of ChatGPT in the field of nutrition emerged and used for the classification of works, as shown in Table 1. These categories are nutritional content, diet planning, meal variability, dietetics practice and education and food appropriateness. More specifically, nutritional content refers to the evaluation of ChatGPT meals in terms of calories and nutrients, diet planning concerns the ability of ChatGPT to generate credible meal plans, meal variability is related to the variation of foods inside the meals generated by ChatGPT usually in a weekly base, dietetics practice and education refers to the use of ChatGPT as a tool for answering nutrition-related questions for educational purposes and food appropriateness is concerned with the assessment of foods suitability in terms of minerals and allergens with respect to specific populations, such as patients with NCDs.

4 RESULTS

Taking into consideration the categories in Table 1 for evaluating ChatGPT in the field of nutrition, this section aims to present the results of the respective studies regarding the capabilities of ChatGPT in suggesting appropriate foods to individuals with specific medical conditions, generating personalized meal plans in terms of nutritional content and providing credible nutritional guidance. The findings of the studies are analyzed and the strengths and limitations of ChatGPT in each category of evaluation are highlighted below, with the main points summarized in Table 2.

Nutritional content. The ability of ChatGPT to provide meal plans with rich nutritional content is evaluated in [5, 10]. Papastratis et al. showed that ChatGPT proposed meals are quite accurate in terms of nutritional content for different user groups [10]. Specifically, ChatGPT achieves an overall accuracy of 83% for obese users, 85% for CVD patients and 93% for T2DM patients. When ChatGPT is provided with the personalized target energy intake in prompt, the authors showed that the average nutrient accuracy of ChatGPT 4 increases from 81.62% to 86.19% and the caloric difference drops from 27.7% to 3.35%. These results reveal the ability of ChatGPT to provide nutritious meals, but its performance can be significantly improved when ChatGPT is guided through nutritional guidelines and personalized goals. Similarly, Haman et al. showed that most than half of ChatGPT predictions was within 10% difference of the USDA reference values [5]. However, the accuracy of ChatGPT varies depending on the nutrient, with calories being the most accurate (almost 97% of ChatGPT values fall within 40% difference of the USDA values) and fat being the least accurate (almost 70% of ChatGPT values fall within 40% difference of the USDA values).

Diet planning. ChatGPT's capability in generating daily or weekly healthy meal plans is examined in [4, 9, 10, 17]. Sun et al. showed that ChatGPT achieves a pretty good score (almost 68%) on diet planning and management, according to the actual registered dietitian exam questions released from the official exam guide in China [17]. The authors mention that ChatGPT is a statistical model that does not contain any rules and therefore further specialization in medical consulting is needed. Niszczota et al. demonstrated that, although generally accurate, ChatGPT can produce inaccuracies in food quantities and meal calories, while it has the potential to generate meals that include unwanted allergens [9]. Moreover, the authors noted the ability of ChatGPT to produce safety messages and provide basic recommendations that are in line with dietary guidelines. In a similar fashion, Chatelan et al. observed that the meals generated by ChatGPT are consistent for T2DM and Hemodialysis patients, although they may include unwanted food items (e.g., avocado) [4]. Finally, Papastratis et al. found that ChatGPT can provide quite accurate daily and weekly meal plans tailored to the needs of the users. The authors also revealed the ability of ChatGPT to adapt to well-defined nutritional guidelines and expressed the need for additional experiments when strict diets or the adherence to allergies are required.

Meal variability. The ability of ChatGPT to generate balanced meal plans with variability throughout the week was examined in [9, 10]. Niszczota et al. highlighted that ChatGPT produces monotonous diets that can be difficult to follow since they lack variety

	Nutritional content	Diet planning	Meal variability	Dietetics practice and education	Food appropriateness
Aiumtrakul et al. [2]					✓
Chatelan et al. [4]		✓		✓	
Haman et al. [5]	✓				
Kirk et al. [6]				✓	
Niszczota et al. [9]		✓	✓		✓
Papastratis et al. [10]	✓	✓	✓		
Ponzo et al. [11]				✓	✓
Qarajeh et al. [12]					✓
Sng et al. [14]				✓	
Sun et al. [17]		✓		✓	✓

Table 1: Categorization of the relevant literature works

	Strengths	Limitations
Nutritional content	• Meals with satisfying nutritional content • Nutritional guidance can improve accuracy	• Accuracy differs among nutrients
Diet planning	• Generally accurate diets • Meal plans tailored to user needs • Adapts well to nutritional guidelines • Produces safety messages and recommendations	• Statistical model that does not follow rules • Risk for unwanted allergens or foods on meals • Requires further medical specialization • Inaccuracies in food quantities
Meal Variability	• High variability throughout the week	• Repetition of food choices observed
Dietetics practice and education	• Reliable answers at common nutrition questions • As good responses as human dietitians • Can assist in research • Answers with adaptable tone, no spelling errors • Free, easy to use and convenient tool	• Generic responses that lack emotion • Limited guidance on multiple comorbidities • Relies on outdated and made-up information • Leads to academic dishonesty • Depends on user to give relevant information • Inaccuracies in pure medical answers • Different answers when asked multiple times
Food appropriateness	• High accuracy for specific diets or patient types • High accuracy in food mineral classification	• Rare inclusion of allergens in meals • Few contradictions with nutritional guidelines • Low classification accuracy for food compounds

Table 2: Main strengths and limitations of ChatGPT in the field of nutrition.

or over-rely on specific food choices [9]. On the other hand, Papastratis et al. showed that ChatGPT can generate meal plans with a high variability for different types of meals (e.g., breakfast, lunch, supper) and this can be attributed to ChatGPT's access to a large pool of meals available online [10].

Dietetics practice and education. The use of ChatGPT as a tool that provides nutritional information, guidance and education have been studied in [4, 6, 11, 14, 17]. Ponzo et al. concluded that ChatGPT's responses to various nutrition-related questions are at least equal, if not better than experts in the field [11]. Furthermore, ChatGPT's advice for T2DM patients were found to be adequate with the information provided by the American Diabetes Association (ADA). However, ChatGPT's responses were generic and lacked emotion, while few of them were considered inappropriate. Moreover, ChatGPT was unable to provide suitable guidance when multiple diseases coexisted. Sun et al. showed that ChatGPT's answers about the ketogenic diet were reliable, but varied when ChatGPT was asked multiple times the same question [17]. Similarly, Chatelan et al. highlighted ChatGPT as a helping tool that is limited in each answers due to made-up, unsourced, and outdated information [4]. Additionally, the authors concluded that ChatGPT can assist in research and produce answers with adaptable tone and no spelling mistakes, but it can lead to academic dishonesty due to lack of practice from the students. Kirk et al. concluded that ChatGPT is at least as good as human dietitians at answering common nutrition questions, especially if the case is not very specific, i.e., NCD patients [6]. They also highlight ChatGPT as being free, easy to use and convenient, while they refer to ChatGPT's credibility, outdated information and dependence on the user to provide relevant information as limitations. Finally, Sng et al. concluded that ChatGPT generates accurate responses on questions related to diabetes self-management, but inaccuracies were observed especially in pure medical answers, such as insulin storage [14].

Food appropriateness. The use of ChatGPT to identify appropriate food items under specific dietary conditions was studied in [2, 9, 11, 12, 17]. Sun et al. observed that ChatGPT achieves an accuracy of 95% when it recommends food items for ketogenic diets, although with some minor inconsistencies. When the questions

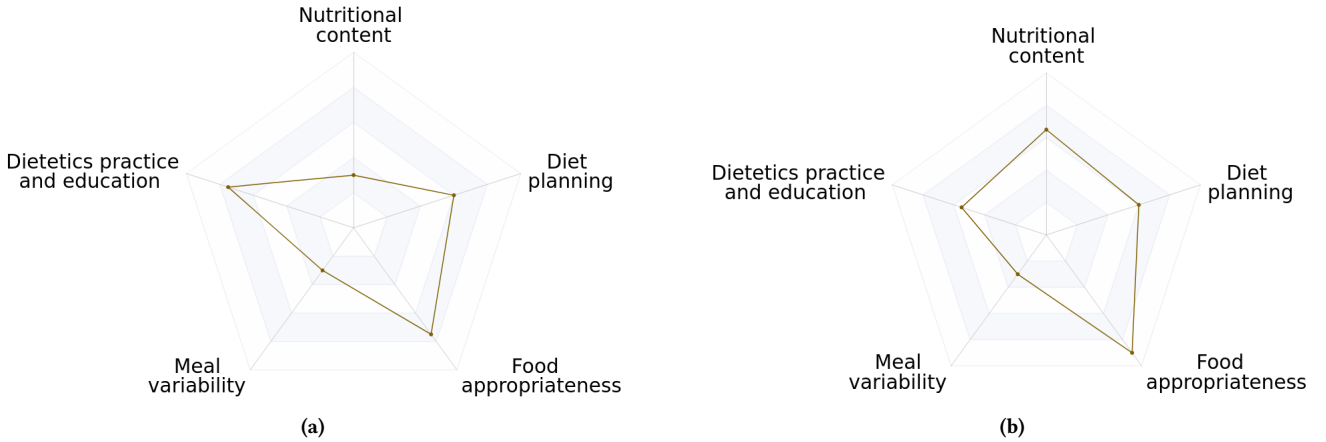

Figure 2: Radar charts showing (a) the direction of current scientific work and (b) the challenges of ChatGPT in nutrition

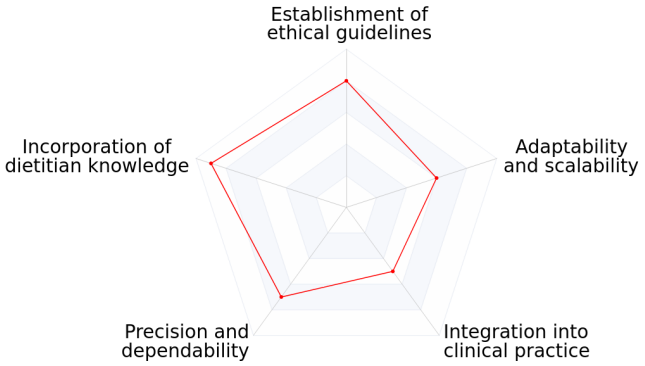

Figure 3: Proposed directions of future scientific work

were repeated, ChatGPT did not produce the same errors due to being a statistical model without specialization [17]. Ponzo et al. proved that ChatGPT's food recommendations for various NCD patients were pretty accurate, with appropriateness rates ranging from 55.5% for Sarcopenia up to 73.3% for non-alcoholic fatty liver disease [11]. The authors also observed a few food recommendations to be in contradiction with the nutritional guidelines, while some recommendations for T2DM patients undergoing hemodialysis were not found to be optimal. Niszczota et al. found that although ChatGPT excluded the allergens in most cases, there were cases in which allergens were included in diets propositions, leading to harmful diets. On the other hand, Aiumtrakul et al. employed ChatGPT to classify foods based on a specific compound (i.e., oxalate) and concluded that the accuracy of ChatGPT is not so satisfying, reaching just 52% and highlighting the need for significant model improvements and nutritional expert guidance [2]. Finally, Qarajeh et al. showed that ChatGPT can accurately classify food items based on their minerals (low or high potassium and high phosphorus with 81% and 76% accuracy, respectively) [12]. The authors highlighted the need for further enhancements to ChatGPT to achieve accuracy levels of 90% or above, since wrong categorization can be harmful to NCD patients.

5 DISCUSSION AND FUTURE DIRECTIONS

The review of the available literature works and the analysis of the advantages and disadvantages of ChatGPT in nutrition has led to the identification of the current and future research directions, as well as the challenges ChatGPT faces. Currently, the main focus of the research and ChatGPT evaluation is on the areas of dietetics practice and education, and food appropriateness in order for ChatGPT to offer nutritional guidance and identify which food items should be included in a personalized diet based on the user profile, respectively. The ability of ChatGPT to generate meal plans is studied, followed by research on nutritional content and meal variability. A radar chart (Fig. 2a) is created to demonstrate the current research directions of ChatGPT in nutrition, as identified by the volume of literature works in each nutritional area. Additionally, the challenges are defined based on the assessment of the performance of ChatGPT in each nutritional area and are presented in Fig. 2b. It can be concluded that food appropriateness is the most challenging area for ChatGPT due to its mediocre performance in identifying allergens, minerals and nutritional compounds in food items. On the other hand, meal variability seems the least challenging area for ChatGPT because of its access to a huge pool of meals available online.

Given the current research directions and the challenges of ChatGPT in nutrition, future directions for research can be proposed. Fig. 3 illustrates these future directions, along with weights that are assigned after studying relevant literature works and based on the importance of the directions in the field of nutrition. One of the main issues of ChatGPT lies in the accuracy in generating healthy and nutritious meal plans for NCD patients or patients with multiple diseases. To overcome this, nutritional guidelines and dietitian knowledge should be incorporated in their decision making process, significantly enhancing their potential [16]. Establishment of ethical guidelines is also an area for future research. Examining issues like informed consent, patient's autonomy and the role of supervision in ChatGPT are the building blocks for trust between patients, healthcare experts and ChatGPT [13]. Furthermore, the scientific community pointed out ChatGPT's scalability and adaptability as serious limitations to its use. Scientific research should address that

issue by allowing ChatGPT to scale up and adapt to different user populations with various diseases and allergies. Another important area of future research includes the improvement of the precision and dependability of ChatGPT. ChatGPT should depend less on the ability of the user to explain thoroughly the situation and provide relevant information. In addition, constant training of ChatGPT would allow it to be up-to-date with the latest developments and provide credible guidance in the ever-expanding fields of nutrition and medicine. Finally, further investigation is needed in order to integrate ChatGPT into clinical practice. Healthcare experts should be able to use ChatGPT's responses as an additional tool to provide better consultation. This will have a positive impact on the workload of healthcare experts and the quality of their work.

6 CONCLUSIONS

The aim of this work was to study the use of LLMs, and specifically ChatGPT, in the field of nutrition. To this end, several academic databases were searched and literature works that employ and evaluate ChatGPT in nutrition-related areas were identified. The findings of these studies were analyzed and important conclusions on the advantages and limitations of ChatGPT in nutrition were drawn. In a nutshell, ChatGPT was found to be a convenient tool that can be used for nutritional guidance and education. ChatGPT, with access on a huge pool of online meals, can also generate detailed meal plans with high accuracy in terms of calories and macronutrients. Moreover, it can be used to assess the appropriateness of food items with satisfying accuracy in most cases. On the other hand, ChatGPT present inaccuracies when dealing with specialized cases of patients with several comorbidities [11]. The rare inclusion of allergens in the proposed meals creates cautiousness when giving diet recommendations, thus requiring constant expert supervision. In addition, the lack of knowledge on nutritional guidelines has shown that it can severely affect the accuracy of ChatGPT generated meal plans. Finally, the training of ChatGPT should be constant, otherwise there is a high risk of relying on outdated and made-up information from unidentified sources.

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