Meta-Analysis

Health Economics of Primary Care Nutrition Interventions: a Systematic Review and Meta-Analysis

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Context: *Non communicable diseases (NCDs) impose a major global health and economic burden, with poor diet recognized as a leading modifiable risk factor. Nutrition interventions delivered by qualified professionals in primary care settings are recommended for prevention and management of NCDs, yet their economic value remains uncertain.*
Objective: *We sought to systematically review and synthesize evidence on the cost-effectiveness of nutrition care interventions delivered by nutrition professionals in primary care, from both societal and health care system perspectives.*
Data Sources: *A comprehensive search of 6 databases (Ovid Medline, PubMed, Embase, CINAHL, Cochrane CENTRAL, EconLit) was conducted up to October 2024 following Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines (Supporting Materials). The protocol was registered in PROSPERO under the number: CRD420251029435.*
Data Extraction: *Randomized controlled trials reporting economic evaluations of primary care nutrition interventions were eligible. Two reviewers independently screened studies and extracted data on intervention characteristics, cost perspective, incremental costs, incremental effects, and quality-adjusted life years. Risk of bias was assessed using the Consolidated Health Economic Evaluation Reporting Standards 2022 (CHEERS 2022) checklist.*
Data Analysis: *The incremental net benefit (INB) was calculated using harmonized cost and effect data. The meta-analysis employed random-effects models stratified by perspective. Sensitivity analyses excluded influential outliers. Subgroup analyses explored variations by delivery mode, target condition, and study quality.*
Conclusions: *Among 25 included studies, 56% were cost-effective and 20% were moderately cost-effective. Pooled INB favored cost-effectiveness from a societal perspective (€650.32), while the health care system perspective indicated initial investment requirements (−€402.65). Telehealth delivery and diabetes-focused interventions demonstrated the strongest economic outcomes. Despite high*

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heterogeneity, sensitivity analyses improved pooled estimates, reinforcing the robustness of findings. Nutrition interventions in primary care represent a strategic opportunity to improve health outcomes and optimize resource allocation, particularly when integrated into telehealth models and multidisciplinary care frameworks.
Systematic Review Registration: *PROSPERO registration No. [CRD420251029435].*
Key words: ***nutrition therapy, cost-effectiveness, primary care, health economics, systematic review, meta-analysis, quality-adjusted life years.***

INTRODUCTION

Poor dietary intake is now recognized as the predominant modifiable risk factor for non communicable chronic diseases (NCDs), accounting for 41 million fatalities annually (71% of all global deaths).[1] Diet quality directly influences 7 of the 10 most common NCDs worldwide, including obesity, cardiovascular disease (CVD), and type 2 diabetes mellitus.[2] Unfortunately, the vast majority of the population does not follow nutrition recommendations for NCD prevention, typically consuming diets high in processed meats, refined grains, saturated fats, salt, and simple sugars while consuming inadequate amounts of fresh fruits and vegetables.[3] This dietary pattern significantly increases NCD prevalence, resulting in substantial economic consequences that adversely affect health care budgets, diminish productivity, and impose considerable social costs.[4]

The economic implications of diet-related diseases are profound and multifaceted. According to the latest World Economic Forum estimates, the projected economic costs of NCDs are expected to reach \$47 trillion between 2012 and 2032, equivalent to approximately 75% of the global gross domestic product (GDP) in 2020.[5,6] In 2022, updated World Bank calculations estimated the direct medical expenses for 7 major NCDs at over \$20 billion annually, with indirect costs approaching \$100 billion.[7] These expenditures continue to rise due to population aging and increasing unhealthy dietary patterns, highlighting the urgent need for cost-effective interventions to promote healthier dietary choices.[8] Given the rising burden of NCDs, the need for cost-effective interventions becomes ever more critical, particularly in primary care settings where resources are often constrained.

Governments implement various public health policy measures to address the growing burden of NCDs.[9] Primary care interventions are particularly important, as they provide an accessible entry point for early prevention and management.[10,11] In this context, dietary modification is recognized as the first-line approach to manage NCDs and can improve clinical biomarkers and hard endpoints alike.[12] Registered dietitians and nutritionists are the only health care professionals specifically trained to facilitate dietary behavior change.[13] For the purposes of this review, the term "nutrition professional" includes registered dietitians and nutritionists who are specialized in the management of dietary needs and nutrition-related health conditions. Research has shown that primary care interventions provided by multidisciplinary teams—including nutrition professionals, general practitioners (GPs), nurses, and allied health professionals working collaboratively—positively affect patient outcomes in diabetes mellitus, cardiovascular disease, and obesity, reducing hospital admissions and enabling better management of chronic diseases and their implications.[14] Because of limited public resources, funding for dietary interventions competes with funding for other preventive and public health services. This situation highlights the importance of conducting rigorous health economic evaluations to inform evidence-based societal decision-making about resource allocation.[15] By systematically assessing the costs and benefits of different interventions, policymakers can direct funding toward programs with the greatest potential to improve public health outcomes, ensuring that investments are both cost-effective and impactful.

Economic evaluations of health interventions typically fall into 3 distinct categories, each with specific methodological approaches and outcome measures.[16] In cost-benefit analysis (CBA) monetary values are assigned to both costs and outcomes, expressing results as net benefits or benefit-cost ratios, thus allowing direct comparison across diverse sectors beyond health care. In cost-effectiveness analysis (CEA) intervention costs are compared to outcomes measured in natural units (eg, BMI reduction, blood pressure improvements), providing an incremental cost-effectiveness ratio (ICER) that represents the additional cost per unit of health outcome gained. In cost-utility analysis (CUA), a specialized form of CEA, both quality and quantity of life gains are evaluated using standardized metrics such as quality-adjusted life years (QALYs), producing an incremental cost-utility ratio (ICUR) that can be compared against predetermined willingness-to-pay thresholds that represent societal valuations of health improvements. This framework enables meaningful comparison across diverse health interventions and guides resource allocation decisions.

The economic evaluation of nutrition interventions in primary care settings presents unique methodological challenges. Unlike clinical environments with more homogeneous patient populations and clearly defined outcomes, primary care settings involve diverse populations with complex health needs.[17] Numerous studies have highlighted specific challenges related to economic evaluations of public health interventions, which represent a substantial subset of nutrition programmes.[18] Establishing causal effects is particularly difficult, as randomized controlled studies (RCTs) - while considered the gold standard—may be prohibitively expensive, poorly generalizable, or unfeasible in public health contexts.[19] Furthermore, determining the attribution of effects in public health programs is often complex due to their multifactorial nature and the influence of environmental factors.[20,21] Consequently, the relationship between a nutrition intervention and its final health outcomes in primary care is shaped by a range of social, behavioral, and biological factors that complicate the economic analysis in primary care settings.[17]

While substantial research has focused on the health benefits of dietetic interventions within primary care, fewer studies have explored their economic impact. Nevertheless, existing evidence suggests potential for cost-effectiveness and improved health outcomes associated with these interventions. In a previous systematic review the authors concluded that nutritional care can effectively prevent and reduce disease prevalence, which is expected to generate significant economic benefits over time even though it requires an initial investment.[22] A meta-analysis focused on diabetes prevention demonstrated that nutrition programs delivered by registered dietitians are more cost-effective than those provided by unqualified nutrition-care professionals.[23] More recently, a 2023 systematic review reinforced the economic value of dietetic interventions delivered via telehealth, particularly for NCD management.[24] This study found that mobile health interventions were the most cost-effective modality, with 60% of telehealth interventions viewed as cost-effective from a health service perspective.

Although many studies report positive cost-effectiveness outcomes, there is a need for further research to standardize economic evaluation approaches and assess the long-term sustainability of nutrition interventions across various diseases and conditions within primary care. The heterogeneity in willingness to pay (WTP) thresholds, methodologies, intervention types, and target populations across studies complicates broad generalizations about cost-effectiveness, presenting challenges for meta-analysis. Bagepally et al. (2022) highlighted the need to develop methods for harmonizing data and conducting a meta-analysis to address these challenges, providing a framework for overcoming the methodological and analytical complexities.[25]

This review was performed to fill the existing gap in policy-relevant economic evidence by synthesizing the most recent data on the cost-effectiveness of nutrition interventions in primary care. Therefore, we aimed to critically evaluate and synthesize the evidence on the economic impact of nutrition care interventions delivered by nutrition professionals in primary care settings, with a particular focus on their cost-effectiveness from both societal and health care system perspectives.

METHODS

A systematic review was performed following the Preferred Reporting Standards for Systematic Reviews (PRISMA) guidelines to identify and appraise economic evaluations of nutrition interventions conducted in primary care settings.[26] Specifically, we aimed to determine whether nutrition professionals are able to offer new models of care within the primary care setting for patients with relevant diagnoses, providing less costly and more effective service in comparison to the traditional approach (eg, GP support). The systematic review protocol has been registered in the International Prospective Register of Systematic Reviews (PROSPERO) (registration number: CRD420251029435).

Systematic Review Search Strategy

The full search strategy is outlined in the supplementary material. A comprehensive search of the literature was carried out with guidance from academic supervisor S.O. R. and University College Dublin librarian D.S. A comprehensive literature search was conducted across 7 databases—Ovid Medline, PubMed, Embase, CINAHL, the Cochrane Central Register of Controlled Trials (CENTRAL), and EconLit—between September and October 2024. The search strategy included a blend of key terms derived from prior research and database-specific indexing terms (eg, MeSH for Medline) to locate pertinent studies. Boolean operators, adjacency searching, and truncation techniques were applied to capture articles containing at least 1 term from each of the following 3 categories: (1) nutrition and food, (2) economic evaluation, and (3) study design (including randomized controlled trials and other randomized trials). Records were screened for suitability based on PICOS eligibility criteria (Table 1). The search was limited to studies involving human participants. No year limit was applied to the literature search. A language restriction was applied as English only, and no gray literature were searched due to time constraints.

Table 1. Summary of PICOS Terms and Inclusion/Exclusion Criteria of Studies Analyzed in this Review

	Inclusion criteria	Exclusion criteria
Design	Randomized controlled trials with quantitative data, quasi experimental designs	Nonrandomized controlled trials, observational studies; cross-sectional studies; cohort studies; qualitative data; systematic reviews
Participants	Free living people of any age, gender, race, or ethnicity	Patients undergoing treatment in hospital; outpatient clinics based in hospitals; animal studies
Intervention	Nutritional care delivered by nutrition expert (eg, dietitian, registered nutritionist) provided to groups of people or individuals; multifaceted health behavior change interventions alongside diet (eg, exercise, smoking cessation)	Nutrition care provided by nonspecialists (eg, GP, nurses, community health workers, weight watchers staff, volunteers); Interventions involving drugs/medication
Comparator	Standard care; absence of care; minimal care (eg, printed brochures); comparable care without nutritional consulting (eg, physical activity alone)	Therapy outside standard care
Outcomes	Cost-effectiveness analysis conducted to compare economic outcomes between intervention and control groups	Studies that do not account for economic evaluation between intervention and control group
Setting	Studies conducted in primary care; Studies conducted in nonacute community-based consultations, including internet interventions (eg, private practice dietitians, community-based allied health, general practice, community health clinic)	Studies conducted in institutionalized health settings (ie, acute care or facility-based care of aged patients); studies conducted in outpatient care (eg, oncology outpatient, heart failure rehabilitation clinic)
Publications		Trials for which full text is not available; Gray literature will not be used

Abbreviations: GP, general practitioner; PICOS, Population, Intervention, Comparator, Outcomes, Setting.

Selection Criteria

Studies involving free-living individuals in primary or community-based care (eg, general or private practice) were included. Multifaceted intervention studies involving nutrition professionals and other health care professionals were included to reflect the realistic and collaborative nature of health care, through which patient care often benefits from a multidisciplinary approach.[27] Institutionalized individuals (eg, in hospitals or aged care) were excluded due to controlled food intake, which could affect the outcomes of the interventions, as well as interventions involving medication due to drug-nutrient interactions, which may skew the results of a nutrition-focused intervention.

Eligible studies were required to include at least 1 consultation with a nutrition professional (eg, a registered dietitian or nationally certified nutritionist) in which nutrition care was provided. Nutrition interventions are purposefully planned acts aimed at positively altering a nutrition-related behavior, environmental factor, or well-being for an individual, specific group, or the broader population.[17] Cost-effectiveness analysis was included in this study to evaluate whether nutrition care interventions provided by nutrition professionals offer value for money compared to alternative approaches or standard care.

Data Extraction

The review was carried out by 2 researchers (C.W. and K.A.) and supervised by an academic supervisor (S.O.R.). Covidence by Veritas Health Innovation Ltd was used to manage studies throughout the screening process. The auto-marking feature of Covidence was utilized to automatically screen and exclude studies deemed ineligible based on predefined criteria, without the aid of machine learning–based prioritization tools. Additionally, the deduplication of results was carried out. Following this, the studies were assessed based on the prespecified inclusion and exclusion criteria (Table 1). This involved screening of titles and abstracts of 9433 papers, followed by full-text screening of 153 papers. Both researchers were blinded to each other's decisions and disagreements were resolved through discussion.

Following the completion of full-text screening, 25 texts were eligible for inclusion. An Excel sheet was used to extract the data, which included study author, country, design, description of intervention, description of comparator, number of participants, type of participants, age of participants, time of final measure, and overview of outcomes. A separate table was used to group the cost-effectiveness, which included cost perspective, intervention cost, comparator cost, incremental costs, and time horizon.

Quality Assessment

Quality assessment was carried out using the Consolidated Health Economic Evaluation Reporting Standards 2022 (CHEERS 2022) checklist checklist for determining the risk of bias in economic evaluation studies.[28] Each of the 25 studies eligible was assessed for risk of bias across 28 domains. This assessment was carried out independently by 1 researcher (C.W.). Study risk of bias was considered low risk at >75%, some risk at <75% and >65%, and high risk at <65%.

Data Synthesis and Meta Analysis

The review findings were compiled into narrative synthesis to present comprehensive information on all included studies (Tables 2 and 3). For the quantitative synthesis, we conducted meta-analysis following the methodology reported in Bagepally et al. (2022).[25] For inclusion in the meta-analysis, studies were required pto include reports of both incremental costs and incremental effects with corresponding measures of variance (95% CI or SD). Only studies reporting quality adjusted life years (QALYs) as the outcome measure were included in the meta-analysis to ensure comparability. We derived incremental net benefits (INB) using the formula: INB = (incremental effect × willingness-to-pay threshold) − incremental cost. Positive INB values indicate that the monetized health benefits of the intervention exceed its costs, suggesting cost-effectiveness at the specified threshold. To address the methodological challenge of comparing economic data across different countries, health care systems, and time periods, we implemented a comprehensive 3-step harmonization approach. First, all cost data were adjusted to 2024 values using country-specific Consumer Price Index data obtained from national statistical agencies, with inflation rates applied cumulatively year by year to account for compounding effects. Second, we converted all values to Euros using Purchasing Power Parity conversion factors as of November 12, 2024,[29] which account for differences in relative price levels between countries rather than merely exchange rates. Third, we standardized time horizons by calculating annualized costs for studies reporting outcomes over different periods, applying appropriate discount rates (3.5% for costs and outcomes) where studies exceeded 1 year, consistent with international health economic guidelines. This systematic approach enabled meaningful comparison of economic outcomes across heterogeneous studies while preserving methodological rigor.

For the meta-analysis, we employed country-specific WTP thresholds based on established health technology assessment standards. For high-income countries, we used thresholds of €30 000/QALY for the UK, Ireland, Western Europe, and North America and €25 000/QALY for Southern and Eastern European countries, reflecting documented variations in health care spending and economic capacity. For middle-income countries, we applied the WHO-recommended threshold of 1 to 3 times the per capita GDP of each country. These thresholds were essential for calculating INB. Sensitivity analyses using alternative thresholds (±20%) were conducted to assess the robustness of our findings to variations in societal valuations of health outcomes.

Given the anticipated heterogeneity in economic evaluations, we stratified studies by (1) country income level (high vs middle income); (2) model type (trial based vs model based); (3) time horizon (≤1 year, 1-5 years, >5 years); and (4) perspective (societal vs health care system). We assessed heterogeneity using I^2 statistics and Cochran's Q test, with values of I^2 >75% to be considered indicative of high heterogeneity. Based on these assessments, we employed a random-effects model for pooled INB calculations. We conducted prespecified subgroup analyses to explore variations in cost-effectiveness by (1) target condition (diabetes, obesity, cardiovascular disease, malnutrition), (2) intervention delivery mode (face-to-face vs telehealth), and (3) study quality (low vs moderate/high risk of bias). We performed sensitivity analyses by removing influential outlier studies to assess the robustness of our findings. Publication bias was evaluated using funnel plots and Egger's test.

RESULTS

The search resulted in 19 466 studies (Figure 1). Of these, 153 full-text studies were assessed for eligibility and 128 studies were excluded. Of the 25 studies included in this review, 17 reported both incremental costs and incremental QALYs, enabling comprehensive CEA (Figure 2). Three studies were excluded from the quantitative synthesis due to the absence of variance measures (95% CI or SDs), leaving 14 studies eligible for meta-analysis.

Study Characteristics

The 25 studies included are outlined in Table 2. Most studies were performed in primary health care facilities and enrolled participants had at least 1 risk factor for chronic disease (eg, elevated BMI or high serum cholesterol) or had been diagnosed with a health condition (eg, obesity, CVD, or type 2 diabetes mellitus). Additionally, 7 of the 25 studies included telehealth as part of intervention delivery.[30–36]

Most studies were conducted in Europe,[30,31,32,34,36–43] United Kingdom[44–49] and North America.[33,35,50,51] Fewer studies were from Australia[52] or New Zealand,[53] the

Table 2. Study Characteristics of the 25 Studies Included in This Review

Reference/country/setting	Participants/aim of intervention	Intervention/comparator	Duration, wk/dropout %	Health outcomes
Malnutrition treatment				
Pohju et al.[37] 2016/Denmark/home visits	$n = 71$ (I = 34, C = 37) aged >70 y, at risk of malnutrition/to reduce hospital readmissions	Home visits with dietitian focusing on optimizing daily protein intake and distribution/C received no dietitian follow-up	12/11.8%	Positive effect of I on nutritional status for weight, energy, and protein intake No differences in functional status, quality of life.
Dorhout et al.[38] 2021/The Netherlands/primary care	$n = 168$ (I = 82, C I = 86)/older adults/assess cost-effectiveness	12-wk intensive support program, followed by a 12-wk moderate support involving dietitians and physiotherapists. Received usual health care during first 24 wk and keep their exercise and diet habits.	24/NR	Improved chair-rise test performance over time in I, whereas C decreased their performance. No significant QALY changes between groups.
Endevelt et al. 2011.[54]/Israel/primary care	$n = 94$ (I = 35, C = 59)/Aged 75 or over at nutritional risk/To improve quality and quantity of food consumed.	Received intensive nutritional intervention led by dietitian Received standard care, which was Medical Treatment led by physician	26/NR	Intervention showed significant improvement in cognitive function and depression score compared with control group. Intervention showed significant improvement in nutritional status
Reinders et al. 2022.[39]/Finland and The Netherlands/primary care	$n = 276$ (I 1 = 96, I 2 = 89, C = 91)/older adults (aged ≥ 65 y)/To examine cost effectiveness of dietary advice on 6-mo change in physical functioning among older adults.	Intervention 1: received dietary advice face-to-face by nutritionists with aim to increase protein intake to ≥1.2 g/kg Intervention 2: intervention 1 plus ≥7.5-10 g protein within 30 min after physical activity. Control received usual care with no dietary advice	26/7%	Positive effect on intervention walk time observed for PROT −12.4 s, and for PROT + TIMING −4.9 s. Leg extension strength significantly increased in PROT (+32.6 N and PROT + TIMING (+24.3 N) compared to CON.
Schilp et al. 2014.[30]/The Netherlands/primary care	$n = 146$ (I = 72, C = 74)/older patients (aged >65 y)/To improve nutritional status of undernourished older adults.	Face-to-face and telephone consultations with dietitian. No. of consultations depended on nutritional situation, needs, and desires. Control group received usual care and standard brochure	26/11.5%	After 6 mo no significant body weight change between intervention and control (mean difference, 0.78 kg; 95% CI, −0.26 to −1.82)
Weight loss				
Anderson et al. 2018.[53]/New Zealand/Home visits and Community center	$n = 199$ (I = 100, C = 99)/aged 5-16 y, BMI ≥98th/Determine whether multidisciplinary	12-mo program with wkly group sessions during school year delivered by physical	52/1%	BMI SD score reductions similar in both groups

(continued)

Table 2. Continued

Reference/country/setting	Participants/aim of intervention	Intervention/comparator	Duration, wk/dropout %	Health outcomes
	child obesity intervention was cost effective	activity coordinator, dietitian, and psychologist and follow-up phone calls. Offered home visits every 6 mo and assessments with advice from healthy lifestyle coordinator at baseline, 6, and 12 mo		
Barton et al. 2009.[44]/UK/ Home visits	n = 198 (I = 122, C = 76)/ Adults aged ≥45 y with self-reported knee pain and overweight/Estimate cost effectiveness of 4 different lifestyle interventions for knee pain.	Participants visited dietitian and received dietary plan for 600 kcal/d deficit. Monthly visits for first 6 mo and every other mo for remainder. Leaflet based on the Arthritis Research Campaign Osteoarthritis of Knee leaflet	104/26%	Both strengthening exercises and dietary intervention more effective (0.090 and 0.133 mean QALY gain, respectively) but not cost-effective compared to control.
Gussenhoven et al. 2013.[40]/The Netherlands/ Workplace	n = 1386 (I1 = 462, I2 = 464, C = 460)/Employees with BMI >25 kg/m^2/To reduce body weight	Received lifestyle intervention program. Nutritionist trained in cognitive behavioral therapy. 10 modules regarding nutrition and physical activity over 6 mo conducted by phone or internet. Controls received self-help materials about physical activity and nutrition and no counseling.	104/45%	Body weight loss between intervention and control were not significant. 0.2 kg reduction in body weight in intervention compared with control. 0.8 kg reduction in intervention compared with control.
Hagberg et al. 2014.[31]/ Sweden/Home visits and primary care	n = 68 (I = 33, C= 35)/post-partum women who are overweight/obese and lactating/ Cost-utility analysis of dietary behavior modification treatment, compared to control	1.5 hours of individual counseling at start of intervention. 1 hour follow-up home visits after 6 wk of intervention. Additional phone support every 2 wk provided by registered dietitian. Controls received usual care.	12/16%	Costs per gained QALY were 8 643-9 758 USD.
Hagberg et al. 2019.[32]/ Sweden/Community	n = 110 (I= 54, C=56)/post-partum women/To reduce weight	Once-off 1.5 h dietitian session with personalized dietary plan, and biwkly text message or phone call for 12 wks. Usual care: Once-off written advice on healthy eating	12/NR	Intervention lost significant weight at 1 y compared to control (–10 kg vs –4.3 kg; P = .004). Weight regained at 2 y, though group differences remained significant (–8 kg vs –0.2 kg)
Panca et al. 2018.[45]/UK/ Primary Care	n =174 (I=87, C=87)/Obese adolescents/To assess costs	Intervention participants and ≥parent attended 12	26/NR	Changes in BMI in adolescents with obesity who

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Table 2. Continued

Reference/country/setting	Participants/aim of intervention	Intervention/comparator	Duration, wk/dropout %	Health outcomes
	and cost-effectiveness of HELP intervention from Health System perspective	fortnightly ∼60-min sessions with nutritionist in one-to-one meetings over 6 mo. Controls attended one one-to-one enhanced standard care session delivered by primary care nurse at general practice.		received intervention same as controls. No differences in adjusted QALYs between groups.
Robertson et al. 2017.[46]/ UK/Home visits	$n = 128$ (I= 63, C=65)/Eligible families had overweight or obese child aged 6–11 y/ Evaluating effectiveness and cost-effectiveness	10 wkly 2½-h sessions with family delivered by nutritionist. Program combines information on parenting skills and healthy eating and exercise Control received usual care which is a group-based family intervention.	52/21.4%	Change in children's waist z-score, was significantly different between groups in favor of control (0.15, 95% CI, 0.00-0.29)
Woolford et al. 2022.[33]/ USA/Community center	$n = 312$ (I= 154, C=158)/Obese adolescents/Assess ICER of 2-year motivational interviewing intervention vs usual primary care	Offered 4 in-person counseling sessions over 2 y plus 6 motivational interview-based counseling sessions (by phone or in person) with dietitians over 2 y. Control received primary care paediatrician visits only.	104/28%	Mean BMI percentile point change was 4.9 and 1.8 for intervention and control, respectively, yielding incremental reduction of 3.1 BMI percentile points (95% CI, 1.2-5.0)
Diabetes treatment				
Broekhuizen et al. 2018.[34]/ 8 EU countries and UK/ Primary care	$n = 325$ (I1= 107, I2=114, C=104)/Pregnant women with a pre-pregnancy BMI of ≥29 kg/m^2/To evaluate cost-effectiveness of intervention	Lifestyle coaching was offered during 5 face-to-face sessions of 30–45 min and 4 telephone calls of ≤20 min by nutritionist/dietitian During pregnancy, control received care as usual by their midwife.	10-15 w/32%	Intervention had less gestational weight gain compared with control at 35–37 wk (−2.3, 95% CI, −3.7 to −0.9).
Franz et al. 1995.[50]/USA/ Primary care	$n = 179$ (I = 94, Cl = 85)/ Subjects with non-insulin dependent diabetes (aged 38-76 y)/To conduct cost analysis and cost-effectiveness study	Intervention had 3 visits with dietitian, who selected appropriate nutrition prescription and educational interventions Standard care encompassed visit with GP where principles of nutrition were discussed.	26/NR	Intervention experienced mean 1.1 +-2.8mmol/L decrease in fasting plasma glucose level, 6 mo after baseline.

(continued)

Table 2. Continued

Reference/country/setting	Participants/aim of intervention	Intervention/comparator	Duration, wk/dropout %	Health outcomes
Herman et al. 2015.[35]/ USA/Community Center	$n = 2161$ (I= 1079, C=1082)/ People with glucose intolerance aged ≥25 y and overweight/To maintain a weight reduction of at least 7% of initial body weight through low-calorie, low-fat diet and physical activity	16-lesson curriculum covering diet and exercise. Curriculum was taught by nutritionists on one-to-one basis during first 24 wk. Subsequent individual sessions were designed to reinforce behavioral changes. Control received no lifestyle intervention and received placebo.	24/NR	Average follow-up 2.8 y. The incidence of diabetes was 11.0 placebo, 7.8 metformin, and 4.8 lifestyle cases per 100 person-y. Lifestyle reduced incidence by 58% (95% CI, 48%- 66%)
Huckfeldt et al. 2020.[46]/ USA/Primary care	$n = 2796$ (I= 1409, C= 1387)/ Participants with type 2 diabetes/To achieve 7% weight loss in first year and improve management of type 2 diabetes	Sessions with MDT including dietitians and aimed for 7% weight loss in year 1. Sessions occurred wkly in first 6 mo and decreased over intervention period. Phone calls utilized. Controls participated in periodic group education sessions that occurred 3×/y in first y and decreased to 1×/y later in trial.	573/NR	Similar associations with weight and HbA1c for linked sample compared with full Look AHEAD study during and after trial. During sample period from 2012 to 2015, linked intervention continued to have lower weight than control (adjusted difference: −1.9% of initial body weight; $P < .001$).
Irvine et al. 2011/UK.[47]/ Primary care	$n = 177$ (I = 118, C = 59)/ Participants were eligible for screening if they were aged 45-70 y and had a risk factor for chronic disease/ To promote 7% weight loss within 6 mo	Intervention delivered by nutritionists. 4 "core" group education sessions in first 3 mo and physiotherapist-led exercise group sessions and phone peer-support by volunteers Controls offered once off 2-h session of diet and exercise advice, considered equivalent to usual care for newly identified IFG patients.	52/NR	Over follow-up period, QALY loss of –0.001 in I group compared with –0.004 in C group. Mean loss in both groups; with I group less loss associated with QALY gain of 0.003.
Xin et al. 2019.[48]/UK/ Primary Care	$n = 298$ (I = 149, C = 149)/aged 20-65 y, diagnosed with type 2 diabetes/To estimate effectiveness and cost-effectiveness of weight management program	Total diet replacement, food reintroduction, and ongoing maintenance, delivered by dietitians in primary care. Control received usual care according to standard clinical guidelines for Type 2 diabetes	104/10%	Intervention achieved significant diabetes remission at 1 y (46% remission), improving health outcomes for participants.

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Table 2. Continued

Reference/country/setting	Participants/aim of intervention	Intervention/comparator	Duration, wk/dropout %	Health outcomes
Xin et al. 2020.[49]/UK/Primary Care	$n = 298$ (I = 149, C = 149)/aged 20-65 y, diagnosed with type 2 diabetes/To estimate effectiveness and cost-effectiveness of weight management program	Total diet replacement with low-energy formula diet for 12-20 wk, followed by structured food reintroduction and weight loss maintenance strategies by dietitians. Usual care under current clinical guidelines	104/10%	Intervention showed 46% remission at y 1; 36% remission at y 2; cost savings per participant over lifetime; incremental cost per remission achieved was £1907.
Cardiovascular disease				
Nieuwenhuijse et al. 2023.[41]/The Netherlands/Primary Care	$n = 787$ (I = 276, C = 511)/Adults (aged >18 y) at high risk for the development of cardiovascular disease/To evaluate effectiveness and cost-effectiveness of offering combined lifestyle program	Consisted of 8 group sessions and 3 individual sessions, supervised by nutritionist, on lifestyle behavior change, motivation and personal goals for behaviour change. Control received usual care	104/34%	Intervention did not improve lifestyle behavior nor cardiovascular risk.
Olsen et al. 2005.[42]/Denmark/Primary Care	$n = 503$ (I= 312, C= 191)/Patients with high BMI, dyslipidaemia, or type 2 diabetes were included/to compare costs and effects of providing nutritional counseling by GP or dietician.	Intervention by dietician consisted of individual counseling based on indication for referral, dietary history, and diet routines. Focus was on principles of good nutrition, advice on food shopping, cooking methods, meal planning, and exercise. Usual care was counseling with GP for general advice and delivery of leaflets on healthy diet.	52/33%	Nutritional counseling, compared with no counseling was an average gain of 0.0528 year. This effect, which is equivalent to 19.3 days, appears to be in the lower end, but the effect is significant (95% CI, 0.0317–0.0739). When GPs and dieticians are compared, it shows that the greatest effect appears when counseling is performed by a GP.
Other				
Chatterton et al. 2018.[52]/Australia/Primary Care	$n = 69$ (I = 33, C = 34)/Adults with mental disorders and poor diet quality/To improve diet quality among people with poor mental health	Personalized dietary advice and nutrition counseling was provided by Dietitian for up to seven individual face-to-face sessions of approximately 60 min each. Social support condition comprised manualized "befriending" protocol.	12/NR	Significant differences in mean QALYs were not found between groups. However, 68% and 69% of bootstrap iterations showed the dietary support intervention was dominant (additional QALYs at less cost) from the health sector and societal perspectives.

(continued)

Table 2. Continued

Reference/country/setting	Participants/aim of intervention	Intervention/comparator	Duration, wk/dropout %	Health outcomes
De Kinderen et al. 2016.[36]/The Netherlands/Tertiary epilepsy center	$n = 48$ (I = 26, C = 22)/Aged 1-18 y; having uncontrolled seizures/Cost-effectiveness of delivering ketogenic diet by dietitian	Keto diet introduced by dietician. Wkly telephone meetings between parents and dietician. Usual care: anti-epileptic drugs continued	17/20.8%	At 4 mo, 50% of interventions had seizure reduction ≥50% from baseline, compared with 18.2% of control.
Hoogendoorn et al. 2010.[43]%/The Netherlands/Home visits and community centers	$n = 199$ (I = 102, C= 97)/stage 2 or 3 COPD and impaired exercise capacity/to estimate cost-effectiveness of interdisciplinary community-based COPD management	Individual exercise sessions 2×/wk by physiotherapists. Nutritionally depleted patients scheduled to visit dietician 4× in first 4 mo. Patients then visited dietician 4×. Usual pharmacotherapy care received per guidelines and short nutritional advice to eat more and better	104/20.7%	Intervention had 30% (95% CI, 3%-56%) more patients with clinically relevant improvement in SGRQ total score, 0.08 (95% CI, −0.01 to −0.18) more QALYs per patient, but higher mean No. of exacerbations, 0.84 (95% CI, −0.07 to −1.78).

Abbreviations: BMI, body mass index; C, control group; COPD, chronic obstructive pulmonary disease; I, intervention group; NR, not reported; QUALY, quality-adjusted life year; SGRQ, St George's Respiratory Questionnaire.

Table 3. Cost-effectiveness outcomes of the 25 studies included in this review, grouped by disease/condition, where negative incremental costs represent the intervention was cost saving.

Study/ duration/ perspective	Country/WTP threshold	Outcomes measured/ currency	Intervention cost/comparator cost	CPI study y/CPI Oct 24	Incremental cost adjusted to Euro	Reported description of cost-effectiveness	Cost-effectiveness conclusion
Malnutrition							
Pohju et al. 2016[37]/24 wk/health system	Denmark/NA	No. of rehospitalizations	I, €92,020; C, €220,025	99.8/119.6	–€153,400	Adding dietitian to geriatric discharge liaison–team lowered health care costs	Cost-effective
Dorhout et al. 2021[38]/24 mo/societal	The Netherlands/ €80,000	Quality of life (EQ-5D-5L) and physical functioning (Short Physical Performance Battery)	I, €1119; C, €0	101.7/132.26	€1,157	Direct health care costs lower for I compared to C group. I found to have an 82.4% probability of being cost-effective.	Cost-effective
Endevelt et al. 2011[54]/6 mo/health system	Israel	Costs of services (primary care visits, medical specialist visits, no. of hospital admissions, medications).	I, $172.1±232.0 C, $428.1±382.3	91.34/109.1	-€284.38	Intensive dietary I moderately effective in lowering cost of services used, improving medical and nutritional status among older adults.	Moderately cost effective
Reinders et al. 2022[39]/9 mo/societal	Finland/ €20,000	Physical performance (Short Physical Performance Battery (SPPB) and Quality of life (EuroQol 5D-5L)	I, €928 ± 202 C , €1161 ± 256	117.4/122.92	-€243.96	From societal perspective, PROT considered cost-effective compared to CON.	Cost-effective
Schilp et al. 2014[30]/6 mo/societal	The Netherlands/ €20,000	QALY (EuroQol EQ-5D) and Body weight change	I, €4913 C, €3268	99.4/132.26	€2,188.81	Probability that dietetic treatment is cost-effective was 0.78 for a ceiling ratio of €5000 for body weight and 0.06 for a ceiling ratio of €20.000 for QALY.	Not cost-effective
Weight loss							
Anderson et al. 2018[53]/1 y/health system	New Zealand	Change in BMI SD score and program I costs	I NZ$155 (95% CI: 89, 219) C, NZ$939 (95% CI: 872, 1007)	976/1280	-€574.99	A home-based, multi-disciplinary child obesity I had lower programme costs per child, greater reach, compared to the previous hospital-based conventional model.	Cost-effective

(continued)

Table 3. Continued

Study/duration/perspective	Country/WTP threshold	Outcomes measured/currency	Intervention cost/comparator cost	CPI study y/CPI Oct 24	Incremental cost adjusted to Euro	Reported description of cost-effectiveness	Cost-effectiveness conclusion
Barton et al. 2009[44]/2 y/health system	UK/20,000	Incremental cost/QUALY	I, £647 C,£ 0	81.274/135	€1,292.89	The I was found to have a 23.1% probability of being cost effective at a £20 000/QALY threshold. Dietary I plus strengthening exercises was estimated to be cost effective for individuals with knee pain.	Cost-effective
Gussenhoven et al. 2013[40]/2 y/company	The Netherlands	I costs and cost of sick leave d based on gross and net lost productivity d	I, €201; C €	83.48/132.26	€282.01	The probability of cost effectiveness of the Internet I was 45% at WTP of 0 per extra kilogram weight loss and 75% at willingness-to-pay of 1500 per extra kilogram body weight loss.	Not cost effective
Hagberg et al. 2014[31]/2 y/societal	Sweden/USD 50 000	Incremental costs based on QALY (EQ-5D-3 L and SF-6D).	I $302.50 higher per participant	314.61/415.51	€371.55	Diet I is cost-effective	Cost-effective
Hagberg et al. 2019[32]/2 y/health system	Sweden/USD 50 000	Incremental costs based on QALY (EQ-5D-3 L and SF-6D).	I, $229 per participant C, $5	325.23/415.51	€266.15	Probability of cost-effectiveness was 97% at WTP threshold of $50 000 USD; I remained cost-effective when costs were doubled and QALY gains were halved ($7000–$32 000 USD)	Cost-effective
Panca et al. 2018.[45] /1 y/health system	UK/£30,000	Mean costs and QALYs (EQ-5D-3L) per participant	I, £918; £68	99.589/135	€1,153.90	CEAC shows probability that HELP was cost-effective relative to enhanced standard care was 0.002 or 0.046, at a threshold of £20 000 or £30 000 per QALY gained.	Not cost-effective
Robertson et al. 2017[46]/	UK/£20000	Change in children's BMI *z*-score and	I, £998 C, £548	99.589/135	€733.41	I was neither effective nor cost-effective for	Not cost effective

(continued)

Table 3. Continued

Study/duration/perspective	Country/WTP threshold	Outcomes measured/currency	Intervention cost/comparator cost	CPI study y/CPI Oct 24	Incremental cost adjusted to Euro	Reported description of cost-effectiveness	Cost-effectiveness conclusion
1 y/health system		incremental cost per QALY gain (EuroQol Five Dimensions Questionnaire Youth Version)				the management of obesity compared with UC, as the children did not lose a significant amount of weight or improve QALY.	
Woolford et al. 2022[33]/2 y/health system	USA	ICER, calculated as cost per unit change in BMI percentile for I vs usual care	I, $2013.11. C, $886.38	233.049/315.664	€1,419.18	Training pediatricians, nurse practitioners, and registered dietitians to deliver MI-based interventions for childhood obesity in primary care is clinically effective and acceptably cost-effective.	Cost-effective
Diabetes							
Broekhuizen et al. 2018[34]/22 wk/societal	8 EU countries/€24,000	ICER based on gestational weight gain	I saved €1627	103.44/132.26	-€2,080.31	Healthy eating and physical activity promotion cost-effective for QALYs after delivery, this study lends support for broad implementation.	Cost-effective
Franz et al. 1995[50]/1 y/health system	USA	Per patient costs and glycaemic outcomes	I, $112.07 C, $41.95	145.8/315.664	€141.18	Findings suggest individualized nutrition interventions can be delivered by experienced dietitians with a reasonable investment of resources. Cost-effectiveness enhanced when dietitians are engaged in active decision making about I alternatives based on the patient needs.	Cost-effective

(continued)

Table 3. Continued

Study/ duration/ perspective	Country/WTP threshold	Outcomes measured/ currency	Intervention cost/comparator cost	CPI study y/CPI Oct 24	Incremental cost adjusted to Euro	Reported description of cost-effectiveness	Cost-effectiveness conclusion
Herman et al. 2015[35]/10 y/ health system	USA/$50,000	ICER based on QALY gain (Self-Administered Quality of Well-Being Index)	I, $24,563 C, $27,468	219.179/315.664	−€3,890.94	Although more expensive, greater costs of lifestyle interventions offset by reductions in costs of non–I-related medical care. Every y after randomization, quality-of-life better for participants in lifestyle I than controls. In 10-y within-trial economic analysis, lifestyle interventions were extremely cost-effective.	Cost-effective
Huckfeldt et al. 2020[51]/11 y/ health system	USA	Total Medicare Spending	I , $15,005 C , $15,096	230.221/315.664	−€116.04	Found that reductions in health care costs in the intensive lifestyle I for type 2 diabetes diminished as participants aged.	Moderately cost effective
Irvine et al. 2011[47]/1 y/ health system	UK/£30,000	ICER per QALY gain (EuroQol EQ-5D)	I, £550.73 C, £324.89	85.498/135	€428.74	Group sessions to prevent T2DM were not estimated to be within current limits of cost-effectiveness.	Not cost effective
Xin et al. 2019[48]/2 y/ health system	UK	ICER based on additional diabetes remission.	I, £1,137 (£1,071 to £1,205) C, £846 (£685 to £1,038)	101.9/135	€463.52	Remission of type 2 diabetes within 1-y can be achieved at cost below the annual cost of diabetes (including complications).	Cost-effective
Xin et al. 2020[49]/10 y/ health system	UK/£30,000	ICER based on additional diabetes remission.	I saved £1337	107.137/135	−€2025.53	DiRECT I incorporating 10-y cost savings due to periods of diabetes remission and its complications predicted to be both more effective (QALY gain) and cost-saving compared with standard care in adults with type 2 diabetes.	Cost-effective

(continued)

Table 3. Continued

Study/ duration/ perspective	Country/WTP threshold	Outcomes measured/ currency	Intervention cost/comparator cost	CPI study y/CPI Oct 24	Incremental cost adjusted to Euro	Reported description of cost-effectiveness	Cost-effectiveness conclusion
Cardiovascular disease							
Nieuwenhuijse et al. 2023[41]/ 2 y/health system	The Netherlands/ €50,000	Health care use over 6 mo and medications. Lifestyle behavior change and cardiovascular risk based on blood test results.	I, €651; C, €671 euros	110.39/132.26	−€172.53	For both the shorter (3-6 mo) and longer term (12-24 mo), offering healthy heart program to high-cardiovascular-risk patients did not improve lifestyle behavior or cardiovascular risk; not cost-effective on population level.	Not cost effective
Olsen et al. 2005[42]/1 y/ health system	Denmark /DKK 25000	ICER based on QALY gain	I , 1642 DKK C, 755 DKK	84.5/119.6	€168.23	GP group most cost-effective, but must be concluded that both counseling strategies were relatively cost-effective. Even though cost of gaining extra life y was estimated to be 59,987 DKK in the dietician group, this price might be acceptable.	Not cost effective
Other							
Chatterton et al. 2018[52]/ 1 y/Health system and societal	Australia/AUD 50,000	ICER based on QALYs (AQoL-8D)	Health sector cost, $340 ($391) Societal costs, $1037 ($1438) Health sector costs, $790 ($1881) Societal costs, $3384 ($7683)	104.8/139.1	−€2,146.29	Novel dietary support I likely to be cost-effective as adjunctive treatment for depression from both health sector and societal perspectives	Cost-effective
De Kinderen et al. 2016[36]/ 1 y/societal	The Netherlands/ €50000	ICERs based on cost per QALY and cost per responder.	Mean total costs, 20,986.35; C mean total costs, 15,245.12	98.44/132.26	€7,713.38	Results show ketogenic diet reduces seizure frequency. No improvements found in quality of life Result: unfavorable cost per QALY ratio.	Not cost-effective

(continued)

Table 3. Continued

Study/ duration/ perspective	Country/WTP threshold	Outcomes measured/ currency	Intervention cost/comparator cost	CPI study y/CPI Oct 24	Incremental cost adjusted to Euro	Reported description of cost-effectiveness	Cost-effectiveness conclusion
Hoogendoorn et al. 2010[43]/ 24 mo/ societal	The Netherlands/ 50000	ICER based on patient with relative improvement and ICER based on QALY gain (EQ-5D)	Total costs: I, €13656 C, €10814	83.48/132.26	€4,358.50	INTERCOM significantly improved disease-specific quality of life but did not affect exacerbation rate. Cost per QALY ratio moderate but within range generally considered acceptable.	Moderately cost-effective

Abbreviations: AQoL-8D, adjusted quality of life– AUD, Australian dollar; CEAC, cost-effectiveness acceptability curve; C, control; DKK, Danish Krone; EQ-5D, EuroQol–5D I, intervention; ICER, incremental cost-effectiveness ratio; INTERCOM, intercommunication system; QUALY, quality-adjusted life years; SGRQ, St. George's Respiratory Questionnaire; UK, United Kingdom; USA, United States of America; USD, United States Dollar; WTP, willingness-to-pay; €, euro; £, UK pound.

Middle East.[54] The 25 studies contributed baseline measures for 11201 participants (median $n = 448$). Notably, 7 studies reported small sample sizes of fewer than 64 participants per group.[31,32,36,37,46,52,54] Within the studies reviewed, 4 demonstrated a greater than 20% difference in participant numbers between the control and intervention groups.[41,44,47,54] Specifically, 3 studies had significantly higher participant counts in the intervention groups,[42,44,47] while 1 study reported a higher number of participants in the control group.[41]

Dropout rates between baseline and follow-up ranged from 1% to 45% (median = 20.5%), with 9 studies not reporting the numbers of dropout.[32,35,38,45,47,50–52,54] Comparison groups included control groups receiving no intervention;[37,40,44,51] standard care, including medical care that did not include nutrition care from any health professional;[30,31,32,34,36,38,39,41,42,46–50,54] or minimal care, including attendance at a single general nutrition session or provision of a diet sheet.[33,43,45,51–53]

Risk of Bias and Quality Assessment

An overview of the quality assessment for each study is reported in Figure 2. Of the 25 studies included, 6 studies were considered low risk of bias,[32,36,41,48,49,51] 14 studies had some concerns about risk of bias[31,33–35,38–40,43–47,52,53] and 5 studies were considered high risk of bias.[30,37,42,50,54] Despite 6 studies being low risk of bias, there was no study that addressed every criterion. All studies reported the mean values for the main categories of costs and outcomes of interest. All studies had appropriate titles and abstracts, stated an appropriate research question, designed an appropriate economic analysis for the research question including the perspectives, and discussed results in line with the data presented.

Poor description of studies in the methods was common. Only 4 studies provided details on whether a health economic analysis plan was developed and where available, limiting the transparency and reproducibility of their economic evaluations.[45,48,50,51] The selection of outcomes was considered partially reported in 11 of the studies, as they failed to measure potential harms to the treatment or address the impact of nutritional intervention.[30,31,33,34,37,42,45,47,50,52,53] Three studies only partially reported their populations.[42,49,50] Characterizing heterogeneity was not accounted for in 18 of the studies as they did not adequately address variability in treatment effects across different populations.[31–34,30,36–38,40,42–45,48,49,51,52,54] Only 3 studies established mechanisms for patient and stakeholder involvement.[45,48,53]

Three studies did not adequately describe methods to characterize any sources of uncertainty in the analysis.[37,41,54] Three studies did not discuss ethical and distributional issues of their results in the discussion.[32,35,46] Five studies did not include a statement on conflict of interests.[37,42,45,49,50] Additionally, 1 study did not state the source of funding.[42] As such, results of those 4 studies should be interpreted with caution. Of the 25 studies reviewed, 14 were deemed as cost-effective by the authors, with 2 studies showing high risk of bias,[37,50] 9 having moderate concerns,[31,33–35,38,39,44,52,53] and 3 being low risk.[32,48,49] Three studies were moderately cost-effective,[43,51,54] and 8 were not cost-effective.[30,36,40–42,45–47] Furthermore, 5 of 7 (71%) of studies that utilized phone or internet to deliver nutrition care were deemed cost effective.[31–35] The study results are described in Table 3. In the malnutrition category, 3 of 5 studies were cost-effective[30,37,38], with 2 demonstrating cost savings from adding a nutrition professional and another showing lower health care costs with a multidisciplinary team. For weight loss, 5 of 8 studies were cost-effective,[31–33,44,53] with interventions reducing program costs and improving outcomes, while 3 studies found no significant difference and were not cost-effective.[33,40,46] In studies of diabetes, 4 of 6 were cost-effective,[34,35,48–50] showing lower costs and better outcomes, while others were moderately cost-effective[51] or not cost-effective[47] due to high INB values. Both studies on cardiovascular disease were not cost-effective, with 1 showing no improvement in lifestyle behavior[41] and the other showing GP interventions being more cost-effective.[42] Finally, 3 studies on mental health, epilepsy, and chronic obstructive pulmonary disease (COPD) demonstrated varied results: the mental health study showed cost savings with dietetic support,[52] the epilepsy study was more expensive without improvements in quality of life,[55] and the COPD study was moderately cost-effective due to improved quality of life, despite higher costs.[43]

Cost-Effectiveness Plane

Of the 25 studies included in this review, 17 reported both incremental costs and incremental QALY, enabling analysis (Figure 3). Of these, 9 studies found that nutrition care was both more expensive and more effective,[31,32,43,44,46] although 4 of these showed only marginal improvements in QALY ranging from 0.001 to 0.008.[38,45,47,55] Five studies reported that the interventions were both less expensive and more effective.[34,35,39,49,52] Two studies indicated that the interventions were more expensive and less effective,[38,42] while 1 study found the intervention to be less expensive and less effective.[41]

A regression analysis exploring the relationship between study duration and effects revealed a moderate association between longer study durations and higher QALY gains ($R^2 = 0.488$), and a weak association with lower incremental costs ($R^2 = 0.221$). On average, longer

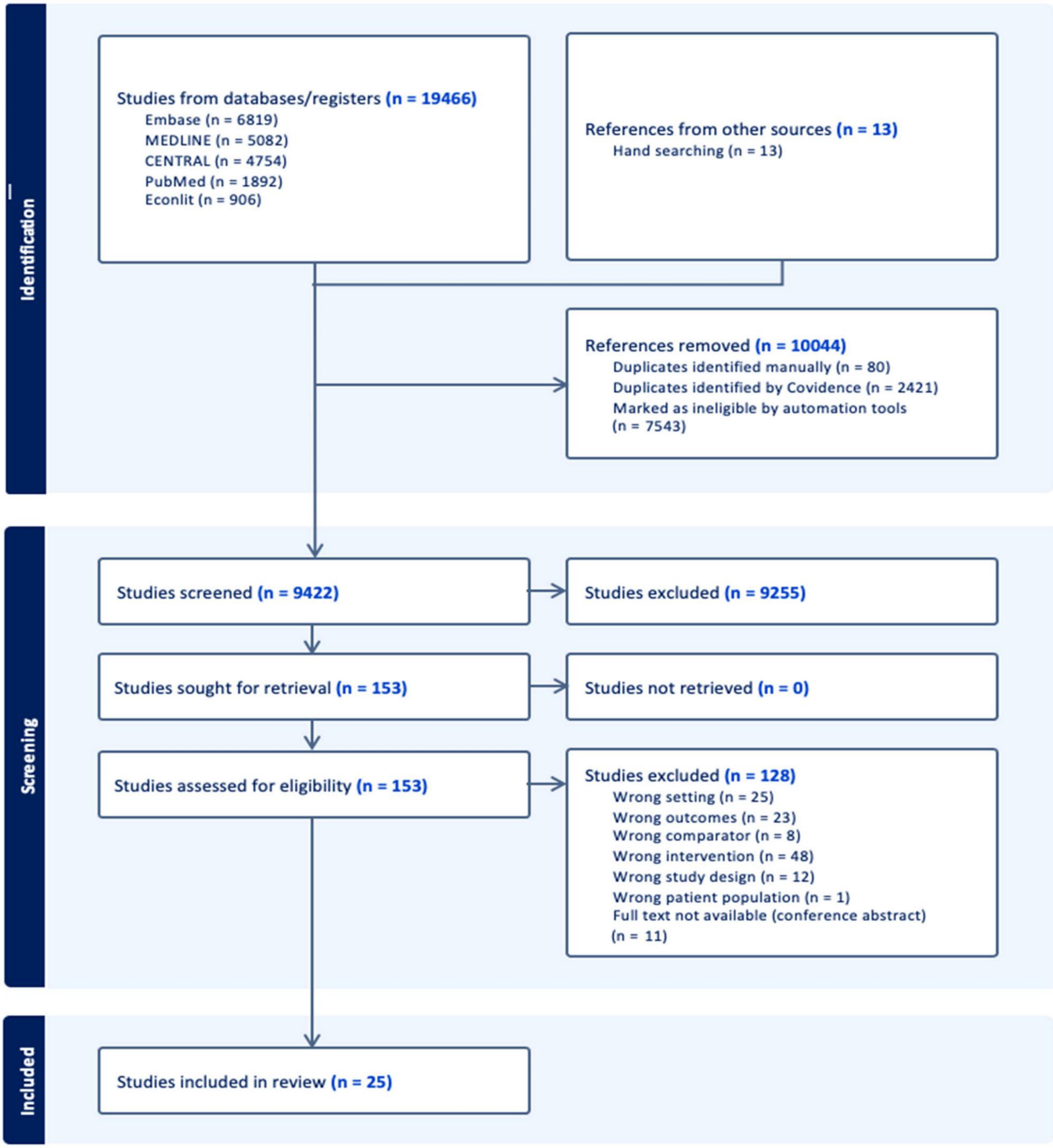

Figure 1. Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) Flow Diagram Showcasing the Screening and Study Selection Process With Reasons for Exclusion at Each Phase.

studies (120 months) demonstrated the greatest cost savings and QALY gains, while shorter studies (6-12 months) showed more variability. Additionally, interventions targeting weight loss and diabetes risk were the most effective, while CVD and malnutrition showed poorer results.

Meta-analysis

Meta-analyses were conducted on 14 studies that assessed INB associated with incremental costs and incremental QALY. Three studies were excluded from the analysis

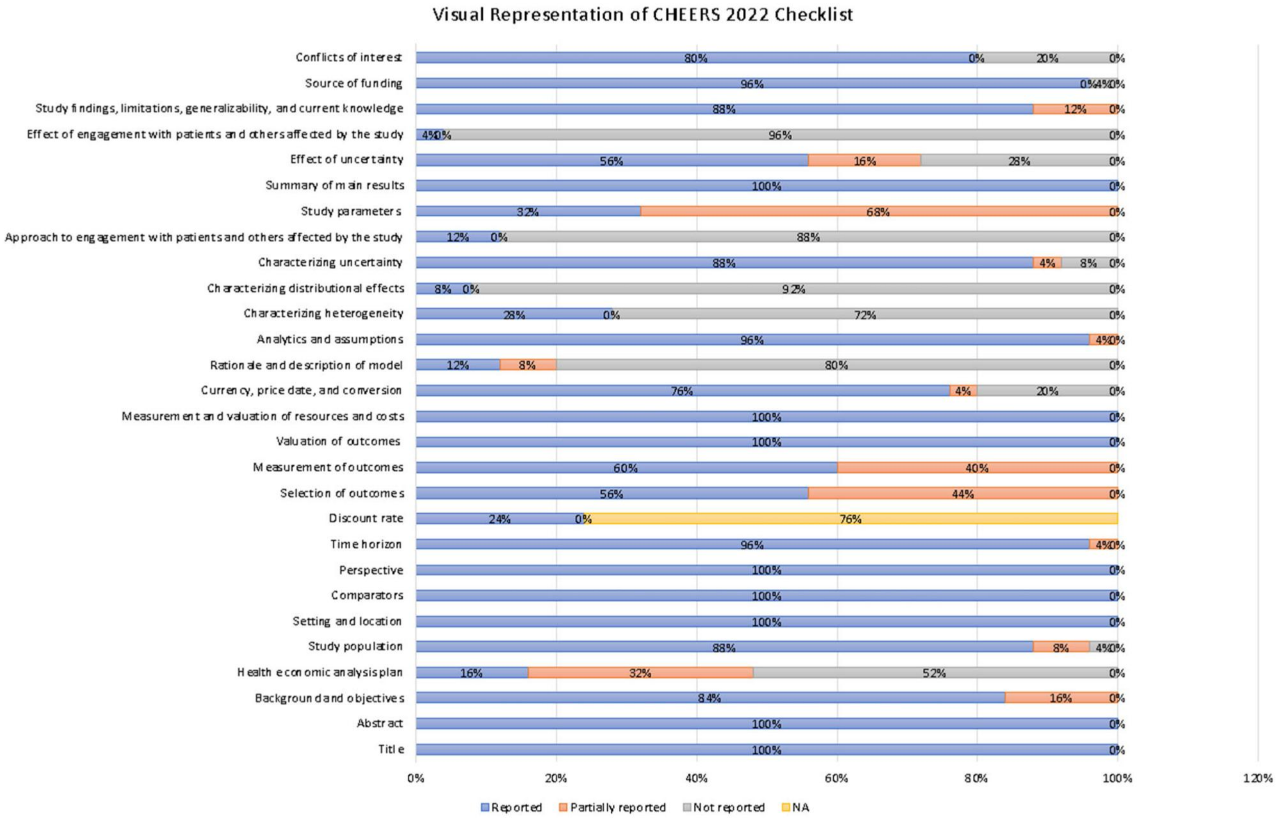

Figure 2. Quality Assessment Rating of Included Studies Using the Consolidated Health Economic Evaluation Reporting Standards 2022 (CHEERS 2022) Checklist Overview of Study Results

due to the absence of 95% CI or SD, which prevented the calculation of variance.[31,32,35] Studies were categorized into 2 perspectives: societal ($n = 7$) and health care system ($n = 7$) with separate meta-analyses for each to enhance interpretability and relevance for different stakeholders. A random-effects model was employed due to significant heterogeneity observed in both subgroups (Cochrane Q test societal 892 672, health care 1 865 083; $I^2 > 99.99\%$), indicating that the observed variations reflect genuine differences between studies rather than random error. The results are shown in Figure 4A-D.

From the societal perspective, the pooled INB was €650.32 (95% CI, €215.48-€1085.16), suggesting that nutrition interventions delivered overall monetized health benefits that exceeded their costs. In contrast, from the health care system perspective, the pooled INB was −€402.65 (95% CI, −€840.23 to €34.93), indicating that while these interventions improved health outcomes, they typically required net investments from health care budgets. Sensitivity analyses removing influential outliers significantly improved pooled INB values for both perspectives: societal perspective increased to €3107.03 (95% CI, €1020.58-€5193.48) and health care system perspective shifted to €425.99 (95% CI, €52.35-€799.63). While heterogeneity remained substantial ($I^2 > 95\%$), these robust positive values strengthen the evidence for beneficial economic outcomes across both perspectives. Publication bias assessment revealed no significant asymmetry in either perspective (Egger's test $P = .409$ for societal; $P = .842$ for health care system), suggesting our findings were not substantially influenced by selective reporting. Although the funnel plot showed some asymmetry and identified the study by De Kinderen et al. (2016) as an outlier,[36] the Egger's test ($P = .409$) did not reject the null hypothesis of symmetry, suggesting the observed asymmetry could be due to chance rather than systematic bias. The low R-squared value (0.139) further indicates that precision accounts for only a small proportion of the variation in standardized effect sizes.

In contrast, the pooled INB for the health system perspective was −€402.65, indicating that, from this perspective, the interventions were not cost saving in terms of QALY benefits. However, 1 study had a substantial impact on this result, accounting for 88.58% of the weight due to its low variance.[42] However, this article was also identified as having the highest risk of bias among the included studies.

Sensitivity Analysis

Removing the 2 studies taking up the significant weight improved the INB values for both perspectives

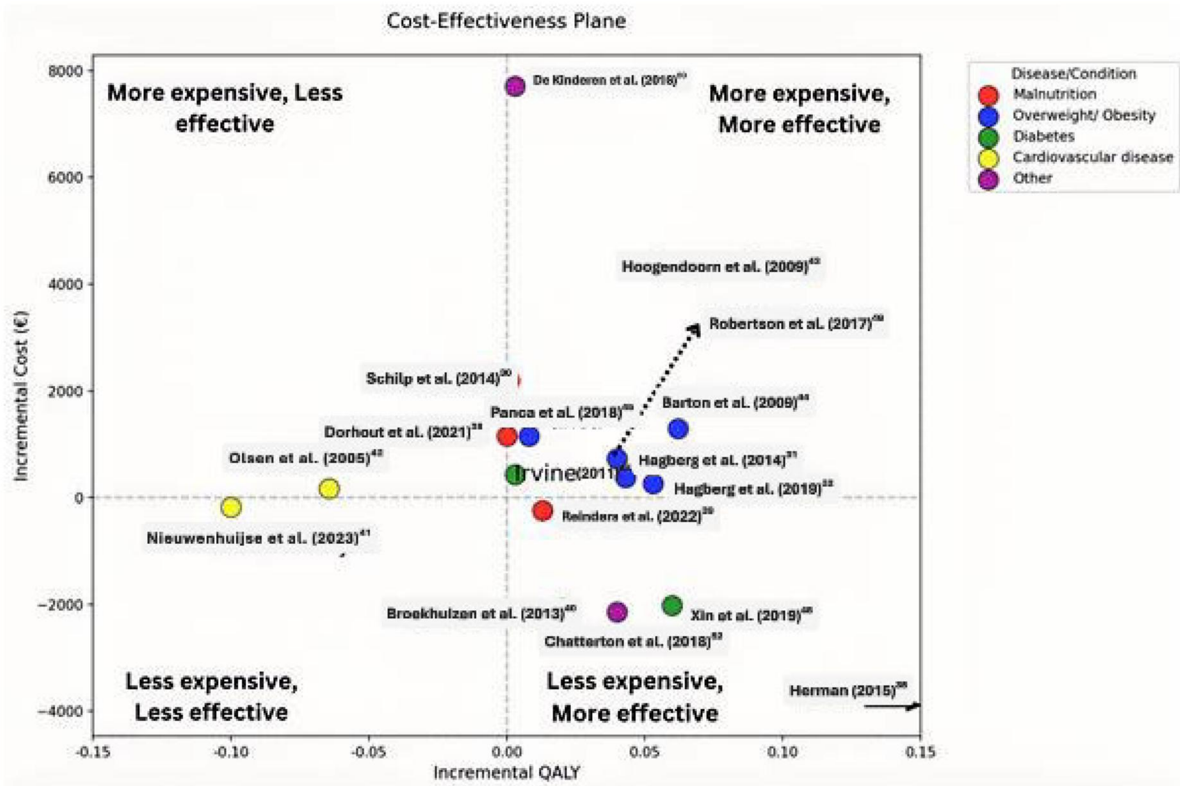

Figure 3. Cost-Effectiveness Studies (Cost-Utility Analyses Only) Mapped on the Cost-Effectiveness Plane With Incremental Costs and Quality-Adjusted Life-Years ($n = 17$), Color Coordinated by Patient Disease/Condition

significantly and improved the distribution of weights (see supplementary material).[39,42] The pooled INB of societal studies increased from €650.32 to €3107.03 and the INB of health care system perspective studies increased from −€402.65 to €425.99. However, by removing these studies, there was still substantial heterogeneity amongst results (Societal Q = 2 883 974; Health care system Q = 1 655 301) (I^2 >99.99%); implying that there is still significant heterogeneity between results.

DISCUSSION

This systematic review and meta-analysis of 25 studies provides to our knowledge the most thorough evaluation to date of the health economics of nutritional care interventions in primary care settings. Our findings reveal 3 key insights: first, nutrition interventions demonstrate advantageous cost-effectiveness from a societal perspective, but typically require initial investment from health care systems; second, specific intervention types, particularly those targeting diabetes prevention/management and utilizing telehealth delivery offer the strongest economic value; and finally, despite methodological challenges in synthesizing economic data, sensitivity analyses support the robustness of our overall conclusions, with improved pooled INB values after removing influential outliers. These results have important implications for health care resource allocation and policy development, particularly as health systems worldwide face mounting pressure to address the growing burden of diet-related NCDs within constrained budgets.

The research reported in this article outlined interventions targeting various health issues across countries with diverse health care systems and financing models, which complicated the provision of precise policy recommendations. Despite these variations, nutritional care was found to be more cost-effective than standard care in 14 of the 25 studies included in the review,[31–35,37–39,44,48–50,52,53] and moderately effective in 3 studies.[43,51,54] One of the key challenges in comparing the articles was the diversity of outcomes reported across the studies, which stemmed largely from the different population groups examined, as each of the conditions has its own specific health outcomes, timeframes, and response to nutritional interventions.

Despite this variation, the incremental QALY was the only incremental effect that could be consistently compared across studies. The pattern within a review by Barnes et al. (2022) reinforces the potential of nutritional care interventions to improve health outcomes, despite higher initial costs.[22] Additionally, 71% of studies that included telehealth in their nutrition interventions were

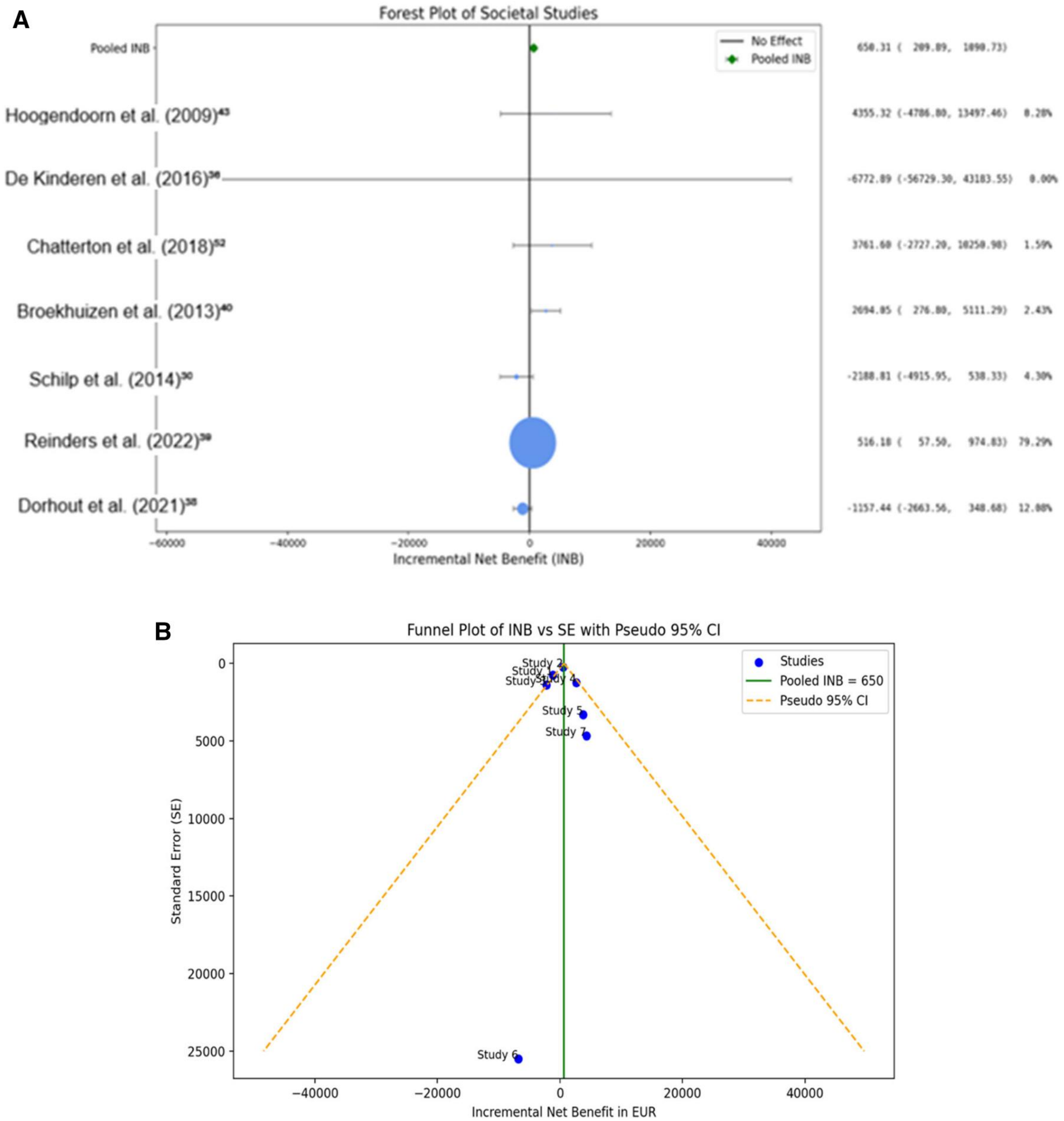

Figure 4. Meta-analytic results for cost effectiveness of primary care nutrition interventions. **A**. Forest plot of societal perspective studies weighted by variance **B**. Funnel plot of societal system perspective with pseudo 95% CI lines. **C**. Forest plot of health care system perspective studies weighted by variance. **D**. Funnel plot of societal system perspective with pseudo 95% CI lines.

considered cost-effective, corresponding with a previous systematic review which found telehealth as a cost-effective method for delivering nutrition care.[24] As telehealth has the ability to reduce travel and clinic costs, improve access, and provide flexible scheduling, it should be considered a priority by stakeholders in health promotion.[56]

The strong economic performance of telehealth-delivered nutrition interventions represents a particularly important finding with significant implications for health care service delivery. These results align with previous systematic reviews that have identified telehealth as a cost-effective delivery mechanism for nutrition care, with mHealth interventions demonstrating especially promising outcomes. The economic advantages of telehealth-based nutrition services appear to stem from multiple factors: reduced infrastructure and travel costs, improved accessibility for underserved populations, enhanced flexibility in scheduling, and potential for greater intervention adherence through more frequent but less resource-intensive patient contacts. The COVID-19 pandemic has accelerated telehealth adoption across health care systems,

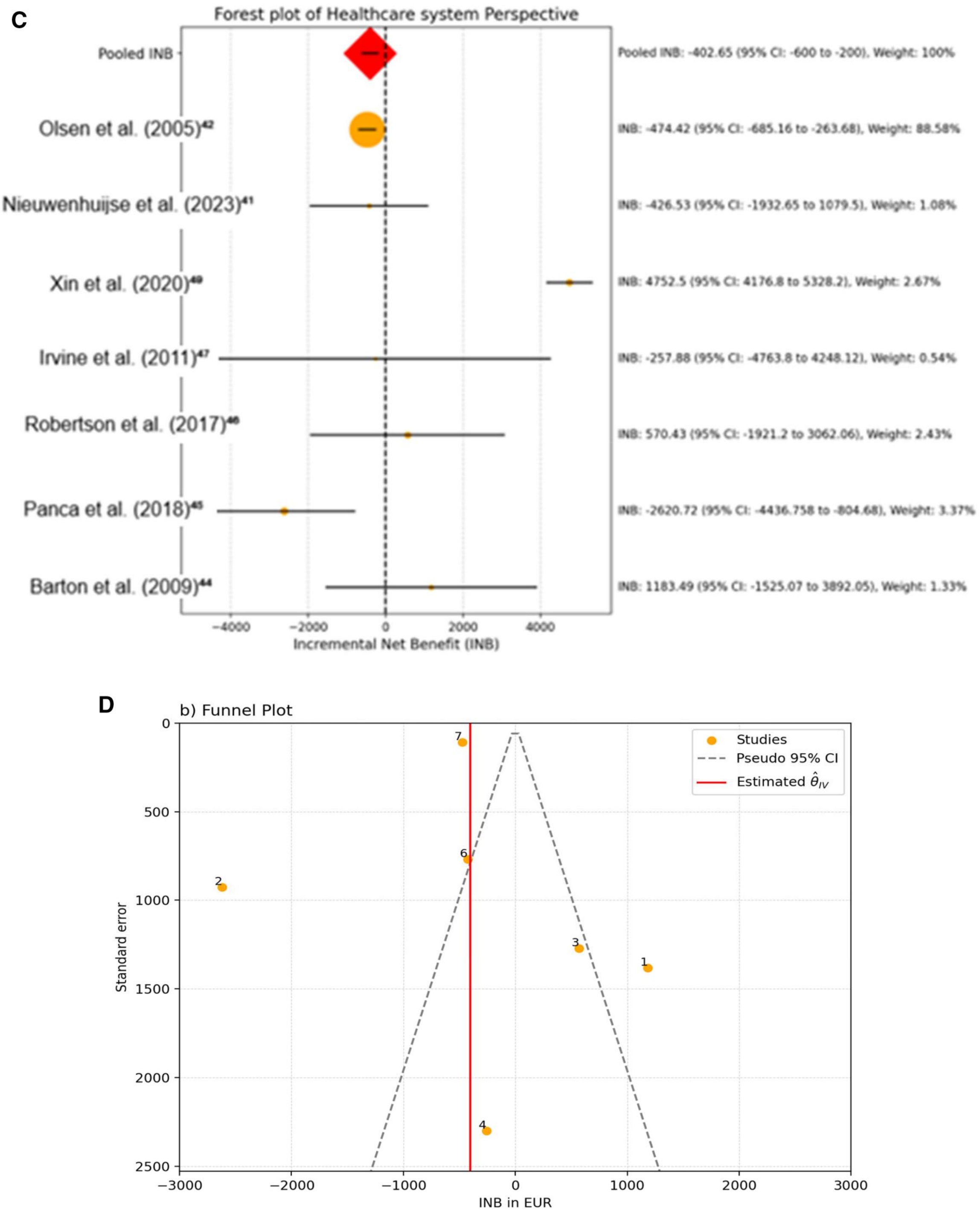

Figure 4. (Continued)

providing both infrastructure investments and institutional acceptance that may further enhance cost-effectiveness.

Our findings suggest that telehealth approaches should be prioritized in the strategic planning of nutrition services, particularly for rural and remote populations where access barriers are pronounced. Telehealth as a financially sustainable model of care offers promising avenues for scaling nutrition interventions without proportional increases in costs, potentially addressing health care workforce shortages through improved practitioner efficiency. However, important considerations remain regarding digital literacy, technology access disparities, and the need for hybrid models that maintain in-person options for complex cases or vulnerable populations. Future research should explore which components of nutrition care are most effectively delivered through telehealth mechanisms and how these approaches can be optimized across different patient populations and health conditions.

Our meta-analysis results provide mixed implications for policymakers regarding the cost-effectiveness of nutritional care interventions. First, the high degree of heterogeneity observed, which was not improved even after the sensitivity analysis, indicates a notable degree of uncertainty. Nevertheless, for the societal perspective, the pooled INB suggests that nutritional care interventions are, on average, cost-saving and could contribute to improvements in QALY. In contrast, the health care system perspective showed a negative pooled INB, indicating that, from this viewpoint, nutritional interventions were not cost-saving. However, the high influence of Olsen et al. (2005),[42] a study with a high risk of bias, and Reinders et al. (2022),[39] a study with moderate risk of bias, suggests that these findings should be interpreted with caution. After excluding these studies in the sensitivity analysis, the pooled INB improved significantly, suggesting that in the absence of influential outliers, the model weights are more consistent and results more robust, highlighting the potential cost-effectiveness of nutritional care interventions from both the health care and societal perspectives.

Disparity was noted among the timeframes, as numerous CEAs employed durations that are likely insufficient to encompass the long-term impacts of nutritional care interventions on outcomes and expenditures. Cost-effectiveness analyses with shorter follow-up durations may not adequately reflect the long-term advantages of behavioral changes, resulting in less favorable outcomes contrary to those with extended follow-up periods.[57,58] Moreover, nutrition frequently displays a preventative effect, with benefits that require extended durations to become evident.[59] Two studies from this review support this hypothesis by showing large decreases in INB when time horizons exceed 10 years, suggesting that the interventions become cost saving in the long term.[35,49] Additionally, the regression analysis on the cost-effectiveness plane indicated a moderate positive association between longer time horizons and greater QALY gains ($R = 0.448$), suggesting that the benefits of the interventions accumulate over time and may be underestimated in studies with shorter follow-up periods.

Gains in QALY varied across populations, with notably smaller improvements observed among malnourished individuals. Since all studies found in this population focused on older patients, which may explain the limited QALY gains compared to younger cohorts. These findings align with previous evidence suggesting that, in older adults, nutrition interventions often do not yield significant improvements in quality of life compared to control treatments.[60] This is likely due to the reduced life expectancy associated with ageing, which shortens the timeframe over which the benefits of interventions can be realized.[61]

This age-related effect is illustrated in 1 included study, which found no improvements in incremental QALY gain, yet had a favorable ICER when physical functioning was used as outcome measure.[38] Therefore, such findings suggest that in older populations, utilizing alternative outcomes, such as handgrip strength, may be more appropriate and sensitive indicators of intervention effectiveness. In contrast, amongst people at risk of type 2 diabetes, the QALY gains demonstrated favorable results. This finding is consistent with a previous systematic review that found lifestyle interventions to be effective in reducing body weight and improving glucose-related outcomes in primary care.[23] The cost-effectiveness of these nutrition interventions underscores their value as a strategic public health measure, particularly within health care systems that are currently facing burdens from the rising diabetes prevalence.[55] In the light of these findings and those of prior research, it would be prudent for policymakers to invest in expanding the dietetic and nutrition professional workforce within primary care. Strengthening this capacity is essential to deliver scalable, cost-effective interventions aimed at preventing and managing type 2 diabetes across high-risk populations.

Significant methodological heterogeneity was also observed between the trial-based and model-based economic evaluations included in this review, with important implications for the interpretation and generalizability of findings. Specifically, trial-based evaluations ($n = 18$) provided robust internal validity through direct measurement of costs and outcomes under controlled study conditions. However, these evaluations were constrained by relatively short time horizons (median, 12 months), which may insufficiently capture the long-term economic impact of nutrition interventions, particularly those for which benefits arise progressively over time. In contrast, model-based evaluations ($n = 7$) projected longer-term outcomes (median, 10 years) by extrapolating intermediate endpoints to final health outcomes using well-established epidemiological models. While this approach provides a more comprehensive assessment of lifetime costs and benefits, it introduces an additional parameter uncertainty that must be acknowledged when interpreting the results.

Our subgroup analysis revealed that model-based evaluations consistently demonstrated more beneficial cost-effectiveness results, primarily due to their ability to capture delayed health benefits and avoided health care costs that accumulate over extended periods. This pattern aligns with theoretical expectations for preventive interventions, which typically involve immediate costs while delivering incremental benefits over time via reduced disease incidence, slowed progression, or delayed complications. This discrepancy between short-term and long-term evaluations underscores a fundamental methodological challenge in in the economic assessment of nutrition interventions. Specifically, short-term economic assessments may systematically undervalue their contribution, particularly for conditions with long latency periods between intervention and clinical manifestation, by failing to capture their full economic potential. To address this limitation, future economic evaluations should adopt approaches that integrate rigorous trial-based data with validated modeling techniques. Such integration would enhance methodological rigor while enabling a more comprehensive estimation of the long-term economic impacts.

CONCLUSION

This systematic review and meta-analysis provided compelling evidence on the cost-effectiveness of nutrition interventions delivered by nutrition professionals in primary care settings. Our findings demonstrate that although these interventions often require initial investment from health care systems, they are cost saving from a societal perspective over the long term. The most favorable economic outcomes were observed in interventions targeting diabetes prevention and management, as well as those employing telehealth delivery models. Despite notable heterogeneity across studies, sensitivity analyses confirmed the robustness of the overall findings, reinforcing the reliability of our conclusions.

Based on these results, 3 strategic priorities for health care policymakers are supported for implementation: (1) strategic investment in primary care nutrition services integrated into multidisciplinary care models for diabetes prevention and management; (2) development of reimbursement frameworks, which acknowledge initial investment requirements, while accounting for longer-term economic benefits across sectors; and (3) expanded implementation of telehealth nutrition services, particularly for underserved and rural populations, where access barriers persist.

Future research should address key limitations identified in this review, focusing on standardization of economic evaluation methodologies for nutrition interventions, extension of follow-up periods to capture long-term economic impacts, and investigation of implementation factors that influence real-world cost-effectiveness. Given the substantial and growing economic burden of diet-related diseases, evidence-based integration of nutrition professionals into primary care represents a compelling opportunity to simultaneously improve population health outcomes and optimize health care resource utilization.

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Supplementary Material

Supplementary Material is available at *Nutrition Reviews* online.

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Conflicts of Interest

No potential conflicts of interest to declare for this review.

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