

A Comprehensive and Practical Guide to Clinical Nutrition in Medical Practice

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Abstract

Clinical nutrition is a medical discipline defined as the study of food nutrients and their application in healthcare for managing diseases, affecting the absorption and metabolism of nutrients. Any nutritional measure, preventive or curative, targeting individual patients, is considered clinical nutrition. Clinical nutrition plays a vital role in both health and chronic disease management. Registered dietitians or nutritionists aid in restoring optimal maintaining patient health. Based on the nature and duration of therapy, medical treatment could be exhaustive to patients. Hence, optimal nutrition management is essential to support the patient's overall health and minimize medical care complications. The main goal of nutrition therapy is to foster faster patient recovery, minimize complications of medical care, and improve clinical outcomes.

For several decades, dietary nutrition has been presumed to have an association with chronic diseases. Through experimental and clinical studies, it has been demonstrated that appropriate nutritional intervention and management results in enhanced outcomes with accelerated recovery in patients with chronic diseases compared to standard pharmaceutical treatment alone. This review explains the origin and development of nutrition science, and highlights the importance of nutritional intervention in clinical practice.

Keywords: Dietary Foods; Functional Foods; Malnutrition; Nutraceuticals; Nutritional Therapy; Refeeding Syndrome

Abbreviations

ADA: American Dietetic Association; CAADE: Commission on Accreditation/Approval for Dietetics Education; CHD: Coronary Heart Disease; ESPEN: European Society of Clinical Nutrition and Metabolism; ESRD: End-Stage Renal Disease; FAO: Food and Agriculture Organization; HHS: Health and Human Services; PG: Patient-Generated; SGA: Subjective Global Assessment; USDA: US Departments of Agriculture; WHO: World Health Organization

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Introduction

The origin and history of nutrition in maintaining health and preventing and treating disease

While the association between dietary foods, nutrition, and health has been considered for centuries, modern nutritional science was once fledgling, but now is emerging as a fundamental scientific and medical discipline [1].

The Greek physician Hippocrates, known as the “Father of Medicine”, recognized the importance and impact of dietary intake on humans’ health and wellness in the 4th century BC. The word “diet” was derived from the Greek word ‘data,’ which means healthy living by consuming a healthy diet [2].

In 1747, a British physician, Dr. James Lind, demonstrated the usefulness of lime in treating a bleeding disorder (scurvy) in sailors for the first time [2,3]. Also in the 18th century, a French chemist, Lavoisier, recognized metabolism and its relationship with breathing. Lavoisier is known as the ‘Father of Nutrition.’ Soon after, components of food and derived elements, such as nitrogen, hydrogen, carbon, and oxygen were identified, and their role in maintaining health was emphasized [2,3].

In the early 20th century, general awareness about the usefulness of dietary components in treating diseases led to the understanding of diet in healthcare with the rapid development of nutritional science. German researcher Justus von Liebig’s study of carbohydrates, proteins, and fats led to further research in the isolation and characterization of vitamins. The term “vitamin” was derived from “vitamine”—a compound word coined by a Polish biochemist, Casimir Funk, from “vital” and “amine,” meaning essential for life [4].

The first half of the 20th century was a remarkable era, heralding numerous discoveries in nutritional science, including the investigation of several key vitamins and minerals. The first vitamin was isolated in 1926 and named “thiamine”. However, ‘vitamin C’ in treating scurvy was the first documented nutritional therapy in 1932. Since then, the use of vitamins in treating several nutrient-deficiency diseases, such as pellagra, beriberi, xerophthalmia, and rickets, has been established [2-4].

Food, nutrition, and national security have been linked for centuries. In 1919, during World War I, veterans suffered hunger and malnutrition. The United States Public Health Services employed dieticians in hospitals to improve World War I veterans’ health through healthy diets.

During World War II, a fear of food shortages and veterans’ poor health led to further emphasis on preventing nutrient deficiency diseases. Further, the US National school lunch program was initiated to control malnutrition and improve children’s specific dietary requirements. Since then, the role of dieticians has been well received and integrated throughout hospitals and health care facilities in the United States [2,4,5].

By the early 20th century, the significance of vitamins had been discovered. In 1929, Sir Frederick Gowland Hopkins, a member of the Medical Research Council, was awarded the Nobel Prize for his discovery of growth-stimulating vitamins.

The vital role of vitamins in preventing various diseases was demonstrated through animal experiments and human clinical studies. This role spawned the chemical synthesis of vitamins at a commercial scale for their usage in treating diseases in the form of dietary supplements. The first vitamin pills were commercially produced in the 1930s. Later, the emergence of food industries brought about a transformation in the field of nutrition and health. Furthermore, healthcare practitioners began recognizing the need for nutrition-based strategies and vitamin supplements in addressing specific nutritional deficiencies and nutrient-deficiency diseases [4].

Food industries began implementing the fortification of foods with essential vitamins, minerals, and micronutrients. Several studies and dietary surveys showed that the approach of fortifying local staple foods with essential nutrients, such as iron, calcium, phosphorous,

iodine, and major vitamins (vitamins A, B, C, D) were effective in reducing the prevalence of nutrient deficiencies in the US population [6,7]. Iodine's addition of iodine in salt resulted in the decreasing prevalence of goiter. Fortification of iron and niacin in wheat flour and bread reduced the prevalence of anemia and pellagra, respectively.

The American Medical Association recognized the lack of nutrition education in US medical schools. In 1940, Dr. Elsie Widdowson and Professor Robert McCance published the first book on nutrition, *The Composition of Foods*, which formed the basis of most nutritional databases worldwide [2,3]. Developed countries witnessed a reduction of malnutrition and vitamin deficiency cases between the 1950s to 1970s. Economic development and the inclusion of fortified and calorie-dense staple foods in the diet played an essential role in reducing malnutrition. Meanwhile, many Western countries witnessed a rise in chronic diseases.

These chronic diseases were regarded as a significant threat to a nation's economic development, promoting intense debate on the cause of the rise in chronic diseases, such as dietary fat or sugar. Finding the culpable source was a massive challenge for the low- and middle-income countries.

The early understanding of fat and sugar was based on a reductionist nutrition policy developed to address nutrient-deficiency diseases—when a deficiency was related to a single nutrient. The low- and middle-income countries relied on implementing similar nutrition policies as the US to increase calorie intake and specific nutrients. The food industry's business upsurged with the principle of “calorie enrichment” and began producing and promoting food products that were vitamin-fortified, rich in calories, starch, and sugar [7-9].

Meanwhile, studies were conducted, evaluating the impact of dietary fat and sugar intake on chronic diseases, such as coronary heart disease (CHD), obesity, cancer, and dental caries [2,3,10,11]. The Sugar Research Foundation's preliminary reports showed that fat and cholesterol were the leading dietary causes of CHD during the 1970s and understated the evidence of sugar as a risk factor [12]. In the late 1970s, John Yudkin's study demonstrated the harmful effect of excessive sugar, and Ancel Keys found saturated fat, total fat, and dietary cholesterol as the leading causes of CHD [2,3,12]. The emerging research and scientific evidence emphasized the need for the development of evidence-based medical policies and regulations.

In 1977, a report, *Dietary Goals for the United States*, published by the United States Senate, recommended a low fat and low cholesterol diet. However, this report was not well accepted due to several controversies. This report, however, led to an evolution of early nutrition science. Considering the need to promote infants' and children's health in the weak and vulnerable residents, food assistance programs, dietary guidelines, and nutrition policies were introduced in several countries [4,13,14].

The application of dietary protein emerged in 1970. There were debates regarding the lack of proteins or calorie intake as the primary cause of malnutrition, which led to the protein gap theory [15,16]. Although it was believed that protein played a significant role in malnutrition and chronic diseases, there was no scientific evidence illustrating the relative role of protein in malnutrition. This uncertainty about the role of protein in malnutrition and chronic diseases influenced the commercial production of protein-rich infant formulas and supplemental foods in developing countries.

After an initial controversial phase, in 1975, scientific evidence from developing countries indicated malnutrition was principally caused by a lack of food. In 1980, the US Departments of Agriculture (USDA) and Health and Human Services (HHS) jointly issued the *Nutrition and Your Health: Dietary Guidelines for Americans* that encompassed seven principles to assist people in choosing a healthy diet [17].

These guidelines were mainly nutrient-focused and originated from a single nutrient deficiency disease model, and recommended avoiding excess fat, saturated fat, cholesterol, salt, and sugar. This recommendation expanded new industrial technologies to produce foods comprising low saturated fat, cholesterol, sugar, and fortified foods with micronutrients [4,18].

Efforts were being made globally, particularly in underdeveloped nations, to eliminate malnutrition and micronutrient deficiencies. Scientific evidence and field studies showed that food fortified with specific vitamins and minerals effectively prevented specific infections, night blindness, xerophthalmia, and goiter [4,19,20]. After the World Health Organization (WHO) recommendations regarding dietary supplementation with vitamin A, iodine, and iron, other international advisory groups, governments, and the United Nations adopted a similar strategy to end the prevalent nutrient deficiencies through fortification of food with these nutrients [20–22].

In the 1990s, chronic diseases emerged as a global threat in both developed and developing countries, with an increased focus on related scientific research and clinical studies, which prompted the beginning of modern nutrition science in that decade. The underlying complex mechanisms behind specific chronic diseases were well established. Several intervention strategies were identified to reduce the impact of chronic diseases on public health.

Population-based epidemiological studies elucidated the role of dietary nutrition in preventing and managing chronic diseases [23–25]. Meanwhile, rapid changes in the diets, lifestyle, industrialization, economic development, and market globalization occurred in developing countries. Moreover, the standard and quality of human life had improved with the increased availability of fortified and processed foods.

Due to lifestyle changes and dietary patterns, a sudden rise in chronic non-communicable diseases, such as obesity, cardiovascular disease, hypertension, cancer, and diabetes mellitus was seen in developed and developing countries. The escalating trend of malnutrition in developing countries with the sudden emergence of non-communicable diseases resulted in an additional burden on rising health care taxes [15,16,26].

In recent years, global reformations in dietary food and nutrition guidelines were witnessed, based on scientific data and evidence, emerging from extensive cohort studies, randomized clinical trials, and relevant scientific studies using animal models. These emerging scientific data from clinical cohort studies indicated that a single nutrient deficiency does not influence chronic diseases. Instead, such diseases are more complex, and the influence of diet on chronic diseases is multifactorial. Recent studies demonstrated the genetic influences on complex diseases concerning diet [26].

Few research articles described certain controversies related to nutrition and its adverse effect on diseases [22,25,26]. Based on scientific data and evidence, the WHO Food and Agriculture Organization (FAO) consortium published specific guidelines in 2003, intending to implement more effective and sustainable policies and strategies to deal with the increasing public health challenges related to dietary food and health [13,14,22].

Discussion

The amalgam of nutritional science and clinical nutrition

Clinical nutrition is a science of dietary foods concerned with the diagnosis and treatment of diseases related to dietary intake, absorption, and metabolism. Further, clinical nutrition involves the awareness of body composition with aberrant changes in body functions related to metabolic disturbances [27,28].

Humans have been practicing clinical nutrition for centuries without understanding the metabolism of dietary foods in the human body and the exact role of food nutrients in promoting health and wellness [5]. The practice of nutrition/dietetics was first defined by the American Dietetic Association (ADA) in 1991. According to the ADA, nutritional science is an amalgam of biochemistry, food, physiology, and behavioral and social sciences in achieving optimal health through practicing nutrition care services [29].

The main objective of nutrition science is to assess nutritional needs, provide nutrition counseling related to health and disease, plus develop, implement, and manage a nutrition care system to prevent further disease-related complications [28].

The significance of clinical nutrition in medical practice

Adequate nutrition can improve patients' quality of life, healthcare provider's performance, and effectiveness of prescribed medicine, thus contributing to enhanced patients' clinical outcomes. Clinical nutrition plays a vital role in restoring patients' optimal health in hospitals through diets and nutrient supplements. It promotes faster recovery of the patients after undergoing treatment, surgeries, or injuries, by preventing malnutrition and boosting energy. Beyond aiding hospitalized patients, clinical nutrition can also be utilized to treat chronic diseases, such as obesity, intestinal disorders, cardiovascular diseases, diabetes, hypertension, and specific cancers by modifying diets and lifestyle [10,11,24,26,30,32,46].

Since nutrient-deficiency affects all age and socio-economic groups globally, it is essential to expand awareness about the benefits of healthy foods, diet modification, and lifestyle changes.

The epistemology of clinical nutrition

Nutritional sustenance involves a multi-disciplinary approach, such as fundamental care involving food intake and drinks through the mouth or parental nutrition. Nevertheless, artificial nutrition is also considered a treatment lawfully. Hence, ethics in utilizing nutrition as a treatment for disease requires attention. In that purview, four ethical fundamentals of care, including responsibility, responsiveness, attentiveness, and competence, must be considered. The bio-ethical principles of respect of autonomy, beneficence, non-maleficence, and justice must be considered during the practice of nutritional support. The ethics in clinical nutrition must be understood in depth [33].

The cost-effectiveness of clinical nutrition

Cost-effectiveness has a strong influence on the treatment of chronic disease. For example, medical care for patients with end-stage renal disease (ESRD) is intense and comprehensive. Procedures, such as kidney transplantation and peritoneal dialysis accompanied with an uncomplicated post-transplant progression, are comparatively less expensive than hemodialysis for both inpatients and outpatients with ESRD.

Similarly, cost-analysis of vascular access-associated care reveals the use of innate arteriovenous fistula is less expensive than synthetic graft, or permanent catheter patients' comorbidity, increasing the expense of ESRD treatment. Appropriate nutritional management has a significant role in delaying the need for dialysis. Malnutrition, accompanied by its economic burden, is often an understated and unrecognized issue in ESRD, especially among hospitalized ESRD patients. A meta-analysis revealed that standard oral nutritional supplements in hospitalized patients provided overall cost savings [34].

Functional foods and nutraceuticals

In recent years, the concept of functional foods has become more popular among the general public, dieticians, and health care professionals. Functional foods offer numerous health benefits beyond their nutritional value, which was first recognized in Japan in the 1980s.

If consumed regularly, functional foods offer numerous health benefits: , boosting the immune system, preventing nutrient deficiencies, protecting against infections, promoting growth and development in children, and aiding the overall health and wellness. Numerous epidemiological studies have reported health benefits of consuming dietary fibers from fruits and vegetables—which play a vital role in reducing the risk of chronic diseases [23,26,37].

Functional foods having the therapeutic potential to treat or prevent any ailment are referred to as “nutraceuticals”. Stephen DeFelice neologized this term in 1989 from the words “nutrition” and “pharmaceutical.” In recent years, the use of nutraceuticals has brought about increasing attention from the general public and physicians due to fewer side effects and lower cost than medicinal products. Thus, functional foods have been recognized as a good alternative for maintaining better health and treating chronic diseases [35].

Functional foods therapy

Some of the Functional foods having therapeutic applications are discussed as follows. Probiotic bacteria such as viable *Lactobacilli* can aid the metabolic activities of the gastrointestinal tract. Probiotics mainly target the immune system, employing anti-microbial activity, increasing the proliferation of immune defense cells, modifying several metabolic enzymes, and restricting degenerative pathways.

Carotenoids are fat-soluble phytopigments that are found to be protective against specific chronic diseases, such as cancer [36], cardiac disease [37], and degenerative eye disorders [38]. The consumption of functional fibers and dietary fibers has several potential health benefits, including constipation prophylaxis [39], reducing cholesterol levels, and reducing the prevalence of coronary and cardiovascular diseases [40].

Clinical nutrition as a medical specialty

Clinical nutrition is a somewhat novel phenomenon with profound professional limitations in need of change. Clinical nutrition is frequently counted under either medical or nutritional-dietetic disciplines. Medical students must attend additional courses and training on clinical nutrition, mainly the courses on the fundamentals of nutrition. Dietitians also need to attend additional courses and training on clinical nutrition. An inter-disciplinary specialty must be identified, not as a sub-specialty, such as gastroenterology, surgery, or endocrinology. Further research is required to determine the core capabilities and applications of clinical nutrition [41].

Guidelines regarding the practice of clinical nutrition

Clinical nutrition has evolved after decades of research on dietary components, nutrition, and health benefits. Numerous disorders or diseases, including malnutrition, inflammation, certain cancers, sarcopenia, frailty, obesity, disease, injury, nutrient deficiency or abnormality, and refeeding syndrome, can be treated with nutritional therapy [42,46].

According to the European Society of Clinical Nutrition and Metabolism (ESPEN) guidelines, patients should be evaluated before selecting optimal nutritional therapy. Assessment tools, like the Subjective Global Assessment (SGA), Patient-Generated (PG) SGA, and Mini Nutritional Assessment, can be utilized to screen the patients.

This assessment involves careful evaluation of the patient’s health condition, including diet and nutritional history, physical and biochemical examinations, and investigations to identify the underlying cause of any nutrient deficiency. Based on the results of these assessments, the nutritional care plan is designed by the experts, including the type of nutrition, delivery of nutrients, and plan for treating any nutrition-related condition are included in the clinical nutritional care plan. Monitoring nutritional therapy is equally important to determine treatment and health outcomes [43,44].

Certificate and degree programs in clinical nutrition

A professional certified from the Commission on Dietetic Registration (CDR, 1999) can work as a registered dietitian, having in-depth knowledge and understanding of food and nutrients in preventing and treating diseases. The Study Commission on Dietetics was formed in 1972 to evaluate the knowledge and educational background for the practice of dietetics.

The fundamental requirement to become a certified dietician is having a bachelor's degree from an accredited college and having passed a national registration examination to obtain a degree from CDR. The Commission on Accreditation/Approval for Dietetics Education (CAADE) of ADA offers a supervised program for entry-level dietitians to develop core competencies in dietetics with required academic coursework as clinical experience. The required core competency skills include problem-solving and decision-making abilities, interpersonal communication skills, and critical-thinking skills. See the Supplementary Note for further information regarding accredited certificate and training programs.

These programs' extensive coursework and comprehensive training include the biochemical composition of nutrients, physiology, and psychology of the human body, genetics, medicine, anthropology, and counseling techniques. They also include food science, involving components of food, effects of processing and preparation of food on nutrient composition, alternate feeding modalities, and socio-economic factors affecting nutrient behavior [29,42,45].

The registered dietician as a clinical nutritionist

Physicians with advanced-level nutrition training and fellowships or graduate degrees in a related discipline can be certified as a certified nutrition specialist by the American College of Nutrition. However, they most often lack specific skills that a trained dietician acquires after thorough coursework on nutrition.

Although hospital nurses, physicians, certified nutrition specialists, and registered dietetic technicians can counsel patients on less complex nutrition problems, they cannot perform a thorough assessment to diagnose nutrition disorders [29,42,45]. Until now, only registered dietitians were qualified to provide clinical nutrition therapy, having have the experience and skills to assess who should be administered nutrition therapy, when and what type of nutrition therapy would be most effective, and what specific interventions is needed.

The need for integration of nutrition science in healthcare

The association between chronic diseases and poor nutrition has been well established. Poor nutrition and a lack of knowledge regarding correct food choices are the leading causes of a rapid rise in chronic diseases. Obesity, malnutrition, and diet-related conditions are the root causes of all emerging major chronic illnesses. The WHO data infer that obesity is accountable for 80% of cardiovascular cases, 90% of diabetes cases, and 35-70% of cancers [15,16,46].

For several decades, health care systems worldwide ignored the implications of proper food choice and consumption in maintaining health and wellness. Nutritional interventions can reduce mortality, morbidity, and malnutrition [14,17,20,21]. Although US health care professionals acknowledged and accepted the concept of dietary nutrition much earlier than their counterparts in developing and under-developed countries, US population is still facing the health concern of obesity and its associated morbidities.

There is an urgent need to introduce nutrition science in health care practices. It is paramount for health care providers and clinicians to understand nutrition science better, evaluating and recognizing the relationship between disease progression and metabolic disorders. Awareness of nutritional science in supplementing appropriate nutrition with clinical treatment can promote better health maintenance and metabolism in chronically ill patients. The beneficial outcomes can only be achieved when physicians counsel patients with accurate nutritional information based on the patients' medical conditions.

However, are vital question remains regarding physicians, who typically are the first point of contact for patients health concerns: are physicians sufficiently competent to diagnose nutrition-related disorders, due to a lack of training and education in nutrition science? Dieticians or nutritionists can provide competent nutritional evaluations and services in developing and developed countries, However, their role is often limited to food industries and community health care centers.

Thus, nutrition and diet-related training programs should be extended to health care practitioners, physicians, and dieticians at both national and international levels. Nutrition-related courses and training programs are available in the US, but not in all countries globally. There is a vital need to implement nutrition-related courses in the medical curriculum globally. If physicians are adequately trained in clinical nutrition, this knowledge may be utilized to diagnose nutrition-related disorders better. Thus, they could play an important role in counseling patients in modifying dietary and lifestyle behaviors.

Conclusion

The application of nutrition and nutritional science has an extensive and remarkable history. Nowadays, there is an extraordinary awareness regarding the importance of nutrition in maintaining health and wellness. The advancements in science and technology have provided adequate evidence in establishing a strong association between dietary nutrients and human health. In the future, improved and straightforward access to information about nutrition related to people's health concerns will positively effect behavioral and lifestyle changes.

Considering the rapidly evolving health care system, the expansion of clinical nutrition is comparatively slow but not stagnant. The increasing chronic disease burden constantly pushes the health care system towards nutrition science, which was neglected for decades. An enhanced understanding of nutrition's role on gene expression through advanced computing technologies is the future path forward. Nutrition and metabolomics research will give rise to new directions and dimensions in human nutritional science.

In the future, it is foreseeable that personalized diets will become common. Food processing industries are expanding and providing engaging opportunities to dieticians and nutritionists. The fundamental goal of the food industry should be to produce healthy and safe food for human consumption. To accomplish that end, the food industry needs certified dieticians and nutritionists. Certified dieticians and physicians pursuing careers in nutrition, can be envisioned as emerging nutrition consultants due to their unique skill sets, and increasing demand for such services.

Conflict of Interest Statement

The authors declare that this paper was written in the absence of any commercial or financial relationship that could be construed as a potential conflict of interest.

Supplementary Note

A complete list of CAADE-accredited Coordinated and Internship Programs, CAADE-approved and accredited Dietetic Technician Programs, and CAADE-approved Pre-professional Practice and Didactic Programs in Dietetics is available on the *Directory of Dietetics Programs* (<http://www.eatright.org/caade.html>).

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