Nutrition Reviews

Special Article

Critical review of economic evaluation studies of interventions promoting low-fat diets

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Various national and local policies encouraging healthy eating have recently been proposed. The present review aims to summarize and critically assess nutrition-economic evaluation studies of direct (e.g., diet counseling) and indirect (e.g., food labeling) interventions aimed at improving dietary habits. A systematic literature review was performed by searching 5 databases (PubMed, Ovid Medline, EconLit, Agricola, and Embase) using a combination of diet-related (fat, diet, intake, nutrition) and economics-related (cost-effectiveness, cost-benefit, cost-utility, health economics, economic evaluation) key words. The search yielded 36 studies that varied in target population, study design, economic evaluation method, and health/economic outcome. In general, all provide limited experimental evidence and adopt the framework of economic evaluations in healthcare. Certain important aspects were not well considered: 1) the non-health-related effects of nutrition interventions on well-being; 2) the private nature of food expenditures; 3) the distributional effects on food expenditures across socioeconomic groups; and 4) the general economic implications (e.g., agrofoods, import/export) of such interventions. Overall, the methodology for the economic evaluation of nutrition interventions requires substantial improvement.

INTRODUCTION

Dietary trends across the world are of increasing concern, with rates of obesity and overweight rising to epidemic proportions.[1,2] Unhealthy diet and physical inactivity, together with tobacco and alcohol use, are key risk factors that contribute to a large proportion of the world's disease burden.[3] Diseases and health conditions linked to poor diet include cardiovascular diseases, diabetes, and cancers, which represent the major contributors to avoidable mortality.

In recent decades, there has been a significant change in dietary habits and physical activity levels worldwide as a result of industrialization, urbanization, economic development, and food market globalization.[3] Parallel to these changes, overnutrition has increased to the extent that 35% of adults worldwide are overweight (body mass index [BMI] ≥25 kg/m^2) and 12% are obese (BMI ≥30 kg/m^2).[4] Many governments have considered or implemented measures to address the causes of obesity by embracing increasingly comprehensive strategies that involve communities and key stakeholders (e.g., mass media campaigns and school-based and worksite interventions). In these interventions, attention has been focused on dietary improvements through nutrition education, health promotion, and counseling of individuals at

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risk. These interventions are also promoted on the basis of economic reasons because the healthcare costs associated with diseases and conditions related to unhealthy nutrition are substantial; estimates for costs associated with obesity alone are 1% to 3% of total healthcare expenditures in most countries (5% to 10% in the United States).[2]

Lifestyle changes related to diet may improve health outcomes and reduce healthcare costs associated with overweight and other disorders. The relationship between nutrition and health is well documented, and the impact of various nutrition changes on health status has been widely investigated and reported. However, evidence about the effectiveness of such interventions is frequently limited and typically involves little awareness about their economic implications (i.e., the cost-effectiveness impact).[5–9]

The increasing interest in policy actions aimed at improving people's diet suggests a crucial role for an economic analysis of nutrition interventions for clinical translational science decision-making.[7,10] The economics of nutrition can be understood as a process of researching and characterizing health and economic outcomes following nutrition interventions and nutrition recommendations.[11] Such an approach is developing as part of evidence-based health and economic research activities aimed at informing decision-makers about strategies to promote healthier and more sustainable lifestyles. Methods for the economic evaluation of healthcare interventions have been developed and refined in the last three decades[12]; however, these methods have been developed primarily to assess healthcare technologies, such as drugs, devices, and medical procedures. By comparison, economic evaluations of broader public health interventions are scarce, and the methods are not as well established.[13,14] No specific reflections or methods have been developed for interventions targeting policy decisions in the area of nutrition, despite the clear need and important stakes, which include industrial interests and direct consumer protection.[10]

Although the benefits of nutritional interventions are potentially enormous, the extant economic literature offering a full assessment of these interventions appears limited. A recent review by Gyles et al.[9] identified 30 studies presenting economic analyses of dietary improvements. These studies cover different types of interventions and are based on a variety of methods to generate data and to provide economic summaries. They generally suggest that interventions are either cost saving (i.e., they improve health outcomes while reducing healthcare expenditures) or cost effective (i.e., they improve health outcomes at acceptable levels of additional costs). Although the review corroborates the claim that nutritional interventions may be highly desirable, it also highlights the variations in the methods used and the lack of common direction about how to conduct economic studies in this area.

The aim of the present study is to summarize and critically assess economic evaluation studies conducted on direct (e.g., counseling) or indirect (e.g., food labeling) interventions aimed at promoting voluntary dietary improvements through reduction of fat intake. Indeed, it is widely reported in the nutrition literature that dietary fat intake plays a role in the development of obesity, since reducing the amount of fat intake decreases the gap between total energy intake and total energy expenditure and thus can be suggested as an effective strategy for limiting the current epidemic of obesity.[15] This review examined studies that adopted a cost-benefit type of analysis, i.e., they produced information about the positive (improved health and/or reduced costs) and negative (any adverse consequence on well-being and/or additional costs) effects of nutrition interventions whose main aim was improving dietary habits via the reduction of fat intake in diets. It is expected that such evaluations are strongly influenced by those developed in the field of economic evaluation of healthcare programs and health technology assessment.[12,16] A number of nutrition interventions that are expected to motivate individuals to modify their nutrition behavior have been considered, including nutritional counseling, information campaigns, food labeling, and extensive educational efforts. The primary aim of such interventions is reducing the intake of fats and other fattening nutrients (e.g., salt, carbohydrates), or promoting the consumption of healthy nutrients (e.g., vegetables and fruits) to rebalance dietary regimens.

METHODS

A systematic literature review was performed by following the PRISMA statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)[17] and searching 5 bibliographic databases (PubMed, Ovid MEDLINE, EconLit, Agricola, and Embase). The search strategy was executed using a combination of two sets of keywords: 1) diet-related keywords: fat, diet, intake, nutrition; and 2) economics-related terms: cost-effectiveness, cost-benefit, cost-utility, health economics, economic evaluation. The search was performed on titles and abstracts only. The search was filtered for English full-text papers only and included literature published up to March 31, 2013. All database search results were imported into EndNote software (version 6; Thomson Reuters, Philadelphia, PA) to identify duplicate papers and to screen titles and abstracts.

Two independent authors (FF and MM) investigated the relevance of the papers obtained from the initial computerized search by screening the titles and abstracts. The full text of the published literature was obtained if either reviewer identified a citation as potentially relevant. In the second phase of screening, both reviewers independently reviewed the full-text version of all included articles. Any discrepancies between reviewers were discussed until a consensus was reached. Follow-up searches (manual search) were conducted on citations found in eligible studies.

Records were screened for inclusion on the basis of predefined criteria. The papers were considered for inclusion if the following criteria were met: 1) they addressed interventions that stimulated voluntary changes in dietary habits at the individual or group level, either directly (e.g., diet counseling) or indirectly (e.g., food labeling); 2) they reported an economic evaluation of any type that documented clinical or other outcomes to improve well-being and information about the use of scarce resources (costs); and 3) they were original studies (i.e., no review articles, meeting abstracts, or editorials). Because the review focused on intentional dietary interventions, studies addressing clinical (i.e., enteral or parenteral) nutrition or undernutrition were excluded. At the same time, papers concerning fiscal policies (i.e., taxes) or other prescriptive measures (e.g., legislation or bans) were excluded unless they compared such policies with other interventions that were voluntary in nature. Studies addressing interventions of industrial modification (e.g., low-fat margarine) or fortification (e.g., with folic acid) of foods were also excluded. A predeveloped data abstraction form was used to extract information regarding title, authors, publication journal, country, year, policy instrument, target population, sample size, study design, time horizon, intervention action, comparator, clinical and economic outcomes, cost assessment, study perspective, statistical methods, data sources, and study results. Studies were assessed using the standard checklist for critical appraisal of economic evaluation studies,[12] complemented by the Consensus on Health Economic Criteria CHEC-list that focuses on the quality of economic evaluations.[18]

RESULTS

The literature search yielded 665 potentially relevant papers with 326 duplicates that were removed, leaving 339 papers to be screened by title and abstract. After exclusion and manual searches, 36 relevant studies were identified for the review.[19–54] Figure 1 outlines the flow of information through the different phases of the review and highlights the reasons for exclusion. The included studies were mainly published in US and UK journals; 3 articles were published between 1992 and 2001, 13 between 2002 and 2007, and 20 between 2008 and 2013.

Study design and population

Studies were based on data from the United States (n = 16), countries in Europe (n = 11; 5 from the Netherlands and 6 from other countries), Australia (n = 7), Vietnam (n = 1), and Canada (n = 1) (Table 1).

A variety of study designs were used. Almost half of the studies (n = 16) were based on models,[20,24,26,27,29,30,33–35,38–41,46,48,51] 7 were based on data generated through full experiments,[22,31,44,47,50,52,53] 3[23,25,54] were classified as quasi-experiments (i.e., with nonequivalent control groups), 3[37,43,46] were based on observational data with no control groups, and 7[19,21,28,32,36,42,49] adopted a mix of approaches (which typically involved modeling on the basis of trial results).

Among the modeling studies, the Markov chain was the preferred approach (n = 9) and was generally used to simulate chronic disease progression.[19–21,28,30,32,39,45,48] Studies adopting an experimental design (either alone or complemented by modeling) included randomized controlled trials (n = 8), for which the units of randomization were individuals,[19,21,22,28,36,47,50,52] and cluster randomized controlled trials (n = 5), for which the units of randomization were groups of individuals (i.e., health centers, schools, and worksites[31,32,44,49,53]). The nonexperimental studies included 1 prospective[37] and 2 retrospective cohort studies.[43,46] Half of the included studies selected study participants on the basis of a single criterion (e.g., BMI), whereas the other half combined 2 or more inclusion criteria (e.g., age, BMI, and the presence of other clinical conditions). In 21 studies, interventions were targeted to healthy individuals (i.e., the general population), whereas the remaining 15 studies[19,21,22,25,28,30,32,36,40,41,47,50–53] selected participants with specific medical conditions (mainly overweight and obesity, diabetes, hypertension).

When examining the sample size by study design (excluding models), important differences were observed. Quasi-experimental studies, such as Wootan et al.,[54] included the highest number of individuals (n = 35,000). In studies based on a pure experimental design (i.e., without modeling), the average number of individuals was 2,113 (range: 129–10,144),[31,50] with cluster randomized controlled trials recruiting more participants than randomized controlled trials. Nonexperimental studies enrolled from 368 to 3,100 subjects,[43,46] whereas the mixed designs enrolled between 64 and 3,234 individuals.[19,36]

Characteristics of nutritional interventions, clinical outcomes, and comparators

Studies were classified according to the categories of foods and/or nutrients addressed by the nutrition interventions. According to the main objective of this review, in 10 studies[21,22,30–33,39–41,54] the intervention consisted

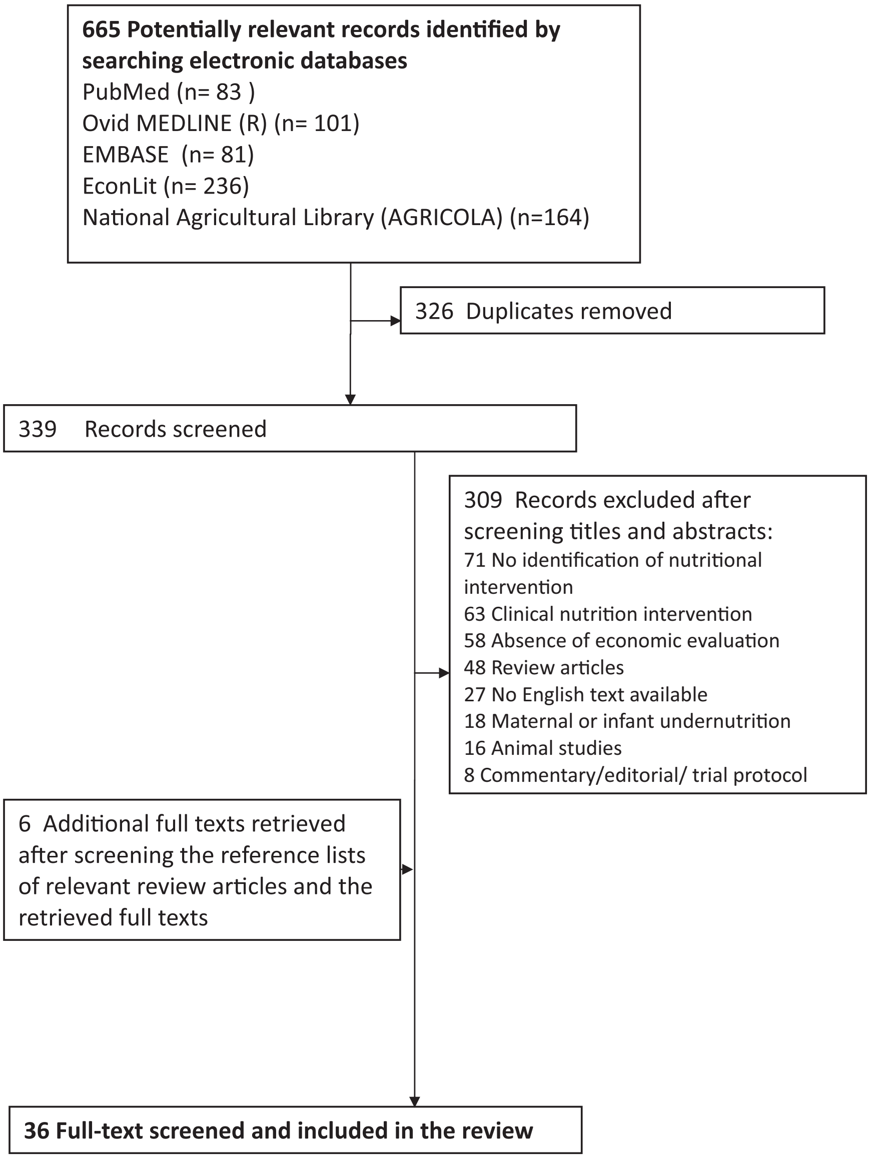

Figure 1 **Flow chart of the literature screening process.**

specifically of promoting a low-fat diet or a replacement of saturated fats with polyunsaturated fats in diet; the other studies involved encouraging salt intake reductions (n = 5),[20,24,35,36,48] fruit and vegetable consumption (n = 5),[27,34,44,49,52] low-calorie diets (n = 3),[26,38,51] low-carbohydrate diets (n = 1),[50] and so-called "junk food" (i.e., pastries, sausages, pre-made meals) avoidance (n = 1).[45] Two studies[28,42] assessed the benefits of a Mediterranean diet (i.e., high monounsaturated-to-saturated fat ratio) versus more Westernized diets. Nine studies[19,23,25,29,37,43,46,47,53] reported evaluations of unspecified or generic dietary improvements. Three studies[32,39,40] combined 2 different primary interventions (e.g., low-fat diet and salt reduction). In the reviewed studies, diet interventions were frequently associated with secondary interventions targeting other health-related behaviors (n = 10), especially physical activity and, sometimes, also smoking and alcohol intake reduction. In these studies,[19,20,30,32,36,40,44,47,52,53] it may be difficult to attribute a health improvement to each specific lifestyle change investigated.

Nutritional interventions were also classified on the basis of their health-related expected outcome and the policy instrument adopted to promote such behavioral change. As the first inclusion criterion was the voluntary nature of the nutritional intervention, the instrument preferred by the retrieved studies was nutritional counseling (n = 24): in these interventions, individuals were educated about a healthier diet and lifestyle through traditional individual and/or group lessons with a dietician or through innovative instruments such as video-lesson packets, picture books, home visits, phone discussions,

Table 1 **Characteristics of the 36 studies included in the systematic literature review.**

Reference	Population (country)	Interventions	Comparison	Clinical outcomes	Study design (no.[a])	Economic evaluation	Time/perspective	Costs categories	Discount rate	IA/SA (method)	Economic results
Ackermann et al. (2006)[19]	Adults ≥25 y with IGT (mean age: 51 y; 68% women; 45% nonwhite; BMI ≥24 kg/m²) (USA)	A one-on-one, 16-lesson core curriculum, followed by monthly visits to achieve at least a 7% weight reduction through diet and PA (DPP)	Placebo intervention: standard lifestyle intervention recommendations (30-min education session)	Intervention provided at 50 y of age: 37% of new cases of diabetes prevented before age 65 y	RCT (n = 3,234) & Markov model	CUA	Lifetime/healthcare sector	Intervention costs & direct medical costs	3%	Yes/yes (Scenario analysis)	Cost/QALY gained: USD 1,288
Bibbins-Domingo et al. (2010)[20]	Adult population (35–84 y) & subgroups (men/women; black/white) (USA)	Potential intervention: reduction of 3 g/day in dietary salt (1,200 mg of sodium per day)	Other interventions (i.e., treatment with statins, anti-tobacco interventions)	Prevention of 60,000–120,000 new CHD cases, 32,000–66,000 new strokes, 54,000–99,000 MIs, & 44,000–92,000 deaths from any cause annually	Markov cohort model	CUA	10 y/healthcare sector (Medicare)	Direct medical costs	3%	Yes/yes (PSA)	194,000–392,000 QALYs saved/USD 10–24 billion in healthcare costs saved annually
Bós et al. (2011)[21]	Postmenopausal women (50–79 y): (1) >36.8% of energy from fat; (2) >32% of energy from fat & at high risk of breast cancer (USA)	WHI Randomized Controlled Dietary Modification Trial; orientation & support meeting to encourage low-fat diet	Control group	HR for invasive breast cancer for all WHI participants, cumulative to the 8th year from the beginning of the intervention, was 0.778 ($P < 0.05$)	RCT (n = 456) & Markov model	CUA	Lifetime/society & healthcare sector (<65 y: private payer; ≥65 y: Medicare)	Intervention costs; direct medical costs; direct nonmedical costs (i.e., food costs); productivity losses	3%	Yes/yes (1-way SA & PSA)	Societal perspective: USD 13,773/QALY for group (1) & USD 10,544/QALY for group (2). Private-payer perspective: USD 66,059/QALY Medicare perspective: USD 15,051/QALY
Brannon et al. (1997)[22]	4- to 10- yr-old children with plasma TC >4.55 mmol/L (USA)	Children's Health Project; (1) Intervention group: parent-child auto-tutorial dietary education	(2) Control group: counseling program with a dietician (45- to 60-min sessions)	(1) Dietary fat as a percentage of total caloric intake (2) plasma LDL cholesterol	RCT (n = 261)	CEA	12 mo/society	Intervention cost; direct medical costs; direct nonmedical costs (i.e., heart-healthy food); parental work loss	No	No/no	(1) vs. (2): Program costs: USD 208.08 vs. USD 213.28 Cost/dietary change: USD 138.72 vs. USD 96.95 Cost/reduction in plasma LDL cholesterol: USD 20.86/mg/dL vs. USD 50.14/mg/dL
Burney & Haughton (2002)[23]	Low-income women recruited from 16 Tennessee counties (USA)	EFNEP nutrition education. Group A: collected cash register receipts from food purchases. Group B: estimated food expenditures from recall	Control group C: delaying participation until groups A & B completed EFNEP	Food, salt, & nutrient (protein, fat, carbohydrate, vitamin A, vitamin C, vitamin B_6, iron, & calcium) intake	Quasi-experimental study (nonequivalent control group); n = 384	CBA	Program costs: 6 mo/food expenditure; 5 y/society	Intervention costs (i.e., personnel, equipment, material); & food costs	3% (5%, 7%)	No/yes (1-way SA)	EFNEP cost/participant: USD 388 Food expenditure: group A, USD 10.36 ± USD 9.79 saved per month; group B, USD 19.5 ± USD 6.79 saved per month; group C, USD 5.52 ± USD 8.64 more spent per month

Table 1 **Continued**

Reference	Population (country)	Interventions	Comparison	Clinical outcomes	Study design (no.[a])	Economic evaluation	Time/perspective	Costs categories	Discount rate	IA/SA (method)	Economic results
Cobiac et al. (2010)[24]	Adult population (≥30 y) (Australia)	Four potential salt-reduction interventions: (1) The current Tick program of incentives for voluntary changes by the manufacturers (2) A government mandate to make Tick salt limits compulsory (3) Dietary advice for everyone at increased risk of CVD (SBP >115 mm Hg) (4) Dietary advice for those at high risk (SBP >140 mm Hg)	Current practice	610,000 DALYs averted (95%CI: 480,000–740,000) if everyone reduced their salt intake to recommended limits. Dietary advice: <0.5% disease burden (IHD & stroke cases) averted; Tick program: <1%; making Tick limits mandatory: 18%	Life-table modeling	CUA	Lifetime/healthcare sector	Intervention costs (Tick study: average cost/ product; dietary advice: mail-out promotion, individual counseling, group sessions); direct medical costs	3%	Yes/yes (PSA)	Both voluntary Tick program & mandatory salt reduction had a 100% probability of being dominant (i.e., cost saving) under all modeled scenarios. Zero probability of dietary advice being cost-saving or cost-effective against the AUD 50,000/DALY threshold
Cox et al. (2003)[25]	Low-income, nonpregnant female homemakers eligible for EFNEP (USA)	Video group (n = 42): 12 self-administered video-lesson packets, phone discussions, & 5 home visits	Traditional group (n = 66): 12 face-to-face group nutrition lessons	Significant improvements in both groups for fruit, calcium, & vitamins A & C. The video group improved in fiber intake ($P \leq 0.005$)	Quasi-experimental study (n = 108)	CEA	Not indicated/healthcare sector	Intervention costs (i.e., program assistant time; mileage; materials)	No	Yes/no	The video series totaled USD 4,820/y (36% of the traditional lesson cost of USD 13,463/y) for 72 participants
Dall et al. (2009)[26]	General adult population (USA)	A potential reduction in daily caloric intake of 100 to 500 kcal below current estimated energy requirements	Current practice	100-kcal reduction in daily intake: 71.2 million overweight/ obesity cases averted; 400 mg/d sodium intake reduction: 1.5 million; 5 g/d SFA intake reduction: 3.9 million	Modeling	CEA	4 y/healthcare sector	Direct medical costs	No	Yes/yes (1-way SA)	100-kcal reduction in daily intake vs. 400 mg/d reduction in long-term sodium intake vs. 5 g/d reduction in SFA: USD 58 vs. USD 2.3 vs. USD 2.0 billion savings annually
Dallongeville et al. (2010)[27]	General population (France)	Three potential policies on F&V consumption: (P1) 3.4% reduction in VAT (P2) €100/year/ person F&V stamp policy for LIC (P3) €10 M information campaign	Current practice	RRs of cancer & CVD deaths for 1 additional portion of F&V (80 g)	Modeling	CEA	Lifetime/public sector	Intervention costs (i.e., loss of tax revenues, F&V stamps, information campaign budget)	No	Yes/yes (PSA & scenario analysis)	P1 cost/LYS: €100K (57–172K); P2 cost/LYS: €474K (299–733K); P3 (pessimistic scenario) cost/LYS: €27K (14–49K); P3 (optimistic scenario) cost/LYS: €3K (1–5K)

Dalziel et al. (2006)[28]	Post-AMI patients; mean age 54 y; 91% men (Australia)	Lyon Diet Heart Study. Intervention group: Mediterranean diet delivered by a dietician or cardiologist (n = 303)	Control group: "prudent" Western diet (usual care) (n = 302)	RR of CHD deaths in the intervention group vs. control group: 0.35 (95%CI: 0.15–0.83)	RCT (n = 605) & Markov model	CUA	10 y/healthcare sector	Intervention costs (i.e., initial consults, follow-up visits, written instructions, food)	5%	Yes/yes (1-way SA)	Mediterranean diet vs. Western diet: AUD 1,013 (USD 703, €579)/QALY gained per person; 0.31 LYG/person; 0.40 QALYs gained/person
Dollahite et al. (2008)[29]	Low-income individuals (USA)	EFNEP: community-based (6 or more) food & nutrition lessons	Current practice	Incidence of diet-related conditions (i.e., CVD, CHD, IHD, colorectal cancer, osteoporosis, obesity, diabetes, foodborne illness)	Modeling	CUA & CBA	Lifetime/public sector (CBA: both societal & public-sector perspective)	Intervention costs (i.e., personnel, facilities, equipment, supplies, travel, staff training)	5%	Yes/yes (1-way SA)	Program cost: USD 892/ participant. 245 (CI: 42–935) QALYs gained; ICER: USD 20,863/QALY (CI: USD 5,467–USD 130,311); BCR (societal): USD 9.58:USD 1.00 (USD 1.44–USD 41.92: USD 1.00); BCR (public sector): USD 0.82:USD 1.00 (USD 0.08–USD 4.33: USD 1.00)
Forster et al. (2011)[30]	All overweight & obese people ≥20 y (Australia)	Two dietary weight-loss interventions: (1) DASH program (2) a low-fat diet program	Current practice	Body-weight related disease burden averted (both interventions): ≤0.1%	Life-table based Markov model	CUA	Lifetime (100 y)/ healthcare sector (societal perspective explored in SA)	Intervention costs; direct medical costs; direct nonmedical costs	3%	Yes/yes (1-way SA)	ICER (DASH): AUD 12,000/ DALY (95%CI: cost saving to AUD 68,000); ICER (low-fat diet): AUD 13,000/DALY (95%CI: cost saving to AUD 130,000)
Gans et al. (2006)[31]	Participants recruited from cluster sites in southern New England; mean age 49 y; men 42%; white 78%; Hispanic 14%; black 6% (USA)	Six minimal-contact nutrition interventions: (1) Feedback tip sheet only (CRF) (2) Tip sheet plus Rate Your Plate (RYP) (3) Tip sheet, RYP, plus Let's Eat Kit (LEK) (4) All written materials plus CD audio intervention (AUD) (5) All written materials plus counseling from a trained lay person (LAY-C) (6) All written materials plus counseling by a nutritionist (NUT-C)	No control group	BC was significantly reduced from baseline to 12-month follow-up among most experimental groups. Generally, the 2 groups receiving counseling resulted in the largest percentage change in BC levels	CRCT (clusters: 144 public, work, religious, & medical sites; n = 10,144)	CEA	12 mo/healthcare sector	Intervention costs (for screening & education)	No	No/no	Most expensive interventions (in terms of total dollar spent per unit change (mg/dL) in BC level): LAY-C (USD 5.72/mg/dL) & NUT-C (USD 5.40/mg/dL)

Table 1 **Continued**

Reference	Population (country)	Interventions	Comparison	Clinical outcomes	Study design (no.[a])	Economic evaluation	Time/perspective	Costs categories	Discount rate	IA/SA (method)	Economic results
Graves et al. (2009)[32]	Adults with type 2 diabetes or hypertension; mean age 58.2 y; 61% female; mean BMI 31.1 kg/m^2 (Australia)	Telephone counseling (a 12-mo intervention involving 18 telephone calls from trained counselors); n = 228 patients	(1) Usual care (brief intervention); n = 206 (2) Current practice (real control)	The counseling group spent substantially more time in good health behaviors (i.e., increased F&V intake, fat intake reduction, PA) than did the existing practice alternative	CRCT (clusters: 10 primary care practices; n = 434); Markov model	CUA	10 y/healthcare sector	Intervention costs (i.e., telephone counselor time; fixed overhead costs, & staff costs); direct medical costs	3%	Yes/yes (PSA & CEAC)	Telephone counseling vs. usual care: AUD 78,489/QALY; Telephone counseling vs. real control: AUD 29,375/QALY; Usual care vs. real control: AUD 12,153/QALY
Gray et al (2006)[33]	General population (Canada)	Three potential interventions: (1) Mandatory labeling system of TFAs content in food	(2) Voluntary labeling system (3) Ban (in industry) on foods with ≥2% TFA	CHD incidence rate & CHD health benefits (in dollars)	Modeling	CBA	20 y/healthcare sector; industry	Intervention costs (e.g., product reformulation); direct medical costs	5%	Yes/yes (scenario analysis)	BCR (mandatory vs. voluntary labeling): 17.6 (2.2–61.8); BCR (TFA ban vs. mandatory labeling): 24.7 (3.1–59.7)
Gundgaard et al. (2003)[34]	A random sample (i.e., 20%) of the general population (Denmark)	Increase of 150 g or 200 g F&V daily intake	Current practice	F&V intake of 400 g: +0.8 LE yrs; F&V intake of 500 g: +1.3 LE yrs. 19% & 32% of cancer incidence prevented, respectively	Life-table modeling	CEA	Lifetime/healthcare sector	Direct medical costs	No	Yes/yes (1-way SA)	Healthcare costs remained stable (≈0% of total healthcare costs) as cost savings due to lower cancer incidence were offset by longer LE
Ha & Chisholm (2011)[35]	General population (Vietnam)	A set of personal (e.g., individual treatment of SBP >160 mmHg) and nonpersonal (e.g., a mass media campaign for reducing consumption of salt) prevention strategies to reduce CVD	Current practice	IHD & stroke incidence; DALYs	Modeling	CUA	Lifetime (100 y)/society	Intervention costs (e.g., mass media) & direct medical (patient) costs	3%	Yes/yes (1-way SA & PSA)	A health education program to reduce salt intake (VND 1,945,002 or USD 118 per DALY averted) & individual treatment of SBP >160 mmHg (VND 1,281,596 or USD 78 per DALY averted) are the most cost-effective measures
Johannesson & Fagerberg (1992)[36]	Male subjects aged 40–69 y; BMI ≥26 kg/m^2; diastolic blood pressure 90–104 mmHg (Sweden)	A dietary treatment (1) to reduce body weight by at least 5%; (2) to restrict sodium intake to ≤95 mmol/d; (3) & to decrease alcohol intake in patients consuming ≥250 g/week	Drug treatment (atenolol 50–100 mg once daily as first-line treatment)	LYG, dietary treatments vs. drug treatments: (0.002–0.031) vs. (0.007–0.034)	RCT (n = 64); modeling	CEA & CBA	12 mo/society	Intervention costs (i.e., laboratory tests, dietician visits, group meetings); direct medical costs; productivity losses	No	Yes/yes (scenario analysis)	Treatment costs: SEK 8,300/patient (diet group) & SEK 7,900/patient (drug group). Drug treatment is the preferred option in 3/5 of cost-effectiveness simulations. CBA: no differences between groups
Joy et al. (2006)[37]	Low-income families (62% Hispanic; 92% female; median age 25–30 y) in 17 counties (USA)	EFNEP: Intensive nutrition education from trained professionals for 6–8 h/week over a period of 4–6 weeks	Current practice	Nutritional behaviors (e.g., increased F&V consumption, decreased fat consumption)	Observational study (n = 13,430 families)	CBA	12 mo/healthcare sector	Intervention costs & direct medical costs	5%	Yes/yes (1-way SA)	BCR ranges from USD 3.67:USD 1.00 to USD 8.34:USD 1.00

Magnus et al. (2009)[38]	Children aged 5–14 y (Australia)	Potential intervention of removing EDNP food & beverage advertising from TV during peak child-viewing times	Current practice (children's television standards, 16:00–23:00 h)	Total BMI units saved: 400,000 (95%CI: 170,000–700,000) Median BMI reduction per child: males 0.17 (95%CI: 0.05–0.32), females 0.17 (95%CI: 0.05–0.33)	Modeling	CUA	Lifetime/public sector	Intervention costs (i.e., enforcement of regulation) & direct medical costs	3%	Yes/yes (scenario analysis)	ICER: AUD 3.70/DALY (95%CI: AUD 2.40–AUD 7.70). DALYs saved: 37,000 (95%CI: 16,000–59,000). Cost savings: AUD 300 M (95%CI: AUD 130 M–AUD 480 M). The intervention is dominant
Martikainen et al. (2011)[39]	Adult population aged 30–74 y (Finland)	A potential reduction in the daily intake of salt (−1.0 g per day) & replacement of SFA (−1.0 energy percent [E%]) with PUFA (+1.0 E%)	Current practice	CVD cases prevented: 8,000–13,000	Markov model	CUA	20 y/society	Direct medical costs & productivity losses (≤65 y)	No	Yes/yes (1-way SA; PSA; scenario analysis)	QALYs gained: 26,000–45,000. Cost savings: €150–225 million
Miners et al. (2012)[40]	Obese population (UK)	A potential use of e-learning device program to promote weight loss	Conventional care (e.g., dietary information, PA)	Mean BMI	Modeling	CUA	Lifetime/healthcare sector	Intervention costs & direct medical costs	3.5%	Yes/yes (1-way SA; scenario analysis)	ICER (e-learning device vs. conventional care): £102,000/QALY
Oster & Thompson (1996)[41]	People aged 35–69 y with TC ≥5.17 mmol/L & free of CHD (Australia)	A potential reduction of SFA intake from current levels to 9% of total energy	Current practice	CHD cases prevented: between 32,000 & 99,700	Modeling	CEA	10 y/society	Direct medical costs & productivity losses	5%	Yes/no	Cost-savings: between AUD 4.1 & AUD 12.7 billion
Panagiotakos et al. (2007)[42]	Adults living in the province of Attica without evidence of CVD (Greece)	ATTICA Epidemiological study. Mediterranean diet	No adherence to the Mediterranean diet (more Westernized diet)	Mediterranean diet vs. Westernized diet: 10-y CHD risk ≥10%: 4.2% vs. 39.8% ($P < 0.001$)	Cross-sectional study (n = 3,042) & modeling	CEA	10 y/healthcare sector	Direct medical costs	No	Yes/no	Participants "closer" to the Mediterranean diet (i.e., above the median diet score) vs. those away from this diet pattern: DALYs: 0.9 vs. 6.8. ICER: €50,989
Rajgopal et al. (2002)[43]	Low-income homemakers who had participated in the Virginia EFNEP during 1996 (USA)	Prior participation in 6–12 food/ nutrition education lessons with subsequent graduation from EFNEP	No control group	Incidence of diet-related conditions (e.g., CVD, CHD, IHD, colorectal cancer, osteoporosis, obesity, diabetes)	Retrospective study (n = 3,100)	CBA	12 mo/society	Direct medical costs & productivity losses	5%	Yes/yes (not specified)	BCR: USD 10.64:USD 1.00 (USD 2.66:USD 1.00–USD 17.04:USD 1.00)
Robroek et al. (2012)[44]	Adults employed in healthcare organization, commercial services, & executive branches of government (Netherlands)	Long-term WHPP on PA & nutrition with website functionalities (i.e., action-oriented feedback, self-monitoring, & monthly e-mail messages)	Standard program (i.e., physical health check with face-to-face advice and personal feedback on a website)	No statistically significant difference in primary (i.e., PA level & F&V intake) or secondary outcomes (i.e., BMI; SBP; TC; self-perceived health)	CRCT (clusters: 74 departments of 6 companies; n = 924)	CEA	24 mo/society	Intervention costs, direct medical costs, & productivity losses	No	Yes/no	Total costs are not statistically significantly different between intervention & reference group (€9,480 vs. €10,952)

Table 1 **Continued**

Reference	Population (country)	Interventions	Comparison	Clinical outcomes	Study design (no.[a])	Economic evaluation	Time/perspective	Costs categories	Discount rate	IA/SA (method)	Economic results
Sacks et al. (2011)[45]	Adult population (Australia)	"Traffic-light" nutritional labeling (i.e., mandatory inclusion of front-of-pack TLL in selected food categories)	"Junk-food" tax (i.e., a tax on a range of unhealthy foods)	"Traffic-light" nutritional labeling versus "junk-food" tax: 1.3-kg (95%CI: 1.2–1.4) vs. 1.6-kg (95%CI: 1.5–1.7) reduction in body weight	Life-table-based Markov model	CEA & CUA	Lifetime/healthcare sector (with some industry costs included)	Intervention costs (i.e., legislation enforcement, social marketing, food labels) & direct medical costs	3%	Yes/yes (PSA; scenario analysis)	"Traffic-light" labeling versus "junk-food" tax: 45,100 vs. 559,000 DALYs averted; AUD 81 million vs. AUD 18 million cost outlays; AUD 455 million vs. AUD 5,550 million total cost offsets; Net costs/DALYs averted: dominant (for both strategies)
Schuster et al. (2003)[46]	EFNEP graduates in 1999–2000; 93% female (USA)	Prior participation in the EFNEP, with a mean of 10.4 nutrition education lessons	No control group	Incidence of diet-related conditions (i.e., CVD, CHD, IHD, colorectal cancer, osteoporosis, obesity, diabetes)	Retrospective study (n = 368)	CBA	12 mo/healthcare sector	Intervention costs (e.g., salaries, utilities) & direct medical costs	5%	No/yes (1-way SA)	CBR: USD 1.00:USD 3.36
Sevick et al. (2009)[47]	Overweight or obese (BMI ≥28 kg/m^2) elderly patients (≥60 y) with knee OA (USA)	ADAPT: (1) Diet group (2) Exercise group (3) Exercise & diet group	Healthy-lifestyle control group	The Exercise and Diet groups experienced the largest reductions in weight & in knee OA symptoms & the greatest improvements in mobility	RCT (n = 316)	CEA	18 mo/healthcare sector	Intervention costs (i.e., value of staff time, facilities, equipment, & materials) & direct medical costs	5%	Yes/yes (1-way SA)	(1) Diet: USD 35/point reduction in body weight; (2) Exercise: USD 10/point improvement in a 6-min walking distance; (3) Exercise & Diet: USD 24/point improvement in subjective function, USD 20/point improvement in self-reported pain, & USD 56/point improvement in self-reported stiffness
Smith-Spangler et al. (2010)[48]	Adults aged 40–85 y (USA)	Two potential strategies to reduce sodium intake: (1) A government collaboration with food manufacturers to voluntarily cut sodium (2) A sodium tax	Current practice	(1) vs. (2): 1.25-mm Hg vs. 0.93-mm Hg decrease in mean SBP; 513,885 vs. 327,892 strokes averted; 480,358 vs. 306,137 MIs averted; 1.3 million vs. 840,113 yrs LE increase	Markov model	CEA & CUA	Lifetime/public sector	Intervention costs (i.e., cost of collaboration with industry) & direct medical costs	3%	Yes/yes (1-way & 2-way SA; PSA)	Collaboration with industry: 2.1 million QALYs gained; USD 32.1 billion medical cost savings. Tax on sodium: 1.3 million QALYs gained; USD 22.4 billion medical cost savings
te Velde et al. (2011)[49]	Trials: children in the last grades of primary education (10–12 y of age). Modeling: all 10-y-old individuals (Netherlands)	Two school-based interventions (Pro Children & Schoolgruiten): Free F&V scheme plus a school curriculum	Control group	Pro Children intervention: 394 DALYs/100,000 averted; Schoolgruiten intervention: 236 DALYs/100,000 averted	CRCTs (Pro Children: n = 735; Schoolgruiten: n = 771); modeling	CUA & CBA	Lifetime/CUA: healthcare sector; CBA: society	Intervention costs (e.g., curriculum & materials) & direct medical costs	3%	Yes/yes (1-way SA; PSA)	ICER (Pro Children vs. no intervention): €5,728/DALY; ICER (Schoolgruiten vs. no intervention): €10,674/DALY

Tsai et al. (2005)[50]	Severely obese subjects (BMI = 42.9 kg/m^2) with diabetes or metabolic syndrome (USA)	Low-carbohydrate diet (i.e., >30 g of carbohydrate per day: 10% of amount normally recommended for a 70 kg-male)	Standard diet (restriction of calories, total fat, SFA, and cholesterol)	Weight low with low-carbohydrate vs. standard diet: 5.1 ± 8.7 kg vs. 3.1 ± 8.4 kg (P>0.2) at 12 mo	RCT (n = 129)	CUA	12 mo/society	Intervention costs (i.e., dietician's wage), direct medical costs, & productivity losses	No	Yes/yes (1-way SA)	Low-carbohydrate vs. standard diet: Costs: USD 6,742 vs. USD 6,249 (P = 0.78). QALYs: 0.64 vs. 0.61 (P = 0.17). ICER: USD −1,225/QALY (the standard diet is dominated)
van Baal et al. (2008)[51]	All individuals between 20 and 70 y of age with a BMI ≥30 kg/m^2 (Netherlands)	Two interventions: (1) low-calorie diet-only (2) low-calorie diet plus 1 year of pharmacologic treatment (orlistat)	Current practice (i.e., current primary care practice in the Netherlands)	Percent of individuals moving from obesity to overweight with diet-only vs. diet + orlistat intervention: 1% vs. 1.9%	Modeling	CUA	Lifetime/healthcare sector	Intervention costs (e.g., drugs, food diaries) & direct medical costs	Effects: 1.5%; costs: 4%	Yes/yes (1-way SA; PSA)	ICER (cost/QALY): €17,900 for the low-calorie diet-only vs. no intervention and €58,800 for the low-calorie diet + orlistat vs. the low-calorie diet-only
van Keulen et al. (2010)[52]	Adults (45–70 y); 55% men; 50% with hypertension (Netherlands)	Three interventions: (1) TPC (2) TMI (3) a combination of the two, with the aim of increasing PA and F&V consumption	Control group	+0.62 (TPC), +0.40 (TMI), +0.50 (combined), +0.26 (control) public health guidelines met compared with baseline	RCT (n = 1,629 from 23 general practices)	CEA & CUA	18 mo/healthcare sector	Intervention costs (e.g., printing & mailing letters for TPC, call charges for TMI)	No	Yes/yes (CEAC)	QALYs: 1.09 (TPC), 1.08 (TMI), 1.08 (combined), 1.07 (control); Intervention cost/per person: €57 (TPC), €107 (TMI), €80 (combined), €0 (control)
van Wier et al. (2012)[53]	Adult employees (≥18 y) from service-sector companies; 67% male; mean age 43 y; mean BMI 29.6 kg/m^2 (Netherlands)	(1) Phone group: self-directed lifestyle brochures plus a workbook-based program with phone counseling (2) Internet group: self-directed lifestyle brochures plus a web-based program with e-mail counseling	Self-help group: self-directed lifestyle brochures only	No significant differences in changes in body weight & QALYs between the intervention groups & control group	CRCT (clusters: 7 service-sector companies; n = 1,386)	CEA & CUA	24 mo/society	Intervention costs (e.g., for website development), direct medical costs, & productivity losses	QALYs: 1.5%; costs: 4%	Yes/yes (CEAC)	Phone group: ICER: €1,009/kg weight loss; ICUR: €245,243/QALY. Internet group: ICER: €16/kg weight loss; ICUR: €1,337/QALY. No intervention was proven to be cost-effective vs. self-help
Wootan et al. (2005)[54]	General populations; 4 West Virginia communities (populations ranging 18,000–35,000) (USA)	"1% or less" mass-media campaign: (1) paid advertising (2) media relations (3) community-based educational programs to encourage a switch from high-fat (whole or 2%) to low-fat (1% or skim) milk	Current practice	Changes in low-fat milk sales & self-reported switching to low-fat milk	Quasi-experimental study	CEA	5 y/public sector	Intervention costs (e.g., media advertising, personnel salaries)	No	No/no	Most cost-effective campaign: (1) + (2): USD 0.57/person (switching from high- to low-fat milk). Less cost-effective campaign: (2) + (3) (USD 11.85/person)

Abbreviations: ADAPT, Arthritis, Diet and Physical Activity Promotion Trial; AMI, acute myocardial infarction; AUD, Australian dollar; BC, blood cholesterol; BCR, benefit-to-cost ratio; BMI, body mass index; CBA, cost-benefit analysis; CBR, cost-to-benefit ratio; CEA, cost-effectiveness analysis; CEAC, cost-effectiveness acceptability curves; CHD, coronary heart disease; CI, confidence interval; CRCT, cluster randomized controlled trial; CUA, cost-utility analysis; CVD, cardiovascular disease; DALY, disability-adjusted life years; DASH, Dietary Approaches to Stop Hypertension; DPP, diabetes prevention program; EDNP, energy-dense, nutrient-poor; EFNEP, Expanded Food and Nutrition Education Program; F&V, fruit and vegetable; HR, hazard ratio; IA, incremental analysis; ICER, incremental cost-effectiveness ratio; ICUR, incremental cost-utility ratio; IGT, impaired glucose tolerance; IHD, ischemic heart disease; LAY-C, lay-administered face-to-face counseling; LDL, low-density lipoprotein; LE, life expectancy; LEK, Let's Eat kit; LIC, low-income consumers; LYG, life-years gained; LYS, life-years saved; MI, myocardial infarction; NUT-C, nutritionist-administered counseling; OA, osteoarthritis; PA: physical activity; PSA: probabilistic sensitivity analysis; PUFA: polyunsaturated fatty acids; QALY, quality-adjusted life-years; RCT, randomized controlled trial; RR, relative risk; RYP, Rate Your Plate; SA, sensitivity analysis; SBP, systolic blood pressure; SEK, Swedish crowns; SFA, saturated fatty acids; TC, total cholesterol; TFA, *trans*-fatty acids; TLL, traffic-light labeling; TMI, telephone motivational interviewing; TPC, tailored print communication; USD, US dollar; VAT, value added tax; VND, Vietnamese Dong; WHI, Women's Health Initiative; WHPP, workplace health promotion program.

[a] Number of subjects at study entry.

and e-mail messages. In 3 articles,[35,38,54] the nutrition education was carried out at a population level; among them, Wootan et al.[54] assessed the effects of a public information campaign encouraging a switch from whole to skim milk, whereas Magnus et al.[38] evaluated a control program of energy-dense food and beverage TV advertising. Four modeling studies[27,33,45,48] predicted the health-related and economic effects of potential policy interventions, such as banning industrial *trans*-fatty acids or raising taxes on a range of unhealthy foods. According to the purpose of this review, these prescriptive measures were compared with voluntary nutrition interventions (e.g., public information campaign, food labeling). In the remaining models,[20,26,34,39,41] the nutrition intervention was not specified, as the objective was to predict the effects of potential diet improvements (e.g., a potential reduction of saturated fatty acids intake) without reporting how to get them.

Twenty-seven studies targeted specific medical conditions, mainly cardiovascular disease (i.e., stroke, myocardial infarction; n = 10)[20,24,27,28,33,35,39,41,42,48] and overweight and obesity (n = 10)[26,30,36,38,40,45,47,50,51,53]; 2 papers focused on cancer[21,34] and 2 on diabetes,[19,32] and 3 addressed outcomes associated with a mix of diet-related diseases such as cardiovascular disease, cancer, diabetes, and osteoporosis.[29,43,46] Nine studies did not address any specific health-related condition and generically aimed to improve food-related behaviors.[22,23,25,31,37,44,49,52,54]

In most studies (n = 21), nutritional interventions were compared with no intervention. Six studies[22,25,28,33,42,45] compared 2 alternative nutritional programs, with the intervention group typically testing a more innovative approach to dietary behavioral change than the control group (e.g., video-lesson packets vs. face-to-face group nutrition lessons; Cox et al.[25]). Seven studies[19,23,32,44,47,50,53] used the same primary intervention as a comparator, but in a milder version (e.g., a 12-month intervention vs. a brief intervention; Graves et al.[32]). In 2 studies,[20,36] the alternative action was a non-nutritional intervention (i.e., a drug treatment with atenolol or statins).

Characteristics of economic evaluations

Three types of economic evaluations developed to assess health technologies were used in the reviewed studies: cost-effectiveness analysis (n = 11), which presents economic results as cost per unit of health gain (e.g., cost per case averted or cost per year of life gained); cost-utility analysis (n = 13), in which the unit of benefit is expressed in terms of an index capturing both quantity and quality of life, which are typically expressed as quality-adjusted life years (QALYs) or disability-adjusted life years (DALYs); and cost-benefit analysis, in which both costs and benefits are expressed in monetary terms (n=5). Seven studies used a combined design of cost-effectiveness analysis, cost-benefit analysis, and/or cost-utility analysis. There was substantial variation in the types of costs used to monetize the use of resources, with most studies (n = 29) reporting direct costs associated with the implementation of the nutritional intervention (e.g., dietician salary). When the policy instrument adopted was a public information campaign, the intervention costs included media and/or communication costs (e.g., media advertising; Wootan et al.[54]). Modeling studies predicting the impact of legal (or fiscal) measures generally estimated the costs of collaboration between government and industry, the costs of enforcing legislation or administering taxes, and, in one case,[33] the industrial costs of product reformulation. On the contrary, 7 studies did not include any intervention costs because the intervention action was not specified, as was often the case in modeling studies.[20,26,34,39,41–43]

Direct medical costs (e.g., hospitalization, emergency room, prescription medications, and medical consultations) associated with the treatment of the targeted diet-related medical conditions were included in the vast majority of the studies (n = 26). Three studies also estimated direct nonmedical costs, such as healthier food costs and travel costs to healthcare facilities.[22,23,30] Eight studies incorporated productivity losses, foregone wages, and time used by patients and family caregivers to obtain treatments.[22,36,39,41,43,44,50,53] A discount factor ranging from 3% to 7% was applied to future costs and effects in 23 studies.

On the basis of the cost categories included in their analyses, papers were classified according to 3 perspectives. Twenty studies adopted a narrow perspective in which only costs borne by the healthcare system were included. Thirteen studies included other costs to proxy a societal perspective; typically, these costs refer to nonmedical services (e.g., social care), productivity losses, and time spent by patients and caregivers.[21–23,30,35,36,39,41,43,44,49,50,53] Three studies[27,29,54] were classified according to a public-sector perspective because they included only costs supported by governmental bodies to implement the nutrition intervention (e.g., media advertising, information campaigns, fruit and vegetable stamps for low-income consumers), with no reference to the impact on healthcare expenditure. The level of specification of cost analysis and the approach used for cost measurement differ widely across studies. Four studies[25,28,31,52] that adopted a healthcare-sector perspective limited their analysis to the intervention costs (e.g., for screening and education) without assessing disease-related costs. By contrast, Gray et al.[33] and Sacks et al.[45] added certain industry costs to the healthcare costs. Two US-based studies[20,21] distinguished between public and private payers. However, all other studies ignored the distinction between public and private sources of costs induced by the intervention and did not discuss their implications in equity terms.

The length of follow-up of the studies with a longitudinal design ranged from 6 months[23] to 10 years.[28,32] Pure experimental studies (i.e., without modeling) typically had a limited length of follow-up (i.e., 2 years maximum[44,53]), which, in other papers, was extended through modeling techniques. Modeling studies had the longest time horizon because they generally predicted health and economic outcomes over the individuals' entire lifespans. None of the studies provided direct empirical evidence of the long-term effects of interventions.

The vast majority of the studies (n = 29) tested the robustness of the results through a sensitivity analysis. The techniques most frequently adopted were one-way sensitivity analysis (n = 17) and probabilistic sensitivity analysis (i.e., Monte Carlo simulations; n = 11). Some studies also presented their results by utilizing different scenarios (i.e., scenario analysis; n = 8), while a few others (n = 3) used cost-effectiveness acceptability curves. A considerable number of authors (n = 10) adopted 2 or 3 sensitivity analysis techniques within the same study.[21,27,32,35,39,40,45,48,49,51] The parameters that were tested primarily through the sensitivity analyses were time-related variables (e.g., time horizon, discount rate, proportion of lifelong effects), disease incidence rates (e.g., cardiovascular risk), and direct medical costs.

Study results/outcomes

The main results of the economic evaluations were abstracted from each study (Table 1). To assess the consequences of a nutritional intervention, 21 studies adopted a clinical endpoint (e.g., strokes prevented), whereas 9 studies[22,31,38,40,44,45,47,50,53] used a clinical surrogate (biomarker), such as systolic blood pressure, high-density lipoprotein, blood cholesterol, body weight, and BMI. Six studies[23,25,32,37,52,54] limited their outcome assessment to the direct behavioral consequences of the intervention (e.g., intake of fat, fruit and vegetables, salt, and other nutrients; milk consumption, health guidelines met). The diet or nutritional status of the individuals participating in the studies was assessed through dietary questionnaires (e.g., diet diaries, 24-h diet recalls, food frequency questionnaires) or through health screening that measured biomarkers (e.g., blood cholesterol) of nutrient intake.

Different economic evaluation techniques were used to assess the interventions. The cost-utility analysis studies generally used QALY as a measure of well-being (n = 13), although 7 studies measured improvement in terms of DALYs,[24,30,35,38,42,45,49] the measure that corrects life expectancy for disability and that is used by the World Health Organization for assessing healthcare systems.[55] Cost-effectiveness studies presented results in terms of cost per unit of physical measure of benefit, such as kcal, body weight, or total cholesterol. However, in these analyses, interventions were frequently cost saving, which made the issue of how to measure clinical benefits less relevant. In only 7 studies,[23,29,33,36,43,46,49] the authors attempted to express both costs and benefits in monetary terms. In these studies, a variety of methodological choices were used, including the manner of presenting results (net monetary benefits, benefit-cost ratio, or [the opposite] cost-benefit ratio). Burney and Haughton[23] derived the net present value to evaluate benefits and costs in a time dimension and expressed benefits as the difference between participants' food expenditures before and after the intervention. In other articles,[33,43,46] benefits were characterized as disease costs avoided because of program results. In 2 recent studies, benefits were expressed as the value of QALYs gained[29] and DALYs averted.[49] Three studies[29,36,49] adopted a willingness-to-pay approach to estimate the program benefits.

The vast majority of the studies concluded that the intervention examined was cost saving (n = 18)[20,22–26,29,33,37–39,41–43,45,46,48,49] or cost effective (n = 11)[19,21,27,28,31,32,34,35,47,51,54] compared with the status quo. By contrast, 7 studies[30,36,40,44,50,52,53] concluded that the nutrition intervention was not cost effective or that health outcome improvements were negligible.

According to the Consensus on Health Economic Criteria CHEC-list, ethical and distributional issues should be considered when evaluating healthcare interventions. In the context of this review, individual accessibility and the affordability of nutritional programs are crucial elements to be analyzed. Fifteen papers mentioned some equity aspects: subgroup analyses (by race, gender, age, income, education, marital status, and health condition) were conducted in 5 studies,[20,27,41,44,45] and 10 studies focused on individuals belonging to ethnic minority groups (e.g., Alaskan) or lower socioeconomic communities.[21,23,25,29,31,32,38,43,46,50] However, no study discussed the equity implications of interventions that may impose additional private expenditure.

DISCUSSION

The research strategy used in this review identified only 36 published studies in the English language that performed economic evaluations of interventions aimed at improving nutritional habits. Given the potential health gains related to such interventions, the paucity of such studies is alarming and indicates that additional evidence in this area is needed. It is difficult to design evidence-based policies with so little empirical evidence.

Fortunately, many more studies than those reviewed here have investigated nutritional interventions from only a clinical perspective. A systematic review of 33 randomized controlled trials and 10 cohort studies by Hooper et al.[56] suggested that diets lower in total fat were associated with lower relative body weight (−1.6 kg; 95%CI: −2 kg to −1.2 kg). The authors included studies in which a low-fat diet was compared with a normal diet or in which a low-fat diet plus any nondietary intervention was compared with a normal diet plus an identical nondietary intervention. However, the authors excluded studies in which a low-fat diet plus any nondietary intervention was compared with the normal diet alone.

Nutritional interventions have many socioeconomic implications, and it is difficult to conceive of evaluations that do not attempt to include these aspects. Without valid and reliable assessments of the effects on well-being and resource consumption attributable to interventions aimed at changing human habits, the risk of policy failure in conception and implementation is very real. To obtain adequate inputs from applied science, policymakers must know the health benefits of these interventions over both the short and the long term, the possible adverse effects (e.g., in terms of loss of well-being due to changes in nutrition), and the costs to individuals and public sector agencies. Without such evidence, policy can be only tentative and is subject to being easily overtaken by vested interests or biased perspectives. Although no specific guidelines or methodological recommendations for economic studies of nutritional interventions could be found in the current literature, some characteristics of the reviewed studies can be discussed. Modeling is the dominant evaluation strategy. As with the evaluation of drugs and other health technologies, it is virtually impossible to produce economic evidence without some modeling. However, to avoid simple speculations, models should be populated with data obtained from valid empirical studies and should follow good-practice recommendations. It is outside the scope of this study to reflect upon the type of empirical designs that are best suited to provide economic evidence for nutritional policies. Such reflections should consider the pros and cons of experiments, quasi-experiments, and observational studies and, equally important, the benefits of combining these designs. In the context of this review, the main point is that few studies are grounded in rigorous evidence, and many modeling studies present potential effects that are conditional on a long series of unproven assumptions rather than valid empirical evidence.

Not surprisingly, the vast majority of studies follow methodological practices developed for the economic evaluation of healthcare interventions. This strategy is endorsed by some scholars.[14] Cost-utility analysis is the preferred type of analysis, and the focus of cost analyses is on healthcare resources. The formidable development of economic evaluation methods for healthcare programs and health technology assessment in general provides a strong methodological basis for the economic evaluation of nutritional interventions. Nevertheless, a thorough understanding of the consequences of the dissimilarities between traditional health technologies and nutrition interventions is fundamental to determine the potential of the dominant methods in health economics. Here, four issues that deserve further attention are addressed.

First, nutrition habits are culturally and socially embedded and therefore differ substantially from medical services. From one perspective, this situation calls for adequate empirical research to evaluate how to induce behavioral changes rather than simply investigating the comparative benefits of nutrients. Policymakers must know not only what nutrients should be promoted or discouraged but also how to trigger change. Both types of evidence are required to provide guidance for policymaking. From an economic perspective, one of the main issues is that nutrition habits are linked to eating and have wider implications for personal well-being. It is limiting to understand nutrition as only functional to health because people enjoy food and the rituals associated with it. This issue challenges the use of QALYs and other health-related measures to fully quantify the effects of nutritional interventions on well-being. Moreover, cost-benefit analyses of nutrition interventions should be expanded on a population basis to identify the most effective and economically sustainable strategies of action.[57]

Second, institutional guidelines, such as those of the National Institute for Health and Care Excellence (NICE) in the United Kingdom, the Agency for Drugs and Technologies in Health (CADTH) in Canada, or the Pharmaceuticals Benefits Advisory Committee (PBAC) in Australia, restrict the analysis of costs to those borne by the healthcare system and, in some circumstances, by the formal social care sector. Typically, they assume that efficiency improvement derives from a better allocation of resources pursued through the systematic use of cost-effectiveness ratios. Given an amount of resources available (e.g., the budget of the public healthcare system), funding the most cost-effective interventions should allow for the maximization of health benefits. The issue with nutrition interventions is that food expenses are generally private and are not part of a public healthcare budget; thus, nutrition interventions aim to change consumer behavior. The relevant constraint in this case is the aggregate disposable family income, which can be used for all possible sources of well-being. For these reasons, research should investigate whether cost-effectiveness and cost-utility analyses are appropriate to evaluate the entire set of relevant costs and benefits associated with nutritional interventions.

A third issue concerns distributional effects. Because food expenses are typically private, changes in food consumption patterns modify households' financial constraints and their allocation of resources. If, as is frequently the case, healthier diets induce variations in expenses, policies will have different economic implications across socioeconomic groups. For example, wealthier households have lower opportunity costs for additional food expenses than poorer households. In other words, unless they are highly subsidized, interventions targeted to change nutritional habits have relevant equity implications that cannot be addressed by standard economic evaluations developed in healthcare. Given the importance of private resources in nutrition decisions, analysis of the equity implications of different policies is much more relevant than in standard health technology assessment, in which the main issue is the best use of limited public resources and in which equity concerns involve the distribution of health effects across population groups rather than the distribution of costs.

A fourth issue involves the economic consequences of food policies. Agriculture and the food industry are strategic sectors in most countries, and agricultural products are traded worldwide. Health policies targeting food can substantially shift patterns of food consumption. Higher demand for healthier food can boost domestic production or imports, which may produce significant economic impacts (e.g., trade levels, prices of food) between and within nations. On the other hand, banning or limiting the consumption of suspected unhealthy food may have serious consequences for producers. Lock et al.[58] used a general equilibrium model to show that the benefits and costs of healthy diets may vary considerably between different populations because of the indirect effects of policies on agricultural production and trade. Policymakers frequently face broad trade-offs when establishing policies and should be provided with adequate economic evidence that encompasses all the costs and benefits of different courses of action. This issue calls for advances in research toward more holistic assessments that consider the potential health, trade, agricultural, and environmental implications of changes in diet.[11,58]

CONCLUSION

This review reveals that the four above-mentioned issues are virtually absent in the published literature. The few available studies tended to ignore the peculiarities of interventions aimed at healthier diets and, thus, risk providing weak economic evidence for policy. Both the paucity of published studies and the absence of specific accounts of the consequences of these nutrition policies for the economy at large suggest that much more innovative research is seriously required. Food consumption is a modifiable risk factor for a number of diseases, including cardiovascular diseases, diabetes, and cancer. The potential of major health gains from adequate food policies is high, but in its present state, the overall social evidence of specific interventions in this area is limited because of the paucity of studies and major methodological inadequacies.

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