Artificial Intelligence in Nutritional Management of Patients with Inflammatory Bowel Disease: A Scoping Review Postprint

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Abstract

Background: Diet is closely associated with the occurrence, development, and prognosis of inflammatory bowel disease (IBD). In the absence of specific dietary and nutritional guideline recommendations, nutritional management for IBD patients is fraught with challenges and uncertainties. Existing research indicates that artificial intelligence (AI) demonstrates promising application prospects in nutritional management for chronic disease patients; however, current research on its application in nutritional management for IBD patients remains limited.

Objective: To conduct a scoping review of research on the application of artificial intelligence in the field of IBD nutritional management.

Methods: A systematic search was conducted across PubMed, Web of Science, Embase, Cochrane Library, CINAHL, IEEE Xplore, Association for Computing Machinery Digital Library, China Biology Medicine disc, CNKI, Wanfang Data Knowledge Service Platform, and VIP Chinese Periodical Database, among other Chinese databases, to screen studies on the application of artificial intelligence in nutritional management for IBD patients, with the search timeframe spanning from database inception to March 2024. Two researchers independently screened literature according to inclusion and exclusion criteria and extracted basic characteristics of the literature.

Results: A total of 15 studies were included. Applications of artificial intelligence in this field include exploring the interrelationship between diet and disease, assisting nutritional assessment, and supporting nutritional interventions. AI technologies are primarily based on machine learning, with others including natural language processing, deep neural networks, etc.

Conclusion: Artificial intelligence facilitates the exploration of healthy dietary patterns for IBD patients and personalized nutritional guidance; however, its ap-

plication in IBD nutritional management remains in a preliminary stage. Future efforts should strengthen multidisciplinary collaboration, emphasize integration with clinical guidelines, and evaluate its application effectiveness in clinical practice to ensure result rigor and accuracy.

Full Text

Application of Artificial Intelligence in Nutritional Management of Patients with Inflammatory Bowel Disease: A Scoping Review

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Abstract

Background: Diet plays a critical role in the development, progression, and prognosis of inflammatory bowel disease (IBD). Given that specific nutritional guidelines are limited, nutritional management for patients with IBD remains challenging and fraught with uncertainty. Although previous studies have demonstrated that artificial intelligence (AI) shows promising applications in the nutritional management of patients with chronic diseases, research specifically focused on its application in the nutritional management of patients with IBD remains limited.

Objective: To conduct a scoping review of studies on AI in nutrition management of patients with IBD.

Methods: Following the methodology of scoping reviews, the databases of PubMed, Web of Science, Embase, Cochrane Library, CINAHL, IEEE Xplore, Association for Computing Machinery Digital Library, SinoMed, CNKI, Wanfang Data, and VIP were systematically searched from inception to March 2024 for studies on the application of AI in the nutritional management of patients with IBD. According to the established inclusion and exclusion criteria, two investigators independently screened the literature, and the basic characteristics of the selected studies were extracted.

Results: A total of 15 studies were included. The applications of AI in this field include exploring the relationship between diet and IBD, assisting in nutritional assessment, and aiding nutritional interventions. The majority of AI technologies utilized in the included studies are machine learning, with some also employing additional techniques such as natural language processing and deep neural networks.

Conclusion: AI is beneficial for exploring healthy dietary patterns for patients with IBD and providing personalized nutritional guidance. However, its application in the field of nutritional management in patients with IBD is still in its infancy. Future efforts should focus on strengthening multidisciplinary collaboration, emphasizing the integration of clinical guidelines, and assessing the effectiveness of AI applications in clinical settings to enhance the rigor and accuracy of the results.

Keywords: Inflammatory bowel disease; Artificial intelligence; Nutrition; Scoping review

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1. Materials and Methods

This scoping review was guided by the framework proposed by Arksey and O' Malley and reported according to the PRISMA extension for scoping reviews (PRISMA-ScR). The study protocol was registered on the Open Science Framework (OSF) platform (DOI: https://doi.org/10.17605/OSF.IO/6SJDQ).

1.1 Definition of Artificial Intelligence Artificial intelligence is a broad term that has not yet been uniformly defined. In this paper, AI primarily refers to theories, methods, technologies, and application systems that simulate, extend, and expand human intelligence through computer algorithms, enabling computers to perform intelligent activities such as reasoning, task execution, and autonomous response. In the medical field, machine learning, computer vision, and natural language processing are widely applied. Machine learning is mainly used for processing structured medical data, natural language processing for unstructured data such as clinical records and electronic medical records, and computer vision has unique advantages in processing image data such as medical imaging. The AI involved in this study refers to software or hardware systems designed by humans that can simulate human consciousness and thinking processes and make human-like responses and behaviors based on human-set goals and collected structured or unstructured data.

1.2 Research Questions The research questions addressed in this scoping review are: (1) What AI technologies are applied in the nutritional management of patients with IBD? (2) What are the application scenarios of AI in the nutritional management of patients with IBD? (3) How can the application of AI in the nutritional management of patients with IBD be evaluated?

1.3 Search Strategy We systematically searched PubMed, Web of Science, Embase, Cochrane Library, CINAHL, IEEE Xplore, Association for Computing Machinery Digital Library, SinoMed, CNKI, Wanfang Data, and VIP for studies on the application of AI in the nutritional management of patients with IBD, with the search period from database inception to March 2024. The Chinese search strategy for Wanfang Data is provided as an example: (Inflammatory bowel disease OR Inflammatory intestinal disease OR Ulcerative colitis OR Crohn's disease) AND (Food OR Nutrition OR Recipe OR Diet OR Dish) AND (Artificial intelligence OR Machine intelligence OR Data mining OR Fuzzy algorithm OR Neural network OR Bayesian network OR Text mining OR Fuzzy logic OR Knowledge representation OR Machine learning OR Deep learning OR Natural language processing OR Random forest OR Support vector machine OR Algorithm). The English search strategy for PubMed is shown in Table 1 .

1.4 Inclusion and Exclusion Criteria Based on the PCC principle (participants, concept, context), the inclusion criteria were: (1) study participants included patients diagnosed with IBD; (2) study content involved the application of AI in dietary management for IBD patients; (3) studies included algorithm or model construction, usability evaluation, or application research. Exclusion criteria were: (1) review articles; (2) conference abstracts without full text; (3) non-Chinese or non-English literature.

1.5 Literature Screening, Data Extraction, and Bias Risk Assessment After importing records into NoteExpress to remove duplicates, two trained investigators independently screened titles and abstracts for initial selection, then reviewed full texts for final inclusion. Any disagreements were resolved through discussion with a third investigator. Data extraction from included studies covered first author, publication year, country and ethical considerations, data sources, AI technologies, construction methods, application effects, study participants, sample size, evaluation methods, and technology stage.

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2. Results

2.1 Literature Screening Results A total of 2,150 records were retrieved from the databases. After deduplication, title/abstract screening, and full-text review, 15 studies were finally included [15-17, 26-37]. The literature screening process and results are shown in Figure 1 [Figure 1: see original paper].

The 15 included studies were published between 2015 and 2023. Geographically, 6 studies were from North America [16-17, 26, 30, 32], 5 from Asia [28, 31, 33-35, 37], and 4 from Europe [15, 29, 34, 36]. Study types included data analysis studies (n=3) [16, 28, 30], text analysis studies (n=3) [26, 33, 35], usability validation studies (n=3) [17, 31, 37], model construction studies (n=1) [15], and algorithm/model construction and validation studies (n=4) [29, 32, 34, 36]. Most studies (13/15, 86.7%) used a single AI method (non-hybrid), while

the remaining 2/15 (13.3%) used hybrid AI methods. The most commonly used method was machine learning (9/15, 60.0%). The basic characteristics of included studies are shown in Table 2 and Table 3 .

2.3.1 Exploring the Relationship Between Diet and Disease Five studies [16, 27-28, 30-31] used AI technologies to explore the relationship between diet and disease. Machine learning algorithms such as random forest, Bayesian networks, and K-means clustering were used to analyze complex clinical and dietary nutrition data. Pan et al. [28] used random forest algorithm and logistic regression to explore the clinical characteristics of L4-type Crohn' s disease and their correlation with nutritional status in 869 diagnosed CD patients, finding that L4-type CD patients often had higher body weight and BMI, elevated serum albumin, and low serum iron at diagnosis. Jones et al. [27] used fecal sample detection data and clinical data from 132 CD children receiving exclusive enteral nutrition (EEN) to construct a random forest model for predicting whether children receiving EEN would achieve sustained remission, with an AUC of 0.9, indicating good predictive performance.

Kaplan et al. [16] conducted a series of N-of-1 trials comparing the effects of the specific carbohydrate diet (SCD), modified SCD, and normal diet on improving inflammatory status, using Bayesian generalized linear model (GLM) and generalized linear mixed model (GLMM) to analyze individual-level PRO data and aggregated results to obtain average treatment effects and smooth estimates. They found that SCD and modified SCD had anti-inflammatory effects but with significant individual variation. Limketkai et al. [30] used K-means clustering to classify foods consumed by IBD patients, identifying five common dietary patterns, and further analysis found that increased intake of water, vegetables, and fruits and decreased intake of meat and sweets were beneficial for reducing inflammation risk. He et al. [31] used AI programs to analyze literature on dietary therapy and found that research hotspots in this field focused on finding beneficial dietary patterns for IBD and their relationship with gut microbiota, with fatty acids and gut microbiota being research hotspots.

2.3.2 Assisting Nutritional Assessment AI applications in nutritional assessment for IBD patients can be broadly divided into two categories: analyzing patients' attitudes toward nutrition and assessing patients' nutritional status and providing feedback. Three studies used natural language processing and Latent Dirichlet Allocation (LDA) to conduct thematic analysis of posts published by IBD patients on public forums [26, 33, 35]. Rubin et al. [26] collected posts from 6 UC forums, used AI text analysis software and NLP software to screen posts related to relapse and conduct text analysis, finding that emotion and diet were the most frequently mentioned relapse triggers among UC patients. Sun et al. [35] collected posts and replies from the "Crohn' s Disease Bar" (a Chinese online forum), used LDA model combined with grounded theory for text analysis, and found that diet and nutrition were the most discussed topics. Stemmer et al. [33] found that when tweets mentioned diets that stimulate

intestinal symptoms, patients had higher negative emotions. Additionally, this study used a self-developed IBD patient screener to filter tweets posted by IBD patients on Twitter before conducting text analysis, which helped improve the reliability and accuracy of research data.

Three studies [15, 34, 36] used intelligent algorithms to accurately assess and provide feedback on dietary intake and core nutrients in IBD patients. Blajovan et al. [15] used Deep Neural Network (DNN) to construct a food image recognition model that matches food nutrition data with special nutritional requirements for gastrointestinal diseases, thereby simulating the process of dietitians calculating dietary nutritional value and providing avoidance/recommendation suggestions. Stawiski et al. [34] used machine learning methods to construct a model for predicting diet-related physical changes based on patients' nutritional intake. After preliminary application in 4 IBD/IBS patients, the 95% confidence interval of predicted values could include actual values, showing good prediction effect. Broekstra et al. [36] constructed a learning algorithm that could compare patients' dietary records with Dutch dietary guidelines and generate personalized feedback and dietary adjustment suggestions. Interview results showed that although it could improve dietary quality, there were deficiencies such as poor usability and conflicts between dietary suggestions and professional recommendations.

2.3.3 Assisting Nutritional Intervention Three studies [29, 32, 37] used AI technology to assist in monitoring dietary intake in IBD patients. Jactel et al. [32] used supervised machine learning to label 246 common symptom-triggering foods with patient clinical data, enabling prediction of 21 high-risk foods for patients after inputting clinical characteristics, to guide active IBD patients in implementing elimination diets. After validation, it showed good effects in improving symptoms, disease knowledge, and quality of life. Chen Yuping et al. [37] applied an intelligent bowel sound monitoring tool to postoperative CD patients and found that the monitoring group had shorter time to first flatus, earlier start of oral nutritional supplements (ONS), shorter postoperative hospital stay, and lower anastomotic leakage rate compared with the control group. Jatkowska et al. [29] used fecal detection data from healthy individuals following different degrees of EEN compliance to construct decision tree models for EEN compliance. After applying the two models to 30 CD children, the selected model showed good performance in distinguishing CD children on EEN from those not on EEN, which is beneficial for screening EEN treatment compliance. Samaan et al. [17] collected 88 nutrition questions from IBD patients to evaluate ChatGPT-4' s responses to these questions, finding good performance in accuracy, comprehensiveness, and reproducibility, though some answers contained errors or outdated information.

3. Discussion

3.1 AI Applications in IBD Nutritional Management Are Still in Their Infancy The 15 included studies were unevenly distributed in terms of time, region, AI application scope, and study type. AI applications in IBD dietary management started relatively late, with 86.7% published in 2023 and 2022. The United States published the most studies (5) [16-17, 26, 30, 32], followed by China (4) [28, 31, 35, 37]. The scope of AI applications focused primarily on data analysis (7 studies) [16, 26, 28, 30, 33, 35-36], followed by model construction and validation studies (3 studies) [29, 32, 34]. The included literature mainly consisted of retrospective studies and cohort studies. Research content focused on exploring diet-disease relationships and nutritional assessment, with only 5 studies [29, 32, 34, 36-37] validating the clinical application effects of AI in nutritional prediction and intervention. It is evident that with the integrated development of AI and medicine, applications of AI in IBD nutritional management are still in their infancy. However, technologies such as intelligent dietary assessment systems, food recommendation systems, and wearable devices have been widely applied in chronic non-communicable diseases such as diabetes and obesity [38-42], but are rarely used in IBD dietary management. Furthermore, AI effectiveness evaluation in the nutrition field is mainly presented through model evaluation indicators such as accuracy, specificity, positive predictive value, and negative predictive value, which may not be the best indicators for clinical applicability [43]. Therefore, future research should strengthen AI applications in IBD nutritional management and comprehensively evaluate their clinical application effects.

3.2 AI Demonstrates Powerful Advantages in Processing Nutrition-Related and Clinical Data With the rapid development of digital information technology and big data, AI has demonstrated unique advantages in IBD nutritional management through its powerful data processing capabilities. Compared with traditional statistical methods, AI can handle increasingly complex learning tasks and extract data features according to research purposes [44], making it suitable for analyzing complex relationships between diet and disease in large-sample retrospective data and follow-up data, and promoting the exploration of beneficial dietary patterns for IBD patients [16, 30-31]. Additionally, using machine learning algorithms to construct prediction models based on patients' fecal detection, gut microbiota, and blood test data shows good application prospects in helping clinical medical staff monitor IBD patients' EEN treatment compliance [27, 29] and guide patients to reasonably avoid symptom-triggering foods [32]. The commonly used nutritional assessment method for IBD patients is the dietary diary method, but its results are limited by compliance and accuracy [45]. In contrast, food image recognition systems based on deep neural networks can objectively and quickly assess food and related nutrient intake in IBD patients [15]. ChatGPT is a technology based on Large Language Models (LLMs) that can not only provide high-quality responses superior to human levels but also interact based on context, finding wide application

in the medical field [46-47]. Samaan et al. [17] validated that ChatGPT has relatively ideal accuracy and reproducibility in answering common dietary questions from IBD patients, and may assist medical staff in providing dietary nutrition education to patients and improving patients' nutrition literacy in the future.

3.3 Implications for Future Research AI applications in IBD nutritional management are limited and still in their infancy. Most studies are in the design, development, and construction stages, with insufficient research on actual clinical application effects. Future research can be explored in depth from the following aspects: (1) **Strengthen interdisciplinary integration between AI and IBD nutritional management:** Most existing studies in this field use machine learning, while applications of natural language processing, computer vision, and other AI technologies are relatively limited. Future research can form interdisciplinary teams of medical, nursing, and computer science experts to jointly promote AI applications in IBD nutritional management. (2) **Improve accuracy of dietary intake assessment:** The data used in included studies were mainly from retrospective research, and issues such as data timeliness and accuracy remain to be solved. Additionally, most used patient-reported outcomes (PRO) as data sources, which are affected by assessment tools, patient cooperation, and the Hawthorne effect, making data authenticity and accuracy difficult to guarantee. Data is the cornerstone of AI, and untrue or inaccurate clinical data can greatly weaken algorithm reliability. Compared with traditional food assessment methods, food image recognition assistance systems help improve food assessment accuracy; however, their application in IBD nutritional management is limited, and future research should strengthen their application in the IBD field. (3) **Establish food recommendation systems for IBD patients:** The roles of elimination diets, FODMAP diets, and SCD in IBD patient nutritional management have been confirmed by numerous studies. Future research can establish food recommendation systems suitable for IBD patients based on existing dietary guidelines to promote IBD patient nutritional management. (4) **Emphasize ethics and privacy protection:** With the continuous development of data mining and collection technologies, the protection of patient privacy and informed consent rights faces great risks. Future research should focus on personal data privacy and security, ensuring ethical and legal use and protection of data.

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4. Conclusion

This study analyzed relevant research on AI applications in IBD patient nutritional management, summarizing the AI technologies, application methods, effects, and evaluation indicators used in this field. Overall, AI has been applied to multiple aspects of IBD patient nutritional management, showing promising results and broad application prospects. However, deficiencies remain in multidisciplinary integration, data quality assessment, and application effect

evaluation. Future research should scientifically apply AI technology to further expand its applications in this field.

Author Contributions: Li Yiting and Tu Wenjing were responsible for conceptualization, design, writing, and revision; Yin Tingting, Mei Ziqi, and Wang Meng were responsible for literature collection and organization; Zhang Sumin was responsible for feasibility analysis; Xu Guihua was responsible for quality control and review, overall responsibility, and supervision; Li Yiting was responsible for English revision; all authors confirmed the final version of the paper.

Conflict of Interest: The authors declare no conflict of interest.

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