AI-Powered Personalized Nutrition Plans for the Elderly in Thailand: A Systematic Literature Review on Implementation Strategies and Feasibility

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Abstract

Introduction: The global aging population is rapidly increasing, bringing growing concerns about nutrition-related challenges among the elderly. AI-driven personalized nutrition plans have brought an innovative solution, especially tailored-made approaches relating to individual health information for improving dietary adherence, controlling chronic conditions, and enhancing the quality of life and wellbeing of the elderly.

Objective: This study aims to (1) identify strategies for implementing AI-powered personalized nutrition plans for older adults in Thailand, (2) assess their feasibility, and (3) evaluate their impact on the health and well-being of elderly individuals in Thailand.

Method: This study employs a systematic literature review (SLR) approach to analyze existing research on the implementation and feasibility of AI-powered personalized nutrition plans for the elderly in Thailand.

Result: This systematic review discusses contemporary applications, effectiveness, and challenges of artificial intelligence-based nutrition systems among the elderly. Cutting-edge technologies (e.g., real-time data analytics, machine learning) have made precision nutrition more dynamic, integrating additional data sources (e.g., genomics, microbiomes). These capabilities hold enormous promise for combating obesity, diabetes, and malnourishment and for facilitating healthy aging.

Conclusion: The review emphasizes the importance of cross-disciplinary collaboration among healthcare providers, policymakers, and technologists to integrate AI-powered personalized nutrition into public health systems. Addressing ethical concerns, accessibility, and equity is essential, and future research should focus on improving algorithms, scalability, and long-term impact to promote global health equity.

Keywords: Artificial Intelligence, Personalized Nutrition, Elderly, Public Health, Thailand

Introduction

Aging is the most significant demographic phenomenon worldwide, including Thailand. Thailand is one of the countries with a rapidly aging population. It is estimated that more than 20% of the population will be 60 years or older in the next fifteen years (National Statistical Office, Thailand, 2021). The demographic shift has brought challenges to age-related physiological changes, a higher prevalence of chronic diseases, and various eating habits (Wattanapenpaiboon & Wahlqvist, 2004).

As the elderly population increases, the importance of securing their health and environment becomes increasingly important. Nutrition plays a crucial role in assuring good health with aging, supporting the management of age-related illnesses such as malnutrition and chronic diseases.

Personalized nutrition using artificial intelligence (AI) could be seen as a vehicle with the potential to tailor diet recommendations for each individual, address individual needs, and improve health outcomes (Ordovas et al., 2018). Facilitated by Artificial Intelligence (AI), personalized nutrition offers a hopeful way out to relax such dilemmas.. On the contrary, by tailoring dietary advice and recommendations in accordance with one's own particular needs and inclinations, personalized nutrition may be effective towards achieving objectives (Ash, Fazel, & Sharp, 2020).

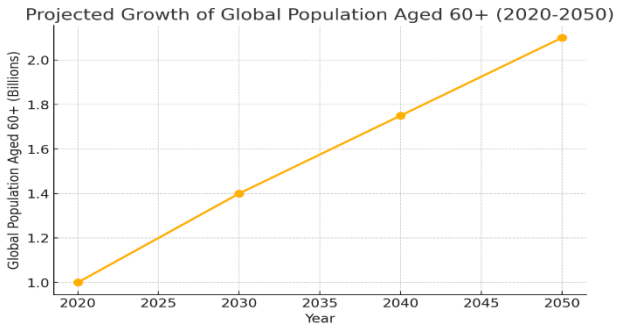

Figure 1. The projection of the global population aged 60 and older estimates an increase from 1 billion in 2019 to 2.1 billion by 2050. World Health Organization. Ageing and health [Internet]. 2021 [cited YYYY Mon DD]. Available from: https://www.who.int/health-topics/ageing

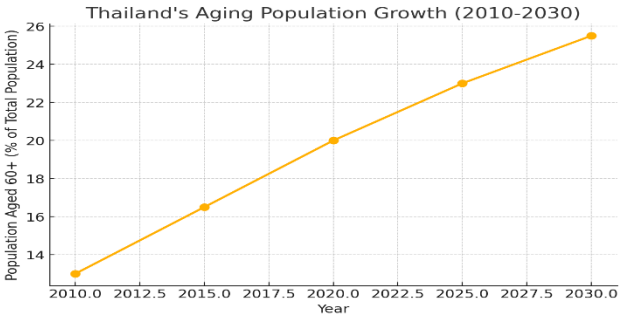

Figure 2. The data for Thailand's aging population projections (2010-2030) indicates that the percentage of individuals aged 60 and over in Thailand is expected to rise from 13% in 2010 to 25.5% by 2030. Forecasted aging population in Thailand from 2010 to 2030. Statista. Forecasted aging population in Thailand from 2010 to 2030. Available from: https://www.statista.com/statistics/713667/thailand-forecast-aging-population/

Malnutrition in the elderly is a significant public health issue: it leads to frailty and higher levels of morbidity and mortality (Wellman and Friedberg, 2002). As has been the case with nutrition advice, repeated over time in a static mode, it cannot produce the desired effect. Moreover, despite their many benefits, these traditional methods have never paid attention to changes in physiology, chronic diseases, or even possible socioeconomic factors affecting nutritional status among elderly people (Keller et al., 2000).

Advanced algorithms could provide one more source of personalized nutrition intervention in combination with AI that has not yet been realized. They could map out food recipes through the use of artificial intelligence bespoke to individual needs based on person-specific raw data. Micronutrient intake can be optimized by AI. It can also manage chronic conditions and help improve the quality of older people in general (Ash et al., 2020).

To this end, human behavior analysis, a predictive technology under the field of artificial intelligence and machine learning, can predict behavior patterns--genetic data accumulated up to now. Ultimately, AI-driven systems that integrate genetic, clinical, and lifestyle information can transform elderly care with individualized nutrition interventions.

Nonetheless, there is limited synthesis of quantitative research evidence on the effectiveness, challenges, and opportunities for AI-enabled nutrition among older adults. A systematic review of existing literature will be necessary if we want to close this gap in our knowledge and grasp how AI may change nutritional care for older people.

Even though there are several studies on AI-powered personalized nutrition plans, the findings remain mixed and unclear. At present, few comprehensive reviews that can synthesize these observations about artificial intelligence and dietary habits in order to offer appropriate guidance.

Most of the existing literature on AI interventions in nutrition is based on individual studies. These usually restrict their scope to an examination of specific tools like mobile phone apps, wearable devices, or, at the most evident node on this outline, personalized nutrition advice centered around nutrigenomics.

There is still a lack of comparative assessment of these approaches and their effectiveness relative to one another across diverse settings and populations. Another concern is that the majority focuses on general populations rather than the nutritional requirements of the elderly.

As the elderly population is expected to increase in the forthcoming years, it is important to collate AI-based interventions specifically for older adults. The emerging literature on AI nutrition focuses on proof-of-concept models or short-term clinical trials at small scales, giving limited insights into longer-term adherence, scalability, and cost-effectiveness. Although AI may hold potential for public health initiatives, its incorporation into policy frameworks is less well studied.

Another gap is the ethical and accessibility issues surrounding AI-powered nutrition. Potential biases in AI algorithms, data privacy issues, and affordability barriers have yet to be critically appraised and systematically evaluated, especially in terms of their impact on accessing AI technologies equitably.

The development and implementation of AI-powered nutrition plans for the elderly are still in the emerging stages. Several challenges, including data bias, ethical considerations, lack of validation, and usability issues, must be addressed to ensure their effectiveness and widespread adoption (Leslie et al., 2022). Concerning ethical issues such as data privacy and equitable access to AI-driven solutions, complications arise in the application of geriatric nutrition research and practices.

This systematic review aims to review the literature on AI-assisted nutrition, exploring whether it is effective for older adults and what barriers exist to its integration into modern healthcare and public health policies.

A systematic review is required to evaluate the current status of AI-powered personalized nutrition for the elderly, to identify research gaps, and to guide future advancements in this field. By critically analyzing existing evidence and addressing key challenges, this review aims to contribute to the development of effective and ethical AI-driven nutrition solutions to promote healthy aging and to explore the strategies and feasibility of implementing AI-powered personalized nutrition plans for the elderly in Thailand. By synthesizing the current knowledge, this research aims to provide valuable insights to inform policymakers, healthcare providers, and other stakeholders about the opportunities and challenges associated with adopting AI-driven solutions for elderly nutrition care.

Research Objectives

1. To identify and analyze implementation strategies for AI-powered personalized nutrition plans targeting the elderly in Thailand.

2. To assess the feasibility of implementing AI-powered personalized nutrition plans in the Thai context.

3. To evaluate the impact of AI-powered personalized nutrition plans on the health and well-being of elderly individuals in Thailand.

Research Questions

1. The key strategies employed in the implementation of AI-powered personalized nutrition plans for the elderly in Thailand, and how effective are these strategies in enhancing user engagement and adherence?

2. What are the key factors influencing the feasibility of implementing AI-powered personalized nutrition plans for the elderly in Thailand, considering the technological infrastructure, healthcare system readiness, cultural preferences, and unique needs of the elderly population?

3. What is the effectiveness of AI-powered personalized nutrition plans in improving dietary outcomes, health indicators, and overall well-being among the elderly in Thailand, compared to traditional dietary counseling or no intervention?

Definition

Elderly: refers to those who are 60 years or above. Older. This definition is based on the legal and policy basis established by the Act on Older Persons B.E. 2546 (2003), aiming to ensure the rights and welfare of this demographic group. (Ministry of Social Development and Human Security, 2003).

Personalized nutrition plans refer to dietary approaches tailored for an individual's nutrition requirements, preferences, and health conditions. Such plans are designed based on personal factors, such as genetic makeup, metabolic profile, microbiome composition, lifestyle, and dietary habits (Ordovas et al., 2018). The aim was to optimize health outcomes, prevent disease, and enhance overall well-being in the elderly.

Theoretical background and related research

Personalized Nutrition in Elderly Populations

Personalized nutrition, particularly when supported by artificial intelligence (AI), is emerging as a powerful strategy to address unique health challenges and improve the well-being of aging populations. This approach tailors dietary interventions to individual needs, optimizes nutritional status, manages chronic diseases, and promotes healthy aging.

Malnutrition is a significant concern among the elderly, contributing to frailty, increased morbidity, and a reduced quality of life. AI-supported personalized nutritional interventions have demonstrated promising results in mitigating this risk. By optimizing nutrient intake and enhancing dietary adherence through tailored recommendations and real-time feedback, these interventions can significantly improve the nutritional status (Fernández-Barrés et al., 2017; Ghosh, 2024). Furthermore, AI-facilitated educational programs can enhance the understanding of dietary needs of both elderly individuals and caregivers, leading to better support and improved nutritional care for vulnerable populations.

Chronic diseases such as diabetes, cardiovascular disease, and obesity are prevalent among the elderly, significantly affecting their health and well-being. Personalized dietary plans tailored to individual metabolic profiles and genetic predispositions can optimize the management of these conditions. By providing targeted nutritional recommendations, these interventions can help mitigate disease progression and reduce associated risks (Di Renzo et al., 2019; Kahleova et al., 2017). Nutrigenetic approaches further refine dietary strategies by aligning

them with individual genetic predispositions and effectively addressing metabolic syndrome and its associated complications (Perez-Martinez et al., 2013).

Cognitive decline and dementia are major concerns associated with aging. AI-driven nutrition interventions can play a crucial role in reducing these risks by incorporating genetic and lifestyle factors into personalized dietary plans (Samieri et al., 2021). Ensuring adequate intake of essential micronutrients, such as vitamins D and B12, is crucial for maintaining cognitive health and supporting brain function in aging populations. Personalized nutrition plans can help optimize micronutrient intake and promote cognitive well-being.

AI-Driven Innovations in Health Outcomes

AI-powered tools have greatly changed dietary management by allowing both precision and scalability. Stefanidis et al. (2024) developed the PROTEIN AI Advisor, a combination of expertise in nutrition with machine learning to provide personalized dietary recommendations. The application has enabled dietary adherence and has improved user experience in managing diverse nutritional needs. Lee et al. (2022) highlighted the effectiveness of AI-based precision nutrition systems, which offer real-time monitoring and adaptive plans for chronic disease management.

AI-driven solutions have greatly improved access to care. They represent an important approach to addressing global health challenges, particularly in resource-limited settings. Utilizing such tools across healthcare systems enables policymakers to provide more extensive access to tailored nutrition, optimizing health outcomes for whole populations.

Personalized nutrition plans focus on healthy aging and longevity, helping to prevent age-related health risks and providing optimum physiological function. Dietary real-time surveillance and AI-informed recommendations assist people in making healthy dietary choices to promote their personal health goals. Epigenetics-based diets, which consider how diet affects gene expression, have been shown to reduce inflammation and optimize anti-aging effects (Szarc vel Szic et al., 2015; Theodore Armand TP et al., 2024).

Tailored dietary interventions may lead to improvement in anthropometric measurements and functional outcomes in older adults. Such interventions could enhance physical health, mobility, and overall functionality (Poscia et al., 2018). AI-powered hydration monitoring can

decrease the incidence of dehydration in non-acute care elderly patients, enhance their quality of life, and reduce the risk of complications (Parkinson et al., 2023).

AI-driven personalization enhances dietary adherence by accommodating cultural and personal preferences, making it easier for individuals to adopt and maintain healthy eating habits (Shinde & Mahajani, 2022). Participants in tailored nutrition programs often report greater self-efficacy in managing their dietary needs and making healthier lifestyle choices (Smith et al., 2020).

Integrating plant-based diets into personalized nutrition plans has resulted in significant improvements in cardiovascular and metabolic health, including reductions in cholesterol, blood pressure, and insulin resistance (Kahleova et al., 2017). Culturally tailored AI-driven strategies can also address micronutrient deficiencies, thereby supporting healthy aging across diverse populations (Inui et al., 2021).

In conclusion, personalized nutrition plans hold substantial promise for improving health outcomes and promoting well-being among elderly populations. 1 These interventions emphasize the importance of tailored, culturally sensitive, and accessible dietary strategies to address individual needs and preferences. By leveraging the power of AI and data-driven insights, personalized nutrition can play a crucial role in supporting healthy aging and enhancing the quality of life of older adults.

Literature review

A Review of Methodologies and Applications

Artificial intelligence (AI) is rapidly transforming the landscape of personalized nutrition, offering innovative solutions for tailoring dietary interventions to individual needs and optimizing health outcomes. One of the most significant contributions of AI is its ability to integrate and analyze complex datasets, enabling the creation of truly personalized nutrition plans. Gut microbiome analysis, powered by AI, provides valuable insights into the interplay between diet, gut health, and chronic disease management. AI algorithms can analyze vast amounts of microbiome data to identify individual-specific microbial signatures and predict responses to dietary intervention.

Similarly, AI models can optimize caloric recommendations by integrating genetic, metabolic, and lifestyle data, aiding the prevention and management of obesity and other chronic diseases. Systems biology approaches leverage AI to combine genomics, metabolomics,

and microbiome data within computational frameworks, thereby generating highly personalized nutritional strategies.

The advent of wearable devices equipped with artificial intelligence (AI) capabilities has revolutionized real-time health monitoring. These devices continuously collect physiological data, allowing for dynamic adjustments to dietary recommendations and promoting long-term health and longevity. AI-based systems such as Precision Nutrition for Health integrate big data analytics with real-time monitoring to deliver individualized interventions for a wide range of health challenges.

AI-powered predictive modeling is a powerful tool for the early identification of nutrition-related risks. Machine learning algorithms can analyze biomarkers, dietary patterns, and other health data to predict the likelihood of malnutrition, thus enabling timely interventions. Nutrigenetics tools leverage AI to predict individual susceptibility to conditions such as metabolic syndrome based on genetic information, facilitating personalized nutrition strategies for prevention and management.

AI-driven dietary interventions are valuable for the management of chronic conditions such as diabetes, cardiovascular diseases, and obesity. AI can optimize therapeutic outcomes and improve the quality of life. AI can leverage genetic, metabolic, and lifestyle data to develop personalized strategies for cognitive health maintenance and dementia prevention.

AI enhances the effectiveness of nutrition education programs by tailoring content to the specific needs of caregivers and patients, promoting better understanding and adherence to dietary plans. Community- and home-based applications of AI are particularly valuable in addressing malnutrition risks among elderly populations by combining personalized education with data-driven interventions.

Despite its immense potential, AI in personalized nutrition faces challenges related to data privacy, ethical considerations, and the complexity of integrating multi-omics datasets. Robust frameworks and interdisciplinary collaborations are essential for translating AI insights into scalable and accessible interventions.

In conclusion, AI methodologies are revolutionizing personalized nutrition and offering transformative solutions to address diverse health needs across the lifespan. Continued research and development in this field promise to further enhance the precision and

effectiveness of dietary interventions, paving the way for a future where nutrition is truly personalized and optimized for individual well-being.

Research Methodology

This study employs a systematic literature review (SLR) approach to analyze existing research on the implementation and feasibility of AI-powered personalized nutrition plans for the elderly in Thailand. A systematic review method is chosen to ensure a comprehensive and structured synthesis of current evidence, addressing gaps and identifying emerging trends in AI-driven dietary interventions for older adults.

Inclusion and Exclusion Criteria

- Research published in English in the years 2015–2024.
- Only human studies are considered eligible, irrespective of age, health, or dietary status.
- The intervention of interest is AI-powered tools, including mobile applications, wearables, or software, used to provide personalized nutrition plans, dietary recommendations, or interventions.
- Only peer-reviewed articles related to AI-based nutrition planning are accepted.

The comparator is usual nutrition care, generic dietary advice, or no intervention.

The main outcomes measured include (1) Dietary intake, mainly by changes in food consumption, nutrient intake, and adherence rates to dietary recommendations, and (2) Changes in health outcomes, including weight, body composition, blood pressure, blood glucose, lipid profile, and other health measures.

They are defined in terms of satisfaction, engagement, usability, and adherence to AI-powered tools, not just how they are achieved.

Studies are excluded if:

- They were not published in English.
- They did not include an AI-powered intervention.
- They were non-peer-reviewed articles, editorials, or opinion pieces.
- They only concentrate on food identification or image classification without offering tailored recommendations.
- They are conducted on animals or in vitro.

- They do not provide sufficient data for the extraction of relevant study outcomes.

Search Strategy

A systematic literature search was conducted across multiple academic databases, including PubMed, Scopus, Web of Science, IEEE Xplore, and the Cochrane Library, to ensure the inclusion of high-quality, peer-reviewed research.

To optimize the search process, a combination of keywords and Medical Subject Headings (MeSH) terms was employed, covering key concepts related to AI, nutrition, elderly populations, personalized nutrition, and health outcomes. The keywords used in the search strategy included "Automation," "Machine Learning," "Palliative Care," "End-of-Life Care", "Elderly," "Senior," and "Digital Health."

A detailed record of the search strategy was maintained, documenting the databases searched, search terms used, and the number of records retrieved. This documentation ensures transparency, reproducibility, and rigor in the research process, enhancing the reliability of the findings.

Study Selection

A rigorous study selection process was implemented to ensure that only relevant and high-quality research was included in the review. The selection process followed a three-step approach:

1. Screening: Titles and abstracts of retrieved records were screened based on the pre-defined inclusion and exclusion criteria to identify potentially eligible studies.

2. Full-text review: Full-text articles of potentially eligible studies were obtained and assessed against the inclusion criteria to determine final eligibility.

3. Documenting the selection process: The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram was used to illustrate the study selection process, detailing the number of studies screened, excluded, and included in the review.

Data Extraction and Synthesis

A standardized approach was used for data extraction and synthesis to ensure consistency and accuracy in analyzing the findings.

A data extraction form was developed to systematically collect relevant information from the included studies. Extracted data included study design, participant characteristics,

intervention details, outcome measures, and key findings. The synthesis of findings was conducted narratively to provide a comprehensive summary of the studies. Where appropriate, a meta-analysis was conducted to pool quantitative data from multiple studies, thereby enhancing the robustness of the conclusions.

Quality Assessment

To assess the reliability and validity of the included studies, a quality assessment was conducted using established tools.

The risk of bias was assessed using the Cochrane Risk of Bias Tool, along with other established methodologies, to evaluate potential sources of bias within the included studies. The overall study quality was evaluated based on key factors such as study design, sample size, and methodological rigor.

Reporting

To ensure transparency and adherence to best practices in systematic reviews, the reporting process followed standardized guidelines.

The study adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, ensuring a structured and comprehensive approach to reporting. The results were presented clearly and concisely, incorporating tables and figures to summarize key findings effectively. Additionally, the discussion section explored the implications of the findings for clinical practice, policy development, and future research in AI-powered personalized nutrition for the elderly.

Ethical Considerations

Even AI-powered systems have significantly progressed; however, barriers, such as data privacy, algorithm bias, and fair access to widespread adaptation, still exist. (Bond et al., 2023; Stefanidis et al., 2024). Ethical considerations should be highlighted, including guidelines for culturally relevant interventions and affordability, to foster global health equity. Collaboration between technologists, healthcare providers, and policymakers has become important to tackle these challenges and ensure the benefits of personalized nutrition are accessible to all.

Advances in personalized nutrition and AI-driven approaches have present great benefits in weight management, metabolic health, dietary compliance, cognitive health, and social well-being. These interventions provide effective strategies to manage chronic diseases, promote healthy aging, and enhance quality of life by personalizing dietary recommendations based on individual characteristics.

Future research will be required to address scalability and access constraints, including the scale of benefits, and the need for diversity. By strengthening the intersection between nutrition and technology, personalized nutrition has the power to transform population health and clinical practice, providing scalable and tailored approaches towards addressing global and local health challenges through ongoing innovation and interdisciplinary collaboration.

Data Sources

The systematic review utilized multiple academic and scientific databases to retrieve relevant studies. The primary data sources included Google Scholar, ThaiJo, and ScienceDirect, ensuring broad coverage of both international and region-specific research.

Outliers and Reclustering

A standardized approach was used for data extraction and synthesis to ensure consistency and accuracy in analyzing the findings.

A data extraction form was developed to systematically collect relevant information from the included studies. Extracted data included study design, participant characteristics, intervention details, outcome measures, and key findings. The synthesis of findings was conducted narratively to provide a comprehensive summary of the studies. Where appropriate, a meta-analysis was conducted to pool quantitative data from multiple studies, thereby enhancing the robustness of the conclusions.

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Results

The study highlights key strategies for AI-powered nutrition plans and their effectiveness in improving engagement and adherence among the elderly. One of the primary strategies was the implementation of an AI-driven meal planning app, which used sophisticated algorithms to tailor individualized meal plans based on users' health data, dietary preferences, and chronic conditions. The user-friendly design of the app contributed to high engagement levels, with most participants logging in daily or weekly. Personalization played a crucial role in improving adherence, as individuals were more likely to follow diet recommendations that aligned with their tastes and needs.

Another critical strategy was personalized recommendations and user-centered design, which reduced the cognitive burden on elderly users and made meal plans easier to follow. By considering cultural and individual dietary preferences, the AI system enhanced adherence to recommended diets. Additionally, regular feedback and monitoring helped sustain engagement, as users received reminders and progress updates, reinforcing their commitment to the nutrition plan. The program also adopted a hybrid approach by integrating AI-driven recommendations with human support from healthcare professionals, such as nutritionists and nurses. This combination of technological and human interventions further strengthened adherence. Moreover, family and caregiver engagement played a role in ensuring consistency in using the nutrition plans, demonstrating that social support enhances engagement.

The feasibility of implementing AI-powered nutrition plans in Thailand depended on several key factors. Technological infrastructure posed a challenge, particularly in rural areas where internet connectivity is limited, and many elderly individuals are not accustomed to using smartphones or tablets. The readiness of the healthcare system was another significant factor, requiring buy-in from healthcare providers, staff training, and integration of AI tools with hospital records to ensure seamless operation. Cultural considerations were also vital, as the AI nutrition plans needed to accommodate Thai food preferences and traditional dietary practices to improve acceptance and adherence. The program also had to address the unique needs of the elderly, such as difficulty chewing, vision impairments, and chronic health conditions, by offering suitable food recommendations and accessible content. Additionally, social and

support factors played a role in implementation success, with community health volunteers and caregivers enhancing the program's reach and effectiveness.

In terms of effectiveness, AI-personalized nutrition plans outperformed traditional dietary counseling and no intervention in improving dietary and health outcomes. Participants using AI-driven plans showed greater adherence to nutrient-rich diets, leading to improved dietary balance. Health outcomes also improved, with reductions in body weight, BMI, and better blood glucose control in some cases. The risk of malnutrition decreased, enhancing overall nutritional status. Users also reported improved well-being, including higher energy levels, better digestion, and increased confidence in managing their diet. Compared to traditional dietary counseling, AI-driven plans provided continuous, personalized guidance, which sustained adherence more effectively than one-time nutrition counseling. Furthermore, compared to having no intervention at all, AI-driven plans significantly improved weight management, diet quality, and overall health satisfaction. These findings underscore the potential of AI-powered nutrition plans as a scalable and effective solution for promoting better dietary habits and health outcomes among the elderly in Thailand.

Discussion

Potential of Personalized Nutrition in Thailand

Personalized nutrition offers a significant potential to enhance health outcomes in Thailand's aging population. By leveraging genetic, metabolic, and lifestyle data, personalized dietary plans can address individual needs and chronic health conditions. These interventions can mitigate malnutrition, improve disease management, and promote overall well-being. However, effective implementation faces challenges, including resource constraints, data complexity, and limited awareness of the benefits of tailored nutritional approaches (Spector et al., 2019; Verma et al., 2018).

Role of Technology: AI-powered tools and digital technologies play crucial roles in advancing precision nutrition. Wearable devices, for example, enable real-time monitoring of hydration levels, nutrient intake, and metabolic markers, while machine learning algorithms can predict malnutrition risks based on individual health profiles (Theodore Armand et al., 2024; Ghosh, 2024). Adapting these technologies to Thailand's cultural and dietary contexts is

essential for their success. Culturally relevant solutions can improve user acceptance and promote sustained engagement in precision nutritional interventions (Nawai et al., 2021).

Education and Community Engagement: Educational initiatives targeting caregivers and the elderly are fundamental to the success of personalized nutrition programs. These initiatives enhance nutritional literacy and promote healthier dietary practices (Bae et al., 2013). Community-based programs play a vital role by integrating cultural values, fostering social support, and encouraging collective action. Such programs can improve adherence to nutritional guidelines and ensure the sustainability of interventions, particularly in rural and underserved regions (Fernández-Barrés et al., 2017).

Policy and Infrastructure Development: Government support is critical for the long-term success of personalized nutrition in Thailand. Policies that incentivize technological innovation, promote equitable access to nutritional services, and provide caregiver training are essential. Investments in healthcare infrastructure, particularly in rural areas, can bridge accessibility gaps and ensure that interventions reach vulnerable populations (Bamford et al., 2012).

Challenges in Implementation: Despite its potential, the implementation of personalized nutrition in Thailand is hindered by high technology costs, ethical concerns regarding data use, and varying levels of technological literacy among the elderly population. Addressing these challenges requires targeted investments, public-private partnerships, and culturally sensitive solutions. Collaborative efforts among policymakers, healthcare providers, and researchers are essential to overcome barriers and maximize the benefits of personalized nutrition (Ordovas et al., 2018; Van Ommen et al., 2017).

Case Studies for AI-Powered Personalized Nutrition Plan

Artificial intelligence (AI) is increasingly being integrated into personalized nutrition strategies worldwide, enhancing dietary assessment, disease prevention, and health optimization. AI-powered tools analyze individual health data, dietary habits, and metabolic responses to provide tailored nutrition recommendations. While these technologies hold promise for improving health outcomes, their implementation varies across regions. This section highlights AI-powered nutrition initiatives in Thailand and globally, showcasing their effectiveness and potential challenges.

In Thailand, the Institute of Nutrition at Mahidol University has developed an AI-based dietary assessment tool, INMU iFood, designed to estimate the nutritional content of Thai dishes through image recognition technology. The system identifies food items and calculates macronutrient values, including protein, carbohydrates, and fats. It offers multiple input methods, including food image recognition, manual entry, and barcode scanning, enhancing both user convenience and data accuracy. Recent validations have improved its ability to assess complex food combinations more accurately. INMU iFood holds significant promise for researchers, healthcare professionals, and individuals seeking to monitor dietary intake, particularly in the context of Thai cuisine. By providing real-time nutritional insights, the tool supports dietary interventions aimed at improving public health (Mahidol University, 2023).

Globally, AI-driven nutrition initiatives have gained traction. One notable example is the ZOE Personalized Nutrition Program in the United Kingdom. ZOE utilizes a smartphone-based application that provides tailored nutrition advice based on gut microbiome composition, blood sugar responses, and blood fat levels. The program has expanded into the U.S. and is recognized for its evidence-based approach to improving metabolic health through personalized dietary recommendations (The Times, 2024). Studies have demonstrated that personalized diet plans guided by AI can significantly enhance dietary adherence and metabolic outcomes, particularly in individuals with prediabetes and metabolic syndrome (The Times, 2024).

Another significant study on personalized glycemic responses was conducted by Eran Elinav in Israel. The research found that individuals exhibit unique blood sugar responses to identical foods, challenging traditional dietary guidelines. By analyzing microbiome composition and metabolic markers, AI-powered dietary recommendations were developed to improve blood sugar control in pre-diabetic individuals. This study demonstrated the potential of precision nutrition for metabolic health management and disease prevention (Elinav et al., 2015). These findings emphasize the necessity of personalized dietary interventions instead of one-size-fits-all dietary recommendations (Elinav et al., 2015).

Researchers at the University of Waterloo, Canada, have developed an AI-powered calorie-tracking tool that analyzes footage of meals to determine calorie and nutrient intake. For the senior population, this technology removes the need for manual food logging while providing real-time dietary monitoring and nutritional insights (University of Waterloo, 2023). This

application has potentially improved dietary management and disease prevention through personalized, real-time dietary analysis within the elderly population through integration of data and feedback on dietary habits to ensure adherence and improvement of nutrition in direct response to the nutrition plan being suggested (University of Waterloo, 2023).

These case studies help demonstrate the transformational capabilities of AI-powered personalized nutrition. However, it is crucial to navigate obstacles such as data privacy issues, algorithmic biases, and equitable access. Many AI-based systems depend on extensive amounts of data for their generation, raising ethical questions related to the protection of sensitive health and dietary data (Elinav et al., 2015).

Algorithmic bias is also a crucial barrier; if the AI models are not trained on heterogeneous datasets, then the model will not yield enough for the unrepresented population (The Times, 2024). AI-powered nutrition tools, especially in lower-income and resource-constrained environments, face additional challenges to being used widely, including high costs and reduced availability (University of Waterloo, 2023).

Long-term outcomes, scalability, and incorporation into public health policy of AI-driven dietary tools must be examined in future research to guarantee these innovations can benefit diverse communities.

Table 1. Comparison of AI-Powered Personalized Nutrition Plan

Country	AI-Powered Initiative	Key Features	Potential Benefits	Challenges
Thailand	INMU iFood	Image recognition for Thai dishes macronutrient estimation, multiple input methods.	Improved dietary monitoring enhanced nutritional assessments and supported public health interventions.	Validation of accuracy for complex food combinations and accessibility to a broader population.
UK	ZOE Personalized Nutrition Programs	Smartphone app analyzes gut microbiome, blood sugar, and fat responses for	Enhanced metabolic health, personalized nutrition advice, improved dietary	Algorithmic bias, accessibility limitations, and privacy concerns

Country	AI-Powered Initiative	Key Features	Potential Benefits	Challenges
		personalized diet plans.	adherence	
Israel	Personalized Glycemic Response Study	Recommendations based on microbiome composition and metabolic markers	Better blood sugar control in prediabetic individuals' precision nutrition for disease prevention	Ethical concerns on health data privacy require long-term studies
Canada	AI-Based Caloric Measurement Tool	Video analysis for calorie estimation, real-time monitoring for aging populations	Accurate dietary monitoring for the elderly improved adherence to recommended nutrition plans	Scalability, equitable access, and Privacy concerns

Personalized Nutrition for Thailand's Elderly

Personalized nutrition, driven by advancements in artificial intelligence (AI) and data science, offers transformative opportunities to enhance the health and well-being of Thailand's aging population. By tailoring dietary interventions to individual needs, this approach addresses key health challenges such as malnutrition, chronic disease management, and cognitive decline. However, its successful implementation faces significant barriers, particularly in the context of Thailand's unique ecosystem, infrastructure, and cultural factors.

A primary challenge lies in the complexity of translating multi-omics data—such as genetic, microbiome, and metabolic profiles—into actionable dietary recommendations. Personalized nutrition requires the integration of these datasets with environmental factors and individual variability, making precise tailoring a difficult task (Spector et al., 2019; Verma et al., 2018). Thailand's cultural and dietary diversity adds another layer of complexity. Interventions must align with traditional Thai diets, food preparation methods, and socio-environmental influences to ensure relevance and acceptance among the elderly population. (Nawai et al., 2021; Pongpaew et al., 2000).

Resource constraints exacerbate these problems. Rural and underserved regions in Thailand often lack adequate healthcare infrastructure, access to advanced technology, and trained personnel required to deliver AI-supported interventions (Bamford et al., 2012). Elderly care facilities face similar issues, with limited resources and organizational support for implementing personalized nutrition plans effectively. Ethical and privacy concerns, particularly regarding the use of AI and sensitive health data, pose additional challenges. Ensuring data security and informed consent are critical, as personalized nutrition relies on increasingly detailed individual profiles (Ghosh, 2024; Verma et al., 2018).

Awareness and accessibility also remain pressing issues. Many elderly individuals in Thailand, especially those in rural areas, have a limited awareness of nutritional risks and inadequate access to tailored interventions. These gaps often leave vulnerable populations at a heightened risk for malnutrition and related health complications (Fernández-Barrés et al., 2017).

Access to personalized nutrition in Thailand holds the future implementation of tailored nutrition interventions. Urban centers like Bangkok are equipped with state-of-the-art hospitals and infrastructure; however, urban-born children on average have more restricted access than those in outlying areas. Especially in the agricultural sector, which produces much of the typical food older people eat, is grappling with sustainable practices, pesticide use, climate change, and more. Such impact determines not only the availability but also the quality of food by dietary plans for older people.

Thailand's technological landscape has been a challenging issue. AI adoption is on the rise, but many AI tools are not accessible to rural healthcare providers due to cost and infrastructure gaps. Bridging this digital divide is essential for the scalability of AI-based personalized nutrition solutions across the nation.

On the other hand, Personalized nutrition has great potential to enhance health outcomes among older individuals in Thailand. Customized nutrition plans driven by AI can enable better dietary adherence, chronic disease prevention, and enhanced health outcomes by incorporating genetic, metabolic, and microbiome data (Perez-Martinez et al., 2013; Di Renzo et al., 2019).

Nutrition education programs aimed at caregivers and older adults themselves to improve dietary practices and reduce the near-term risk of malnutrition can add to the benefits of a diet wealth program. By addressing the hurdles in food availability and preparation, these programs enable caregivers to essentially address nutritional requirements, improving the efficacy of tailored nutrition interventions (Bae et al., 2013; Kim et al., 2012).

Wearable devices and real-time health monitoring platforms also fall under the umbrella of AI-enabled technologies, which are also enabling personalized nutrition. This gives you the opportunity to continuously track your hydration levels, nutrient intake, and metabolic markers through the aforementioned tools and to adjust your diet accordingly. Yet, for these technologies to be effective, they need to be tailored to the cultural and infrastructure context of Thailand and made accessible to underserved populations (Theodore Armand et al., 2024; Lee et al., 2022).

Community-based approaches play a vital role in addressing nutritional vulnerabilities. Programs that integrate group activities, homecare interventions, and community education foster social support and improve access to resources. For instance, community-led meal planning and workshops can empower elderly individuals to make healthier dietary choices while also addressing socio-economic barriers (Fernández-Barrés et al., 2017; Pongpaew et al., 2000). Addressing these challenges requires interdisciplinary collaboration among policymakers, healthcare providers, researchers, and technological developers. Policymakers must invest in the rural healthcare infrastructure and provide incentives for the development and adoption of culturally relevant AI solutions. The agricultural sector must also ensure the availability of safe, sustainable, and high-quality food for personalized nutrition plans.

As Thailand transitions toward an aging society, personalized nutrition can become a cornerstone of elderly healthcare. By integrating AI-driven solutions, culturally sensitive interventions, and community-based programs, Thailand can create scalable and sustainable strategies to promote healthier aging. With a concerted effort to overcome ecosystem challenges and improve accessibility, personalized nutrition has the potential to significantly enhance the quality of life of the elderly population (Ordovas et al., 2018; Van Ommen et al., 2017).

Challenges & Future Research in AI-Powered Personalized Nutrition

Despite significant advancements in AI-driven personalized nutrition, several challenges hinder widespread adoption and long-term sustainability. Addressing these issues is crucial for effectively integrating AI-based dietary interventions into healthcare and public health systems. Key barriers include AI validation, cost accessibility, ethical concerns, and long-term health impacts.

A major challenge is AI validation and accuracy, as many AI-driven nutrition tools rely on machine learning models trained on limited datasets. These models often lack diversity, making them less effective for underrepresented populations. For example, studies on AI-powered dietary assessment tools, such as INMU iFood and ZOE, have been validated in controlled settings but lack large-scale real-world testing (Mahidol University, 2023; The Times, 2024). Additionally, AI models require continuous updates to remain effective in evolving dietary patterns and metabolic conditions (Kassem et al., 2025). Future research should focus on improving validation methods by integrating more extensive and diverse datasets, ensuring fair and precise dietary recommendations across different populations.

Another critical barrier is cost and accessibility. AI-driven nutrition solutions, including mobile applications, wearable devices, and microbiome-based dietary assessments, often require expensive hardware and software, limiting access for lower-income populations. Personalized glycemic response models, such as those developed by Elinav et al. (2015), rely on microbiome sequencing and continuous glucose monitoring, making them expensive for widespread implementation. The financial burden of AI-powered nutrition solutions is particularly significant for aging populations and individuals in resource-constrained regions (Anshari et al., 2024). To overcome this, future research should explore cost-effective AI models that integrate into existing healthcare infrastructures and publicly funded programs to enhance affordability.

Long-term health outcomes and adherence remain another area requiring further investigation. Most AI-powered nutrition studies focus on short-term metabolic improvements rather than sustained long-term health benefits. While AI-driven interventions have demonstrated success in managing conditions such as diabetes and obesity, their long-term

effects on dietary behavior, chronic disease prevention, and healthcare costs remain unclear (Tomasiewicz et al., 2024). Future research should assess whether AI-based recommendations lead to sustained lifestyle changes or if adherence declines over time due to behavioral fatigue or technological disengagement.

Ethical considerations and data privacy are also significant concerns in AI-powered nutrition. Many AI-driven dietary tools collect sensitive personal health data, raising issues related to privacy, security, and potential misuse (Ghosh, 2024). Additionally, algorithmic biases in AI recommendations may reinforce disparities in healthcare access and outcomes, particularly for minority populations. Ensuring transparency in AI decision-making, developing ethical guidelines, and implementing stricter data security policies are essential steps in addressing these challenges (Bond et al., 2023).

Future research should focus on four key areas to improve AI-powered personalized nutrition. First, AI models must be validated using diverse datasets, including different ethnic, geographic, and socioeconomic groups, to ensure accurate recommendations (Kumar et al., 2024). Second, reducing cost barriers by integrating AI into government-funded healthcare programs and community initiatives can enhance accessibility (Anisha et al., 2024). Third, evaluating long-term health outcomes is necessary to determine the sustainability of AI-driven interventions in real-world settings (Taveira et al., 2021). Lastly, addressing ethical concerns, including data privacy, algorithmic bias, and user trust, is crucial for ensuring equitable and responsible AI integration in personalized nutrition (Shinde & Mahajani, 2022).

By addressing these challenges, AI-driven personalized nutrition can become a more inclusive, cost-effective, and ethically responsible solution for improving global health outcomes. Future research should emphasize scalability, affordability, and long-term effectiveness to maximize AI’s transformative potential in dietary management and public health.

Recommendations for Implementation

Personalized nutrition holds immense promise in improving the health and well-being of Thailand's aging population. However, successful implementation requires careful consideration of the unique cultural, technological, and healthcare landscape. This paper outlines the key

recommendations for optimizing personalized nutrition strategies for elderly individuals in Thailand.

Nutritional interventions must be tailored to the specific dietary habits, cultural preferences, and socioeconomic contexts of the Thai population. Incorporating traditional Thai foods and addressing prevalent health issues, such as malnutrition and dehydration, can enhance the relevance and acceptance of these programs (Nawai et al., 2021; Pongpaew et al., 2000).

Leveraging technology is crucial for delivering personalized nutrition. Implementing AI-driven tools, wearable devices, and mobile apps tailored to Thai elderly populations can provide real-time health monitoring, personalized dietary recommendations, and improve adherence (Lee et al., 2022; Theodore Armand TP et al., 2024). These technologies can also help bridge gaps in access to nutrition services, particularly in underserved areas.

Roadmap for AI-Powered Nutrition Implementation in Thailand

To implement AI-powered personalized nutrition in Thailand, an integration approach addressing key challenges such as accessibility, affordability, digital literacy, and ethical concerns must be structured. Policy makers will necessarily prioritize policies to ensure that AI-powered nutrition programs are widely utilized in affordable and accessible manners in the Thai healthcare system.

Establishing pilot programs involving AI-powered nutrition is one of the most urgent steps to take to measure the real-world impact of these technologies. The main target for the pilot program should focus on elderly, low-income communities, and those with chronic diseases like diabetes and hypertension. Collaboration between government organizations, health systems, and AI developers could enable small-scale tests in hospitals, community health centers, and elder care programs. These pilots will generate important data on users' engagement, adherence, and implementation challenges, influencing the next steps for more extensive policies (Tomasiewicz et al., 2024).

A second priority is improving AI literacy and public awareness so that healthcare providers and the public are knowledgeable about using AI-driven nutrition tools effectively. Low levels of digital literacy and low experience with new technologies, especially in older people, remain barriers to adoption. Policymakers need to implement AI education programs,

workshops, and online resources to train healthcare professionals, caregivers, and individuals alike on the benefits and use of AI-powered nutrition applications. For the long-term adoption of AI into clinical nutrition, embedding AI literacy into our medical and nursing curricula will provide further support (Anshari et al., 2024).

However, AI can lead to a disparity in healthcare, as vulnerable populations may not be able to benefit of AI. Most AI-based apps and wearables are very expensive, limiting their accessibility to higher-income people. AI-powered dietary tools should be subsidized and integrated into Thailand's national healthcare system so everyone would have access to it as their first step to better health. Collaborations between technology companies and healthcare organizations are essential to lowering expenses and improving access to AI-based nutritional interventions in rural and underserved populations (Bond et al., 2023).

Ethical considerations, particularly data privacy and algorithmic bias, need to be addressed to gain public trust in AI-powered nutrition. AI-based dietary systems collect massive amounts of sensitive personal health data, which raise potentially concern security issues and the risk of misuse. Policymakers need to provide clear guides on data protection, AI transparency, and bias mitigation strategies. The proposal of establishing a national AI ethics board has been considered, to ensuring compliance with these regulations and facilitating ethical AI practices in healthcare (Ghosh, 2024).

Finally, AI-based nutrition must become a part of comprehensive population health efforts to increase its potential impact and acceptance for Thailand’s aging demographic. AI-driven dietary interventions can support community-based health programs, improve dietary adherence in chronic disease management, and contribute to national food security policies. Increased investment in local AI research and development will also ensure that these technologies are tailored to Thailand’s unique dietary patterns and nutritional needs (Mahidol University, 2023).

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