**Review Article**

**From Data to Diet: The Impact of Artificial Intelligence on Nutritional Science**

**Abstract**

The rise of artificial intelligence (AI) is reshaping nutrition science, offering groundbreaking ways to refine how we assess diets, tailor nutrition plans, monitor food quality, and enhance public health strategies. Traditional methods—often plagued by unreliable self-reporting, generic recommendations, and slow feedback loops—are being outpaced by AI’s ability to process complex, multidimensional data. By harnessing machine learning, deep learning, and computer vision, AI integrates insights from genetics, metabolism, lifestyle, and environmental factors, unlocking precision nutrition tailored to individuals and communities alike.

This review explores AI’s expanding role in nutrition, from smart diet-recommendation systems that craft hyper-personalized meal plans with near-dietitian-level accuracy, to wearable tech and mobile apps that eliminate guesswork in food tracking. Advanced algorithms now analyze real-time biometric data and multi-omics profiles to adjust dietary advice dynamically, bridging the gap between lab research and real-world eating habits. AI also acts as a high-tech food inspector, using spectral imaging and pattern recognition to detect adulterants, optimize nutrient content, and ensure safety from farm to fork.

On a broader scale, AI empowers public health initiatives by identifying dietary trends, forecasting disease risks, and enabling data-driven interventions. Yet these innovations aren’t without hurdles: privacy concerns, "black box" algorithms, and disparities in access demand urgent attention. For AI to fulfill its potential, the field must prioritize ethical frameworks, robust validation, and inclusive design. Ultimately, this review argues that AI’s true power lies in collaboration—melding cutting-edge tech with human expertise to deliver nutrition solutions that are as equitable as they are revolutionary.

**Keywords:** Artificial Intelligence, Nutritional Science, Wearable Devices in Nutrition, and Public Health Nutrition

**Introduction:**

The realization that traditional dietary evaluation and advice techniques are not accurate enough to suit individual needs has led to a paradigm change in nutrition science in recent decades. While generic dietary recommendations do not take individual variability into account, traditional methods like food frequency questionnaires and 24-hour dietary recalls are frequently impacted by subjective inaccuracies and recall bias. The need for more individualized and accurate nutrition solutions has increased due to the global rise in chronic diet-related disorders. By facilitating the integration and analysis of complex, multidimensional data, such as genetics, metabolomics, lifestyle, and environmental factors, artificial intelligence (AI), which includes machine learning, deep learning, and natural language processing, provides transformative potential. These developments enhance efficacy and adherence by enabling highly customized nutrition therapies that dynamically adjust to individual needs.

In order to emphasize AI's crucial role in influencing the future of public health and personalized nutrition, this study examines the state of AI applications in nutrition, stressing its advantages, difficulties, and potential paths forward.

 **The New Frontier of Nutrition**

The field of nutritional science stands at a pivotal crossroads, where decades of generalized dietary advice are giving way to hyper-personalized, data-driven recommendations—all thanks to artificial intelligence (AI). No longer constrained by the limitations of traditional methods—recall bias in food diaries (24 hour recall and food frequency questionnaire), one-size-fits-all meal plans (calorie deficit, protein rich diet, etc.), or delayed intervention feedback—researchers and clinicians now leverage AI’s computational prowess to revolutionize how we understand and implement nutrition.

At the heart of this shift are machine learning (ML), deep learning (DL), and natural language processing (NLP), which collectively analyze sprawling datasets encompassing genomic profiles, metabolic biomarkers, and even socioeconomic factors (Ülker & Ayyildiz, 2021). For instance, Sharma and Gaur (2024) highlighted AI’s ability to correlate epigenetic markers with individual nutrient absorption rates, enabling diets tailored not just to a person’s weight goals but to their unique biology.

Yet for all its potential, AI’s integration into nutrition isn’t without hurdles. Ethical dilemmas—like algorithmic bias in underserved populations or the privacy risks of wearable-derived health data—loom large. This review unpacks AI’s multifaceted impact, from precision dietetics to food safety, while confronting the challenges that could make or break its role in global health.

**Diet Recommendation Systems: Precision Meets Practicality**

Static meal plans are relics in the era of AI-driven dynamic nutrition. Modern systems, such as the variational autoencoder framework proposed by Bhandari *et al*. (2025), demonstrate how AI transcends generic guidelines. Their model achieved **87% macronutrient accuracy** by synthesizing anthropometric data, taste preferences, and even budget constraints—effectively mirroring a dietitian’s expertise while scaling to millions of users.

What sets these tools apart is their adaptability. Papastratis *et al*. (2024) documented an AI system that iteratively refined its recommendations based on real-time user feedback. For example, if a diabetic patient’s glucose monitor flagged post-meal spikes, the algorithm would adjust carbohydrate distributions in subsequent meals while preserving flavor preferences—a feat impossible with manual planning.

Wearable technology amplifies this precision. Closed-loop systems, like those studied by Prasad and Raj (2025), sync continuous glucose monitors with AI analyzers to tweak meal timing and composition dynamically. Such innovations are particularly transformative for chronic conditions; Gavai and Hillegersberg (2025) reported a **30% improvement** in glycemic control among type 2 diabetics using AI-curated diets.

However, these advances hinge on data quality. Ferreira *et al*. (2025) cautioned that AI models trained on homogenous populations often fail to account for regional dietary customs—a gap that underscores the need for culturally inclusive datasets.

**Advancements in Dietary Assessment:**

**Transitioning from Traditional Recall Methods to AI-Enabled Precision**

For decades, nutrition research relied on flawed tools: food frequency questionnaires skewed by memory lapses, or 24-hour recalls warped by portion-size misestimations. AI is rewriting these standards.

Computer vision now deciphers meals with startling precision. NutriNet, a convolutional neural network (CNN) developed by Sak and Suchodolska (2021), classifies foods from images with **92% accuracy**, even distinguishing between similar dishes (e.g., quinoa vs. couscous). Kassem *et al*. (2025) expanded this with *goFOOD*, a smartphone app that pairs image recognition with nutrient databases to estimate caloric intake in real time—reducing underreporting errors by **40%** compared to pen-and-paper logs.

Passive monitoring tools are equally groundbreaking. The FRANI system (Armand *et al*., 2024) uses discreet wearable cameras to capture meals, then employs AI to log nutrients without user input. Validated in adolescents—a group notorious for erratic eating patterns—FRANI matched dietitian-analyzed recalls in accuracy while eliminating the **Hawthorne effect** (where subjects alter behavior due to observation).

Behind the scenes, AI cleans up messy data. Machine learning algorithms now flag inconsistencies in dietary surveys—like implausible calorie entries or missing micronutrient values—and either correct them using probabilistic models or prompt users for clarification (Kassem *et al*., 2025). This automation is pivotal for large-scale studies where manual data validation would be prohibitively time-consuming.

Some common AI driven tools are: NutriNet, Convolutional Neural Network (CNN), *goFOOD*, FRANI system, *THE FIT AI*, etc, .

**Personalized Nutrition:**

A new technique in nutrition research called "personalized nutrition" goes beyond general dietary guidelines to offer nutritional advice according to each person's genetic, metabolic, and lifestyle traits. The understanding that inter-individual variability has a substantial impact on how nutrients are absorbed, metabolized, and utilized—all of which have an impact on health outcomes and disease risk—lays the groundwork for personalized nutrition. For instance, genetic polymorphisms and the makeup of the gut micro biota, as shown by twin studies and large cohort analyses, are important factors in regulating dietary responses (Rouskas *et al*., 2025). In order to provide highly customized nutrition interventions, AI-powered technologies allow the integration of behavioural and environmental data with multi-omics data, such as microbiome profiles, metabolomics, and genomes (Sharma & Gaur, 2024; Ferreira *et al*., 2025).

**Decoding the “Why” Behind Dietary Responses**

Dynamic meal planning that maximizes nutrient intake for illness prevention and management is made possible by machine learning algorithms, which evaluate complicated datasets to find gene–nutrient relationships and forecast unique metabolic reactions. Platforms like THE FIT AI create meal plans that are in close accordance with the advice of professional nutritionists by combining biological data with individual preferences and lifestyle considerations. These meal plans are then tailored to work schedules, exercise objectives, and circadian rhythms (Gajalakshmi *et al*., 2025). The myth of universal dietary truths has been debunked. Twin studies reveal stark variations in how individuals metabolize identical foods, influenced by genetics, microbiome composition, and even sleep patterns (Rouskas *et al*., 2025). AI’s ability to parse these variables is ushering in true personalization.

Take gut microbiome modulation. Rouskas’ team used ML to analyze metagenomic data from 10,000 individuals, identifying specific fibers that boosted beneficial bacteria in user subgroups. Participants receiving AI-tailored diets saw a **15% greater increase** in microbial diversity than those on standard prebiotic regimens.

Genomics further refines this approach. Sharma and Gaur (2024) reviewed AI models that cross-reference single-nucleotide polymorphisms (SNPs) affecting nutrient metabolism—like the *MTHFR* gene’s impact on folate processing to design diets mitigating chronic disease risks. Meanwhile, platforms like *THE FIT AI* (Gajalakshmi *et al*., 2025) blend these biological insights with practical constraints, generating meal plans that align workouts, circadian rhythms, and even work schedules with nutritional needs.

Yet limitations persist. Solomon and Laye (2025) found that while AI chatbots excel at disseminating sports nutrition facts, they falter in addressing emotional eating or budget barriers reminders that technology complements, but doesn’t replace, human nuance.

Artificial intelligence (AI) functions as an effective instrument to overcome technical constraints and deficiencies frequently faced in traditional human-led methodologies, especially in the integration of knowledge across several scientific fields. A prominent illustration is the intersection of diet and genetics, referred to as nutrigenomics. It examines the intricate, reciprocal relationships between dietary elements and the genome—how nutrients and bioactive food substances can alter gene expression, and inversely, how individual genetic differences affect metabolic reactions to various diets. Utilizing AI's sophisticated data processing and pattern recognition abilities, researchers can examine extensive multi-omics datasets, identify new gene-nutrient interactions, and create personalized nutrition strategies customized to an individual's genetic profile.

In conclusion, AI-supported personalized nutrition uses cutting-edge computational methods to customize dietary recommendations according to a person's biological and lifestyle circumstances, increasing adherence, lowering the risk of chronic diseases, and enhancing general health (Ferreira *et al.*, 2025; Kassem *et al*., 2025).

**Food Composition and Safety:**

**The Role of Artificial Intelligence in Ensuring Nutritional Quality**

The fundamental tenets of nutrition science and public health are food composition and safety. A precise understanding of a food's nutritional makeup and the certainty that it is safe to eat have a direct influence on dietary recommendations, illness prevention, and general health results. Recently, artificial intelligence (AI) has become a game-changing technology in this field, providing improved tools for accurate food composition and safety analysis, monitoring, and verification, protecting nutritional integrity across the food supply chain.

**AI in Food Composition Analysis**

AI’s role extends beyond meal planning to ensure food quality itself. Traditional methods of food composition analysis, such as chemical assays and spectrometry, though accurate, are often time-consuming, labor-intensive, and costly. AI-powered analytical techniques are increasingly being adopted to complement and augment these methods, improving efficiency and accuracy.

Recent developments in deep learning (DL) and machine learning (ML) algorithms enable the quick interpretation of complex spectral data from techniques such as nuclear magnetic resonance (NMR), mass spectrometry, and near-infrared spectroscopy (NIRS). For instance, Magdas *et al*. (2025) showed how AI could be used to analyze oilseed meals, such sesame and groundnut meals, where AI models could accurately identify protein fractions and bioactive peptides. These results demonstrate AI's ability to help fight malnutrition by revealing the nutritional worth of underutilized food supplies. Similarly, AI-driven spectroscopy detects adulterants—like melamine in milk or starch in spices—with **95% sensitivity** (Canatan *et al*., 2025), a boon for food regulators.

Supply chains also benefit. Shehzad *et al*. (2025) deployed hyperspectral imaging AI to grade fruit ripeness and predict shelf-life, reducing supermarket waste by **22%**. Meanwhile, blockchain-integrated sensors track contamination outbreaks in real time, slashing response times during food borne illness incidents (Almoselhy & Usmani, 2024).

**Ensuring Food Authenticity and Detecting Adulteration**

Mislabeling and food adulteration seriously jeopardize consumer health and erode trust in food systems. By identifying patterns and anomalies in chemical and spectral data, AI-based techniques have demonstrated impressive performance in identifying food fraud. According to Canatan et al. (2025), supervised machine learning models were used to identify adulterants in meat and dairy products. AI algorithms were highly successful in differentiating between genuine and tainted items.

In complicated datasets with few labeled samples, unsupervised learning techniques like clustering and anomaly detection allow the identification of odd patterns suggestive of fraud or contamination. Food safety standards are raised when artificial intelligence (AI) is included into food authentication systems to enable real-time monitoring and regulatory compliance.

**AI Tools**

The technological backbone of AI applications in nutrition consists of machine learning models, deep learning architectures, mobile applications, and wearable devices. Machine learning enables pattern recognition in complex nutritional datasets, while deep learning, particularly convolutional neural networks, excels in image-based dietary assessment and food classification (Armand *et al*., 2025; Nelson *et al*., 2025).

Mobile AI applications, such as *goFOOD* and *FRANI*, facilitate user-friendly dietary monitoring and feedback, increasing engagement and adherence (Phalle & Gokhale, 2025). Wearable devices equipped with AI algorithms continuously track physiological parameters and dietary intake, providing actionable data for personalized nutrition plans (Lyroi *et al*., 2025; Prasad & Raj, 2025).

Natural language processing (NLP) enhances user interaction with AI through chatbots and virtual assistants; although current limitations exist in replacing dietitians’ nuanced expertise (Solomon & Laye, 2025). Nevertheless, AI tools are rapidly evolving, with potential to integrate multi-modal data streams and offer comprehensive nutrition guidance.

**Challenges and future perspective:**

The broad use of AI in food composition and safety studies is still fraught with difficulties, notwithstanding these encouraging developments. Model creation and validation are hampered by problems such data heterogeneity, the scarcity of labeled training data, and the requirement for standardized methodologies. Furthermore, for regulatory approval and real-world use, complicated AI models must be interpretable.

Creating explainable AI frameworks that offer transparent decision-making procedures should be the main goal of future research. Robustness and accuracy will be improved by combining AI with multi-modal data, including spectral, imaging, biochemical, and environmental data. Furthermore, to create verified AI-driven processes that adhere to safety regulations worldwide, cooperation amongst fields such as food science, nutrition, data science, and regulatory agencies is crucial.

New technologies have the potential to completely transform food quality assurance, including real-time monitoring systems, sophisticated sensor arrays, and AI-powered robotics for food inspection. AI combined with cutting-edge technologies like block chain and the Internet of Things (IoT) will produce robust food systems that can proactively address contamination and quality problems.

**AI-Based Mobile Applications and Wearables**

Mobile health (mHealth) technologies augmented with AI are transforming dietary monitoring and nutrition education by leveraging smartphone cameras, motion sensors, and wearable devices. Phalle and Gokhale (2025) described how image-based dietary assessment tools utilize smartphone cameras to capture food intake and apply convolutional neural networks to classify foods and estimate nutrient content in real time. These applications enable users to log meals effortlessly, reduce reliance on memory, and improve dietary self-monitoring accuracy.

Wearable sensors integrated with AI track physiological signals such as heart rate, glucose levels, and activity patterns, facilitating dynamic nutrition recommendations. Lyroi *et al*. (2025) reported that AI-powered wearables can provide continuous feedback, alerting users to dietary imbalances and prompting behavior modifications. Similarly, Prasad and Raj (2025) demonstrated that integration of wearable device data with AI algorithms enhances personalized diet planning, especially in managing metabolic diseases like diabetes and obesity.

Chatbots and virtual assistants such as ChatGPT have been evaluated for their capacity to deliver sports nutrition knowledge; however, Solomon and Laye (2025) caution that while useful for information dissemination, these AI tools cannot substitute the personalized, empathetic counseling provided by professional dietitians.

**Positive Aspects of AI in Nutrition**

AI offers several advantages in nutrition science and practice. Abdallah *et al*. (2024) noted that AI-driven dietary assessments minimize human errors and biases inherent in self-reported data, improving data quality for research and clinical decision-making. Personalized AI nutrition interventions account for individual metabolic variability, genetics, and lifestyle, enhancing efficacy in disease prevention and management (Detaskevi *et al*., 2023; Ferreira *et al*., 2025).

In food production and safety, AI optimizes quality control, reduces contamination risks, and facilitates rapid identification of adulterants, thereby safeguarding consumer health (Almoselhy & Usmani, 2024; Savas *et al*., 2024). AI’s ability to process large-scale data efficiently supports the development of customized food products that meet specific health needs, potentially transforming food systems globally (Shehzad *et al*., 2025).

**Future Directions of AI in Nutrition**

Despite promising advances, AI applications in nutrition are still evolving and face several challenges. Detaskevi *et al*. (2023) emphasize the need for rigorous validation studies to assess AI models’ accuracy and cost-effectiveness in diverse populations. Incorporating genetic data and other omics technologies into AI frameworks is anticipated to refine personalized nutrition further (Prasad & Raj, 2025; Kassem *et al*., 2025).

Technological innovations, including AI robotics, blockchain integration in food supply chains, and 3D food printing, are expected to revolutionize the food industry and nutritional interventions (Shehzad *et al*., 2025). Addressing ethical concerns, ensuring data privacy, and promoting equitable access remain critical to maximizing AI’s benefits in nutrition (Wah, 2025).

Interdisciplinary collaboration between nutritionists, computer scientists, ethicists, and policymakers will be essential to develop robust, culturally sensitive, and accessible AI nutrition solutions tailored to global needs (Abdallah *et al*., 2024).

**Limitations of AI in Replacing Human Expertise:**

The rapid advancement of AI in healthcare raises the question of whether AI can replace trained dietitians. While AI excels at processing large datasets and providing evidence-based recommendations rapidly, it currently lacks the ability to fully replicate the nuanced understanding, empathy, and cultural competence that human dietitians bring to patient care. Guner and Ulker (2024) evaluated AI chatbots such as ChatGPT and concluded that although these tools can offer theoretical nutrition knowledge and support decision-making, they do not yet possess the capability to account for individual psychosocial factors and behavioral motivators essential in effective nutrition counseling.

Solomon and Laye (2025) similarly underscored the limitations of large language models in sports nutrition advice, highlighting that AI tools cannot substitute for personalized guidance tailored to individual goals, preferences, and responses. Moreover, AI systems are limited by the quality and representativeness of their training data, which can introduce biases and reduce applicability across diverse populations (Stoian *et al*., 2025). Therefore, AI is best positioned as a powerful adjunct to, rather than a replacement for, professional dietitians, enhancing their capabilities and efficiency in delivering personalized care.

**The Road Ahead: Challenges and Collaborative Potential**

AI won’t supplant dietitians—but it will redefine their toolkit. As Güner and Ülker (2024) noted, while ChatGPT can explain ketosis, it can’t yet navigate a patient’s cultural aversion to fatty meats or budget-driven fast-food reliance. The future lies in synergy: AI handling data-crunching, while clinicians focus on empathy and education.

To realize this, the field must address:

1. **Bias Mitigation**: Diversifying training datasets to serve global populations.
2. **Transparency**: Demystifying “black box” algorithms for clinician trust.
3. **Accessibility**: Lowering costs to prevent AI from widening health disparities.

**Limitations of AI in Nutrition: Data Bias, Privacy Concerns, and Ethical Dilemmas**

Artificial intelligence (AI) has the potential to revolutionize the field of nutrition, but its full potential is hampered by a number of significant issues. Data bias is one of the biggest problems, which occurs when AI models are trained on datasets that aren't diverse or don't accurately reflect the range of people. These biases can result in unfair recommendations and erroneous forecasts, especially for minority or under-represented groups. According to Ferreira *et al*. (2025), AI models that are primarily trained on homogenous cohorts frequently fall short in accounting for genetic variability and regional food preferences, which could lead to the continuation of health disparities. To guarantee the generalization and equity of AI-driven nutritional interventions, Stoian *et al*. (2025) again underlined the need for diverse, high-quality datasets.

Since AI systems usually rely on ongoing data collection from wearable technology, mobile apps, and genomic analyses all of which entail sensitive personal health information—privacy concerns represent yet another important barrier. Almoselhy and Usmani (2024) raised ethical concerns regarding permission, data ownership, and the possible exploitation of health data in their discussion of AI platforms' susceptibility to data breaches and unauthorized access. These risks are increased when AI is integrated with Internet of Things (IoT) devices, making strong cyber security safeguards and regulatory frameworks necessary to protect user data and uphold confidence.

Beyond privacy concerns, the ethical issues in AI nutrition also involve questions of accountability and transparency. Clinical acceptability and patient trust are hampered by the fact that many AI algorithms operate as "black boxes," generating results without providing explicit justifications for the underlying decision-making process (Detopoulou *et al*., 2023). Furthermore, when socioeconomic and cultural aspects are not appropriately taken into account, biases ingrained in AI may unintentionally perpetuate social inequality (Guner & Ulker, 2024). These issues highlight how crucial it is to create ethical standards and explainable AI models that guarantee fair, culturally aware, and open nutrition care.

To overcome these constraints, data scientists, dietitians, ethicists, and legislators must work together across disciplinary boundaries to develop AI systems that are not only precise and effective but also moral, safe, and inclusive (Kassem *et al*., 2025). AI can only realize its potential to improve global nutrition and health without sacrificing individual liberties or social norms through such all encompassing initiatives.

**Conclusion**

Unquestionably, artificial intelligence is changing the field of nutrition science by providing previously unheard-of levels of scalability, personalization, and precision in dietary assessment, recommendation, and public health initiatives. With this change, traditional, generalized dietary recommendations are giving way to dynamic, data-driven therapies that take into account each person's particular genetic composition, metabolic profile, lifestyle choices, and environmental effects. A degree of individualized nutrition treatment that was previously impossible with conventional techniques is made possible by AI's capacity to combine enormous, diverse datasets and continuously adjust to real-time feedback.

The application of AI in nutrition is fraught with difficulties, despite its revolutionary potential. The intricacies of human biology, behavior, and culture necessitate more than computational forecasts; they call for contextual knowledge, ethical stewardship, and sympathetic comprehension qualities that are fully within the domain of qualified human dietitians. Despite their strength in data processing and pattern identification, current AI technologies are constrained by their dependence on the inclusiveness, representativeness, and quality of training data. This limitation emphasizes how important it is to eliminate algorithmic bias in order to guarantee that AI-driven nutrition solutions are fair and efficient for a variety of global populations.

Additionally, the ethical issues of permission, openness, and data protection are crucial. Building strong governance frameworks that safeguard individual rights without limiting innovation is crucial as AI systems depend more and more on private health and lifestyle data, which is frequently gathered through wearable technology and mobile applications. Building trust between users and physicians through the creation of explainable AI models that offer understandable insights as opposed to mysterious "black box" outputs is equally crucial.

Looking ahead, cooperative interdisciplinary studies that connect computer science, nutrition, behavioral science, ethics, and policy-making are critical to the future of AI in nutrition. These collaborations can spur the creation of validated, accessible, and culturally aware AI solutions that are suited to the demands of global health. Food safety, quality, and individualized care will be further improved by innovations like block chain for supply chain transparency, AI-powered robotics, and real-time monitoring.

In the end, AI should be seen as a potent supplement to human knowledge, enhancing rather than replacing the skills of dietitians and other medical professionals. AI frees up doctors to concentrate on the human aspects of care—empathy, motivation, and tailored guidance that are still crucial for long-lasting behavioral change and health improvement by automating routine data processing and facilitating more accurate treatments.

To sum up, the ethical application of AI in nutrition has the potential to completely transform the way we manage and prevent diet-related illnesses, optimize food systems, and advance health equity around the world.

**Disclaimer (Artificial intelligence)**

Author(s) hereby declare that no generative AI technologies such as Large Language Models and text-to-image generators have been used during the writing of this manuscript.

**COMPETING INTERESTS DISCLAIMER:**

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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