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Review

Dietary Recommendations for Ethiopians on the Basis of Priority Diet-Related Diseases and Causes of Death in Ethiopia: An Umbrella Review

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ABSTRACT

Food-based dietary guidelines (FBDG) need to be evidence-based. As part of the development of Ethiopian FBDG, we conducted an umbrella review to develop dietary recommendations. Protein-energy malnutrition (PEM), deficiencies of vitamin A, zinc, calcium, or folate, cardiovascular diseases (CVD), and type 2 diabetes mellitus (T2DM) were selected as a priority. Systematic reviews were eligible if they investigated the impact of foods, food groups, diet, or dietary patterns on priority diseases. After a search, 1513 articles were identified in PubMed, Scopus, and Google Scholar published from January 2014 to December 2021. The results showed that 19 out of 164 systematic reviews reported the impact of diet on PEM or micronutrient deficiencies. Daily 30–90 g whole-grain consumption reduces risk of CVD and T2DM. Pulses improve protein status, and consuming 50–150 g/d is associated with a reduced incidence of CVD and T2DM. Nuts are a good source of minerals, and consuming 15–35 g/d improves antioxidant status and is inversely associated with CVD risk. A daily intake of 200–300 mL of milk and dairy foods is a good source of calcium and contributes to bone mineral density. Limiting processed meat intake to <50 g/d reduces CVD risk. Fruits and vegetables are good sources of vitamins A and C. CVD and T2DM risks are reduced by consuming 200–300 g of vegetables plus fruits daily. Daily sugar consumption should be below 10% of total energy to lower risk of obesity, CVD, and T2DM. Plant-based fat has favorable nutrient profiles and modest saturated fat content. The association of saturated fatty acids with CVD and T2DM is inconclusive, but intake should be limited because of the low-density lipoprotein cholesterol-raising effect. Plant-based diets lower risk of CVD and T2DM but reduce micronutrient bioavailability. The review concludes with 9 key dietary recommendations proposed to be implemented in the Ethiopian FBDG. This review was registered at PROSPERO (CRD42019125490).

Keywords: healthy diet, dietary recommendations, FBDG, malnutrition, noncommunicable diseases

Statements of Significance

To our knowledge, this is the first review to attempt to synthesize the evidence on how dietary factors affect the triple burden of malnutrition (underweight, overweight, and micronutrient deficiencies) and diet-related noncommunicable diseases (NCDs; CVD and type 2 diabetes mellitus). Such a review is relevant for Ethiopia and most other low-and-middle-income countries, where the triple burden of malnutrition and diet-related NCDs coexists.

Abbreviations: AF, atrial fibrillation; ASB, artificially sweetened beverages; CHD, coronary heart disease; CVD, cardiovascular diseases; DASH, dietary approaches to stop hypertension; DHA, docosahexaenoic acid; EPA, eicosapentaenoic acid; FBDG, food-based dietary guidelines; GBD, global burden of diseases; GI, glycemic index; HDL, high-density lipoprotein; HF, heart failure; LCHP, low carbohydrate high protein; LDL, low-density lipoprotein; Med diet, mediterranean diet; NCD, noncommunicable disease; OFSP, orange-fleshed sweet potato; PREDIMED, prevención con dieta mediterránea; PUFA, poly unsaturated fatty acids; QPM, quality protein maize; SSB, sugar-sweetened beverages; T2DM, type 2 diabetes mellitus; TFA, trans fatty acids; TG, triglyceride.

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Introduction

Unhealthy diets contribute to all forms of malnutrition and diet-related noncommunicable diseases (NCDs) [1–4], which are major public health problems in low-and-middle-income countries (LMIC), including Ethiopia [5–8]. According to the 2016 Ethiopian demographic and health survey, the prevalence of stunting, underweight, and wasting among under-5-y children was 38%, 24%, and 10%, respectively [9]. Similarly, the 2016 Ethiopia NCDs report revealed that 44% of deaths in Ethiopia were because of NCDs, such as CVD and type 2 diabetes mellitus T2DM, most of which might have been prevented with a healthy diet [10]. According to the 2019 global burden of disease, dietary risk factors such as low intakes of fruits, vegetables, legumes, and whole grains and a high intake of processed meat are among the top 5 causes of mortality among females (3.48 million, 95% CI: 2.78–4.37) and males (4.47 million, 95% CI: 3.65–5.45) [3]. Understanding how foods, food groups, and dietary patterns impact nutrition, health, and well-being can help design diet-based prevention strategies and develop dietary recommendations [11].

Dietary recommendations are based on scientific knowledge and intended to guide habitual healthy dietary intake to prevent malnutrition and protect populations from morbidity and mortality caused by diet-related diseases [12–14]. In addition, dietary recommendations are based on identifying culturally appropriate foods and food groups that meet the needs of the population's health and well-being [11]. Food-based dietary guidelines (FBDGs) should be evidence-based and country-specific to fill gaps in problem nutrients or dietary components that either need to be promoted for consumption within the population (fruits) or consumed more moderately (sugar). They should be communicated to help consumers make informed food choices for healthy eating [13]. They also support multi-stakeholder efforts to improve the food system for a diet that improves human health [15].

The low dietary diversity in Ethiopia is a major public health concern, with limited consumption of animal-source foods and restricted fruit and vegetable intake [9,16]. The current dietary habits of Ethiopians are influenced by a range of factors, including urbanization, lifestyle changes, population growth, economic growth, and climate change. These factors have led to a shift in dietary patterns, with a greater preference for cheap, processed, and calorie-dense foods over healthier options. To address this issue, it is important to develop dietary guidelines promoting healthier dietary patterns [11]. Additionally, increasing awareness about the importance of a healthy diet through advocacy and behavior change communications can help to promote healthy eating habits. It is critical that policymakers, health and agriculture practitioners, and the general public work together to address this issue and promote a healthier and more sustainable food system in Ethiopia [17].

In 2018, Ethiopia started its first FBDG development process with a coordinated effort of the Ethiopian Public Health Institute in collaboration with Wageningen University and Research, the FAO of the United Nations, and the International Food Policy Research Institute. The Ethiopian FBDG technical committee was composed of 25 nutrition and health stakeholders. The development process was adapted from the Joint FAO/WHO report "Preparation and use of food-based dietary guidelines" [14] and the Dutch FBDGs development process [18]. The first phase in the Ethiopian FBDG development process was to review relationships between diet and priority diseases and secondary data analysis using national datasets [11]. Ethiopia's priority diseases were identified from the 2017 Global Burden of Diseases (GBDs) database (http://ghdx.healthdata.org/) (Supplemental Figures 1 and 2), and the list was finalized after additional discussions with the Ethiopian FBDG technical committee. The committee selected CVD, T2DM, PEM, and vitamin A, zinc, calcium, and folate deficiency as the priority areas of concern for this review.

This review aims to synthesize the evidence and develop dietary recommendations for preventing and controlling selected priority diet-related diseases in Ethiopia among the 2 y and above population. An umbrella review methodology was chosen as these are used to understand broad topic areas with several outcomes [19]. The recommendations derived from this review will be used as part of the evidence base for the technical committee that will develop the full set of FBDGs for Ethiopia.

Materials and Methods

Literature search

The current review was registered on the PROSPERO international prospective register of systematic reviews in 2019, available at: http://www.crd.york.ac.uk/PROSPERO/display_record.php?ID=CRD42019125490. Systematic reviews, meta-analyses, and narrative reviews published in English from 1 January, 2014 to 31 December, 2021, were identified in the following databases: *1*) PubMed, *2*) Scopus, and *3*) Google and Google Scholar. Initially, 1513 articles were identified from a search strategy in PubMed and Scopus databases, including additional articles from Google Scholar. For title and abstract searching, we used the keywords of the selected priority diseases and causes of death in Ethiopia: CVD, T2DM, PEM, and micronutrients (vitamin A, zinc, calcium, and folate; see Supplemental Table 1). Each alternative keyword term was combined using "OR," and all the different strings of keywords were connected using the "AND" operator. We included findings on overweight and obesity if they were reported as intermediate outcomes of CVD or T2DM.

Study selection criteria and quality assessment

Two reviewers independently conducted the title and abstract screening based on defined inclusion and exclusion criteria. The first reviewer searched through all 3 databases (PubMed, Scopus, and Google/Google Scholar) and checked for duplicates. The inclusion criteria were that all systematic reviews, meta-analyses, or narrative reviews had to be conducted on food, food groups, diet, or dietary patterns concerning CVD, T2DM, or nutritional status (protein-energy, vitamin A, zinc, calcium, and folate) and performed in human participants 2 y of age or older. The second reviewer screened a random selection of 10% of the papers. The acceptable level of agreement between reviewers was a Cohen's kappa coefficient of 0.8 [20]. An agreement was reached on the mismatched articles during the title and abstract screening through discussion between the 2 reviewers and co-authors.

The first reviewer assessed the full texts of selected articles based on the title and abstract. Systematic reviews were excluded if they did not include food, diet, or dietary pattern (n = 377), priority diseases (n = 404), or if they investigated only supplementation (n = 212), fortification (n = 34), other types of interventions (n = 154), or other reasons (n = 163) such as study with different conditions than the general population (Figure 1). Five articles were excluded because the full text was not available. A total of 164 systematic reviews and meta-analyses were included.

Two reviewers independently evaluated the publication quality using the checklist "Assessing the Methodological Quality of Systematic Reviews 2" (AMSTAR2) [21], and the discrepancies were discussed and agreed upon (Supplemental Table 2). The scores were used to interpret the findings. Results on the 7 domains that impact the validity of a review (item 2 on review method, item 4 on comprehensive literature search, item 7 on exclusions, item 9 on risk of bias, item 11 on meta-analysis, item 13 on accounting risk of bias in individual studies, and item 15 on publication bias) were used to rate the overall quality, graded as high, moderate, low, and critically low [21]. Two authors were contacted to provide additional information and/or data. If the systematic review and meta-analysis quality was low or critically low, it was reported in the results but not taken forward in the final dietary recommendations.

Data extraction and synthesis

After the full-text screening stage, the following information was extracted into a Microsoft Excel spreadsheet for each included systematic review and meta-analysis: citation identification number, title, source, identifier, journal, study location included in the article, total sample, study design, method/procedure used in the study, population group, age of a sample, mean (SD) of the outcome measures, food (group) reviewed [minimally processed whole grain, fruits, vegetables, nuts, pulses, fish, dairy products (yogurt, milk, and cheese), red meat and poultry, egg, edible oil, coffee, fermentation, processed meat, refined grains, starch, added sugar, salt, *trans* fat, and alcohol], primary outcomes (PEM; deficiencies of vitamin A, zinc, calcium, and folate; CVD; and T2DM), conclusions, limitations, notes for discussion items, notes for introduction items, and relevance. The extracted findings were synthesized using a descriptive approach. The main results from the review were synthesized per food group.

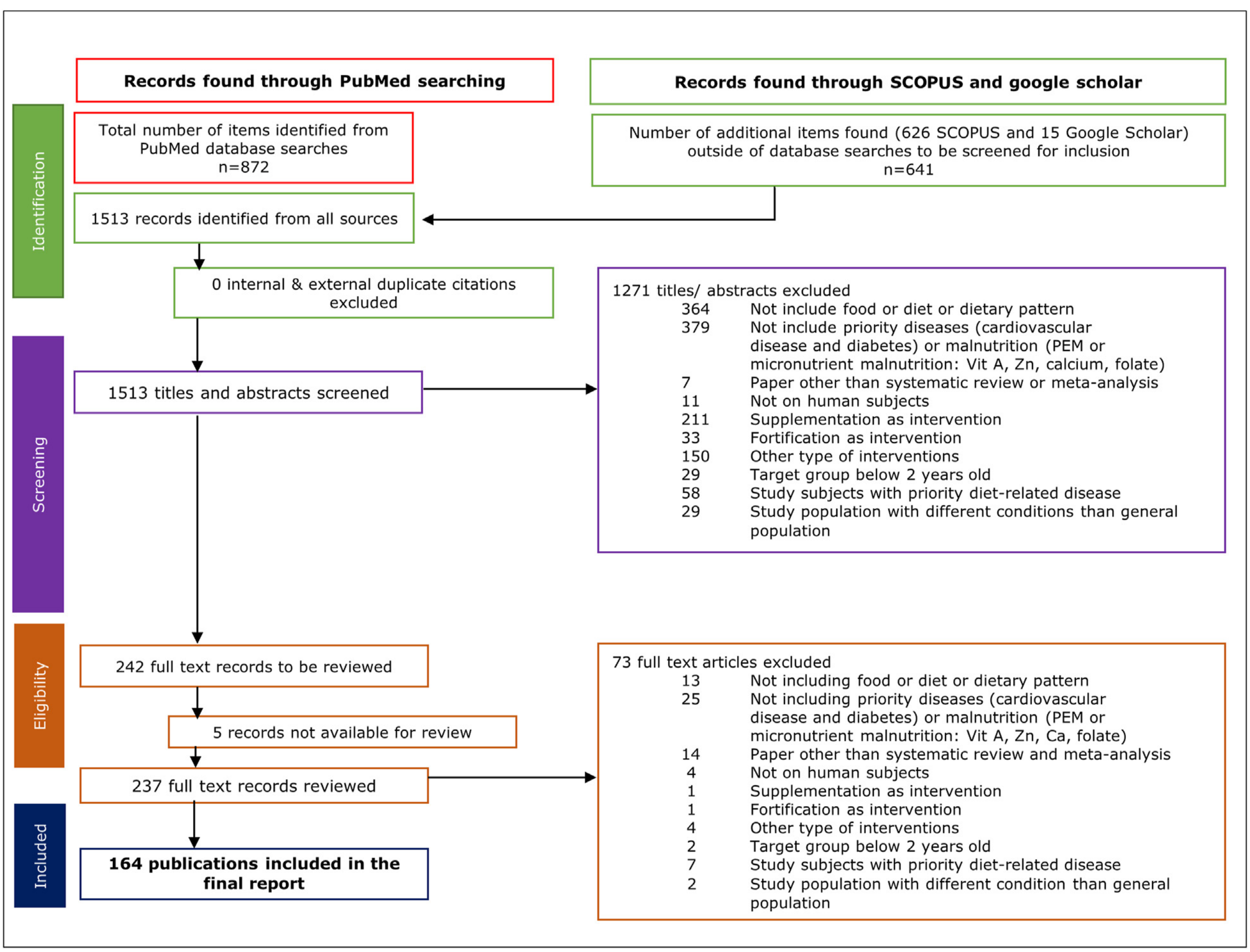

FIGURE 1. Flowchart of evidence search and selection process. Ca, calcium; vit A, vitamin A; Zn, zinc.

Results

This review includes 164 systematic reviews and meta-analyses of primary studies with participants over 2 y of age. Eight food groups, including grains, roots, and tubers; pulses; nuts and seeds; milk and dairy foods; meat, poultry, fish, and egg; fruit and vegetables; sweets and added sugars; fats and oils, were reviewed. Figure 2 shows the number of reviews per dietary pattern and food group with the primary outcome of interest. About 90% of the 164 systematic reviews and meta-analyses focused on NCDs. Dietary patterns were included in 54 systematic reviews, followed by animal-source foods, that is, 29 systematic reviews on meat, poultry, fish, and egg, and 25 systematic reviews on milk and dairy products.

Based on the AMSTAR quality evaluation, 17% were given a high rating, 36% were given a moderate rating, 27% were given a low rating, and 21% were given a critically low rating. As the search was based on Ethiopia's priority diseases, the results for each food group are organized by priority disease, starting with nutrient deficiencies followed by CVD and T2DM.

Grains, roots, and tubers

Cereals, roots, and tubers are the primary sources of energy and minerals in the diet [18,22]. However, only 2 reviews included this food group's impact on PEM and selected micronutrient deficiencies (Figure 2). Quality protein maize (QPM) contains 70%–100% more lysine and tryptophan than non-QPM. According to a critically low-quality systematic review of observational studies, compared with non-QPM–based diets, QPM-based diets resulted in a 12% weight gain and a 9% height gain in young children [22]. QPM-based diets have been introduced as potentially beneficial for eradicating PEM in Ethiopia. The other systematic review addressed orange-fleshed sweet potato (OFSP) [23]. OFSP is a low-cost staple crop and a year-round vitamin A source in most sub-Saharan African countries. The β-carotene content of OFSP varies from 3000 to 16000 μg/100 g, resulting in 250–1300 μg of Retinol Activity Equivalents/100 g. As a result, consuming OFSP can help boost vitamin A concentrations, increase the bioavailability of various micronutrients such as zinc, calcium, iron, and magnesium, reduce vitamin A deficiency, and reduce the child mortality rate by 23%–30% [23].

Twenty papers were found for grain, roots, tubers, and NCD risk. In a review of observational studies, a daily intake of 30–45 g of whole grain was associated with a lower BMI (in kg/m^2) and slower weight gain over time [24]. Higher whole-grain consumption was associated with a lower risk of CVD mortality (RR: 0.81; 95% CI: 0.75–0.89; $P = 0.001$, $I^2 = 56.9\%$). Similarly, there was a 26% decrease in CVD mortality with an increase (3 servings or 90 g/d) in whole-grain consumption [25,26]. A high-quality review found that consuming 2–3 servings of whole grains per day (45 g) reduced risk of CVD (range of RR: 0.63–0.79) and T2DM (range of RR: 0.68–0.80) and led to a modest decrease in body weight (0.06 kg), waist circumference (1.2 cm), and body FM (0.48%) [27]. A meta-analysis of 123 studies indicated an inverse association between whole-grain intake on CAD (RR: 0.95; 95% CI: 0.92–0.98) and heart failure (HF) (RR: 0.96; 95% CI: 0.95–0.97) [28]. The potential benefits suggest that eating 2–3 servings of whole grains per day (30–45 g) is a reasonable public health goal [27]. Scientific evidence supports the recommendation to consume ≥60–90 g of whole-grain foods daily to help prevent T2DM [18,24,29]. There was also evidence of a nonlinear dose-response relationship; increasing whole-grain intake to 50 g/d reduced risk of T2DM by 25%, after which there were only minor benefits to increased intake [29–31].

Dietary fiber intake was associated with reduced CVD incidence and mortality [32,33]. A 10:1 ratio of total carbohydrate to dietary fiber (grams/serving) is a suggested indicator for selecting healthier grain alternatives [34]. Those who consume more dietary fiber have a lower risk of developing T2DM [35,36]. Consumption of refined grains was not associated with a higher risk of stroke, according to a meta-analysis [37]. A

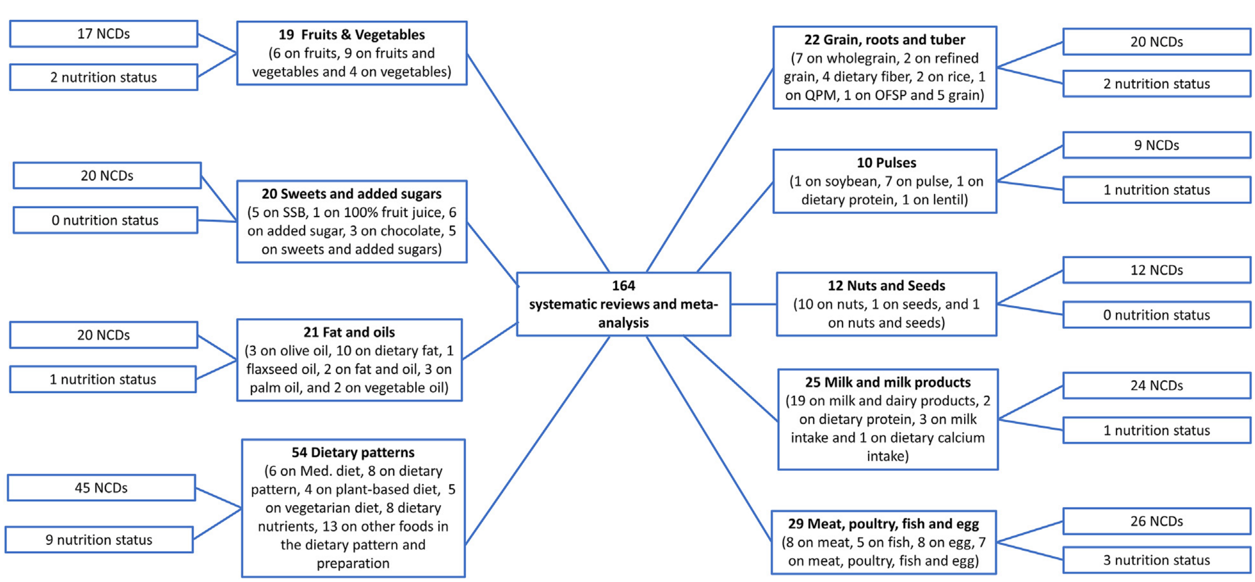

FIGURE 2. Number of selected systematic reviews and meta-analyses according to food group or dietary pattern and primary outcome of interest. Med diet, Mediterranean diet; NCDs, noncommunicable diseases; OFSP, orange flesh sweet potato; QPM, quality protein maize; SSB, sugar-sweetened beverage.

low-quality review indicated that white rice intake is associated with CVD risk factors such as metabolic syndrome and T2DM [38] and that consuming 200–400 g of refined grains per day was associated with a 6%–14% increase in risk of T2DM [30]. Parallel to this, reducing processed grains and starches is a significant dietary priority for cardiometabolic well-being because of risk of NCDs and pervasiveness in modern diets [18,34,39,40].

Pulses

Pulses such as beans, soybean, lentils, chickpeas, peas, and grass peas are commonly consumed. For example, a 50 g serving of lentils contains 3.7–4.5 mg iron, 2.2–2.7 mg zinc, and 22–34 μg of selenium [41]. They are also a good source of protein, carbohydrates, and vitamins (folate) [34]. A low-quality narrative review indicated that lentils are a good candidate for micronutrient biofortification because of their various health benefits, high yield, and nitrogen gain in food systems; however, biofortification research is restricted to a few pulse varieties [41]. Pulses may contribute to reducing PEM and micronutrient deficiencies [34,41]. Consumption of red lentils improved iron concentrations in anemic children in Sri Lanka [41].

Amean diet of 150 g pulses daily (minimum-maximum: 54–360 g/d; cooked) improved blood lipid profile, blood pressure, inflammation biomarkers, and body composition [42]. Consumption of $\leq$4 servings (400 g) of pulses a week was associated with a reduced risk of T2DM (RR: 0.78; 95% CI: 0.50–1.14) [34]. In a high-quality review of 12 prospective cohorts, the highest and lowest pulses consumption groups showed no significant difference in T2DM incidence (RR: 0.96; 95% CI: 0.87–1.05; $I^2 = 85\%$) [30]. A moderate-quality meta-analysis of observational studies found a strong inverse association between soy consumption and risk of T2DM (RR: 0.77; 95% CI: 0.66–0.91; $I^2 = 91.6\%$). In subsequent subgroup analyses, a significant protective effect of soy intake was observed in women (RR = 0.65; 95% CI: 0.49–0.87), in cross-sectional studies (RR = 0.45; 95% CI: 0.30–0.67), and Asian populations (RR = 0.73; 95% CI: 0.61–0.88) [43]. The summary RR for high compared with low soy intake in 8 cohort studies was 0.87 (95% CI: 0.74–1.01; $I^2 = 86.6$) for the incidence of T2DM. Also, in this meta-analysis, soy products were protective factors against T2DM in women with a RR of 0.74 (95% CI: 0.59–0.93) [44].

Pulses may contribute to lowering CVD risk by enhancing satiety, improving glycemic control, and lowering blood pressure and inflammation [42,45]. Consumption of $\leq$4 servings (400 g) of pulses a week decreased risk of stroke (RR: 0.98; 95% CI: 0.84–1.14) and CHD (RR: 0.86; 95% CI: 0.78–0.94) [34]. Eating whole pulses significantly lowered LDL cholesterol) (−0.17 mmol/L, 95% CI: −0.25 to −09), which is a causal risk factor for CHD but did not meaningfully influence HDL cholesterol, non-HDL cholesterol, or apoB [18,45].

Nuts and seeds

Peanuts, walnuts, almonds, hazelnuts, cashew nuts, pistachios, macadamia nuts, Brazil nuts, pecans, sunflower seeds, Niger seeds, and sesame seeds are among the most widely consumed globally [46]. Nuts and seeds are good sources of minerals, proteins, and plant-based fats rich in phenolic compounds, improving diet quality and benefiting health [34,47]. A review of a trial showed no substantial variations between walnut-enriched diets and control diets in terms of change in body weight [weighted mean difference (MD): −0.12 kg; 95% CI: −2.12 to −1.88 kg] or BMI (weighted MD: −0.11; 95% CI: −1.15 to 0.92) [46]. In the overall analysis of evidence, tree nuts (including almonds, Brazil nuts, cashews, hazelnuts, pecans, pistachios, and walnuts) did not significantly minimize waist circumference [MD: −0.62 cm; 95% CI: −1.54, 0.30 cm; $I^2 = 67\%$] [48]. When comparing 45-d intervention studies with 60-d intervention studies, a review found that 35 g of sesame oil showed a greater increase in antioxidants measured in plasma, such as in vitamin E (increased by 90%) and β-carotene (by 113%) [49].

Walnut-enriched diets lowered total blood cholesterol by an MD of −6.99 mg/dL (95% CI: −9.39 to −4.58 mg/dL) compared with the control group, habitual or Mediterranean or without nut diet [46]. When comparing to a control diet intervention, 49 g/d of tree nuts consumption lowered fasting blood glucose (MD = −0.8 mmol/L, 95% CI: −0.16 to −0.5 mmol/L), and TG (MD = −0.06 mmol/L, 95% CI: −0.09 to −0.03 mmol/L) to a moderate extent [48]. In the PREDIMED (Prevención con Dieta Mediterránea) intervention, a daily serving of 15–30 g of nuts reduced CVD incidence [18]. Nut consumption lowered CHD risk (RR: 0.67; 95% CI: 0.43–1.05) and LDL cholesterol in a meta-analysis of randomized controlled trials (RCTs) [18,28,50]. Based on the highest compared with lowest analysis [51] and dose-response analysis [30,49], nut consumption was not associated with risk of T2DM (RR = 0.98; 95% CI: 0.84–1.15; $I^2 = 67.7\%$). Another meta-analysis of cohort studies and RCTs indicated that nut consumption reduced risk of coronary artery disease (CAD) (RR = 0.76; 95% CI: 0.69–0.84) and T2DM (RR = 0.87; 95% CI: 0.81–0.94) [34]. A critically low-quality review indicated that increased intake of areca nut causes acute toxicity, high blood pressure, and high cholesterol [52]. Arecoline, an alkaloid found in areca nut, seems to interfere with fat metabolism resulting in T2DM, metabolic syndromes, and unstable blood lipid concentrations through multiple pathways [52].

Milk and dairy foods

Dairy foods come in various forms, flavors, and compositions, even though all are originally from milk. Milk and dairy foods are primary sources of fat, calcium, and other essential nutrients such as vitamin B12 and protein. In some countries, iodine in milk is obtained by feeding iodine-containing feed to cows [18, 53–55]. Both meat and milk have been recognized as effective in reducing childhood stunting [54]. Milk has a specific growth-promoting effect on young children. This effect is seen in high, middle, and low-income countries, suggesting it has mechanisms beyond energy and nutrient intake, possibly via IGF-I stimulatory effects [54,55]. A review of longitudinal cohort studies and randomly assigned trials indicate that cow milk consumption does not affect body weight in children or adults [55]. Several intervention studies showed that yogurt intake reduced weight gain [55,56]. There was evidence of a positive effect of milk and dairy consumption on BMD, but no association was found with lowering risk of bone fracture [53,55,56]. After 1 y of increasing calcium intake from dietary sources to >800 mg/d in the adult population (over 50 y old), BMD increased by 0.6%–1.0% at the total hip and 0.7%–1.8% in the whole body. There was no effect on BMD in the forearm. The authors concluded that increasing calcium intake from dietary sources produces small, nonprogressive increases in BMD, which are unlikely to lead to a clinically significant reduction in fracture risk [57]. A low-quality review indicated that nations that consume the most milk and calcium also have the highest rates of hip fractures, although this was likely influenced by confounding factors [55]. Plant-based drinks are getting more popular and partly replace dairy drinks in the nutrition recommendations in several countries. However, cow milk and plant-based beverages differ in nutritional content and health impacts [53], and more human research is needed on calcium-fortified plant-based beverages.

The impact of saturated fat from dairy or other foods may not exclusively predict risk of CVD and T2DM, as other constituents from the diet may influence metabolic risk factors [58]. There was no or only a poor inverse association between dairy intake and CVD RR [59]. However, replacing dairy fat with polyunsaturated fats, mainly from plant-based foods, may benefit health [54,60,61]. In a meta-analysis of Korean studies, moderate quality, high TG, and low HDL cholesterol were associated with milk and dairy consumption [50]. The evidence suggests that consuming 200–300 mL/d of milk and dairy foods does not increase CVD risk [53,62]. Cheese intake was inversely associated with CHD (RR: 0.96; 95% CI: 0.93–0.98)/20 g higher intake/d, whereas high-fat milk was positively associated with CHD (RR: 1.08; 95% CI: 1.00–1.16)/200 g higher intake/d [62]. Two reviews report an inverse association between dairy food intake and risk of hypertension or stroke [53,63]. Hence, there is no consistent evidence of an elevated risk of CVD from a high intake of milk or dairy foods [18,53,64,65].

Total dairy product intake (RR: 0.89; 95% CI: 0.84–0.94; $I^2 = 48.8$), whole milk consumption (RR: 0.87; 95% CI: 0.78–0.96; $I^2 = 52.2$), and yogurt consumption (RR: 0.83; 95% CI: 0.70–0.98; $I^2 = 62.1$) were all inversely associated with risk of T2DM [44,54]. The summary RRs of 17 cohort studies on T2DM in a dose-response meta-analysis study were 0.93 (95% CI: 0.87–0.99)/400 g overall dairy products per day, 0.98 (95% CI: 0.94–1.03)/200 g high-fat dairy products per day, 0.91 (95%CI: 0.86–0.96)/200 g low-fat dairy products per day, 0.87 (95% CI: 0.72–1.04)/200 mL milk/d, 0.92 (95% CI: 0.86–0.99)/50 g [66]. Another review indicated that consuming dairy products reduces risk of T2DM by 8%–12% [66,67]. Milk had a RR of 0.89 (95% CI: 0.82–0.97). In the case of low-fat dairy intake, the reduction varied from 11%–19% (RR = 0.81; 95% CI: 0.68–0.96) [67]. Each additional 200 g of dairy consumed daily was associated with a reduction in T2DM risk (RR: 0.97; 95% CI: 0.94–0.99; $I^2 = 74\%$). Yogurt has a RR of 0.74 (95% CI: 0.65–0.84) [30]. Another review also revealed that drinking milk reduces risk of T2DM by 11% (RR = 0.89; 95% CI: 0.82–0.97) and (rate ratio = 1.07; 95% CI: 0.93–1.24), but the association was not statistically significant [68]. Because studies on different dairy subgroups are lacking, it is impossible to derive a definitive statement regarding their impact on T2DM risk [18,34,61,66,68]. However, growing evidence of a lower risk of T2DM is associated with fermented dairy foods, especially yogurt [18,50,53,55,56,61,64,66,69–71]. A meta-analysis of 14 studies found that the RR of developing T2DM was 0.80 (95% CI: 0.69–0.93) and 0.91 (95% CI: 0.82–1.00), respectively, for 30 g/d cheese and 50 g/d yogurts [66].

Meat, poultry, fish, and egg

Red meat comes from cows, calves, pigs, goats, sheep, camels, venison, etc.; white meat includes chicken and turkey. Meat, eggs, and fish are highly nutritious because they contain high-quality protein, fat, and vital micronutrients such as iron, zinc, and vitamin B12 [72,73]. Higher dietary animal-source protein consumption (such as beef, pork, lamb, chicken/poultry, sheep, goat, fish, and seafood) may protect lumbar spine BMD compared with lower protein intake (percentage change: 0.52%; 95% CI: 0.06%–0.97%; $I^2 = 0\%$), but no effect was observed for total hip, femoral neck, or total body BMD [74]. A review of 7 high-quality articles found that 5 studies observed an association between animal meat consumption (85–300 g/d) and iron status. However, the optimum amount and frequency of meat consumption to maintain or attain iron status are unknown [75]. Fish is a good source of essential nutrients such as vitamin D, iodine, selenium, and long-chain PUFA EPA and DHA [18,73,76]. A low-quality systematic review indicated that fish or seafood was listed as the primary source of dietary protein and a good source of iodine in 5 of the 6 small-scale studies in the Pacific Island countries that looked at the contribution of 9–19 g/d of fish consumption [77]. Fermented fish products were high in EPA and DHA, antioxidants, and essential nutrients [71].

Meat consumption was associated with an increased risk of elevated/high total cholesterol (OR: 1.14; 95% CI: 1.06–1.22) [50]. For preservation, meat is often smoked or salted, or preservatives such as nitrate or nitrite are added, resulting in processed meat [18,73]. Saturated fats, cholesterol, salt, nitrite, haem iron, polycyclic aromatic hydrocarbons, and heterocyclic amines can be elevated by consuming ≤50 g/d of processed meat [78]. A positive association was shown between red meat and CHD (RR: 1.15; 95% CI: 1.08–1.23), stroke (RR: 1.12; 95% CI: 1.06–1.17), HF (RR:1.08; 95% CI: 1.02–1.14), and processed meat on CHD (RR:1.27; 95% CI: 1.09–1.49), stroke (RR: 1.17; 95% CI: 1.02–1.34), HF (RR: 1.12; 95% CI: 1.05–1.19) [28]. When comparing the highest compared with the lowest intake of white meat, the pooled OR was 0.94 (95% CI: 0.90–0.97) for all-cause mortality, 0.95 (95% CI: 0.89–1.01) for CV mortality, and 0.99 (95% CI: 0.95–1.02) for nonfatal CV events [79].

The effects of egg consumption on NCDs are controversial [80,81]. Eggs exhibit a range of pro- and anti-inflammatory characteristics, which might have major consequences for the pathophysiology of a number of chronic illnesses but also immunological responses to acute injury [59,82]. Eggs are high in dietary cholesterol and protein (200 mg cholesterol and 5–7.5 g of total protein per egg). Intake of 100 mg cholesterol from eggs raises LDL cholesterol by 0.05 mmol/L [18]. Egg consumption was associated with a lower risk of hypertension (OR: 0.89; 95% CI: 0.79–0.99) and low HDL cholesterol (OR: 0.84; 95% CI: 0.78–0.91) in Korean studies [50]. A meta-analysis indicated a positive association between egg consumption and HF (RR: 1.16; 95% CI: 1.03–1.31) [28]. High egg consumption (>1 egg/d) was associated with decreased CAD (HR: 0.89; 95% CI: 0.86–0.93; $I^2 = 0\%$) but not with increased CVD (HR: 0.99; 95% CI: 0.93–1.06; $I^2 = 72.1\%$) [83].

Moderate fish intake (2 or 3 servings a week) was associated with a lower risk of fatal CHD (RR: 0.79; 95% CI: 0.67–0.92) compared with little or no consumption [18,28,34]. The HRs of stroke for subjects who reported fish consumption 1, 2–4, and ≥5 times/wk were 0.86, 0.91, and 0.87, respectively [28,84]. In 7 prospective cohort studies, the overall RR of atrial fibrillation (AF) was 1.01 (95% CI: 0.94–1.09) for the highest compared with the lowest group of fish intake with no heterogeneity ($I^2 = 0.0\%$) [85]. Six studies were combined to investigate the dose-response association between fish intake and AF risk; the summary RR was 0.99/serving/wk (95% CI: 0.96–1.02; $P = 0.26$; $I^2 = 23.0\%$) [85]. Consumption of 2–5 servings of fish per week may reduce risk of CVD in a moderate-quality review of observational studies [76,86].

The mean RR and 95% CI for red meat consumption on risk of T2DM for high compared with low red meat intake were 1.22 (95% CI: 1.09–1.36; $I^2 = 51.1\%$) [44]. Additional data are needed, especially for processed meat, as there exists an association between red and processed meat intake with risk of T2DM and CVD [18,54,69,72,73,78,87,88]. According to a review of prospective cohort studies, risk of T2DM increases as red meat consumption increases by 100 g/d and processed meat consumption increases by 50 g/d [29,30]. In a meta-analysis of 11 cohort studies, high compared with low processed meat intake was associated with the incidence of T2DM with an overall RR of 1.39 (95% CI: 1.29–1.49; $I^2 = 49.3\%$) [45]. More research is needed to determine the effect and association of each red meat subtype (fresh/unprocessed or processed) on T2DM [72].

In 2 meta-analyses, egg consumption was associated with a higher risk of T2DM as the RR of T2DM of egg/d 1.13; 95% CI: 1.04–1.22 reported by Tamez et al. [87,89]. Another study found egg consumption was associated with a lower risk of T2DM (RR: 0.89; 95% CI: 0.84–0.94; $I^2 = 91.1\%$) [44]. There was no significant association between T2DM comparing the highest and lowest fish consumption group (RR: 1.04; 95% CI: 0.95–1.13; $I^2 = 76\%$) or each additional regular 100 g (RR: 1.09; 95% CI: 0.93–1.28; $I^2 = 84\%$) [30,44].

Fruits and vegetables

Multiple nutrient deficiencies are common in LMICs. Fruits and vegetables are good sources of multiple micronutrients. Fruits found in Ethiopia include banana, papaya, lemon, watermelon, avocado, mango, pineapple, orange, and strawberry. Fruits are a source of vitamins such as folate, β-carotene, vitamin C, and vitamin E [34,90]. Brassica vegetables contain numerous micronutrients, such as carotenoids and minerals, and other beneficial components, such as antioxidants, glucosinolates, and polyphenols. Among brassica vegetables, kale is a popular vegetable in Ethiopia, both in poor and wealthy households. Although high in vitamins A, K, and C; folate; essential minerals (potassium, calcium, and magnesium); and dietary fiber, kale also contains antinutrients such as oxalate, phytate, and tannins [41]. Other vegetables often consumed are onion, green pepper, lettuce, carrot, tomato, head cabbage, and pumpkin. According to a low-quality review, certain vegetables, such as mushrooms, significantly affect weight reduction [91].

Although many wild fruits and vegetable species are available in Ethiopia, very little is known about their consumption. Underutilized fruits and vegetables (wild fruits and vegetables) have several advantages: they are easy to grow and hardy; they can be a solution for social health and nutrition problems; they can provide nutrition to the poor and needy community; and they are high in carbohydrate; fat; protein; energy; vitamins A, B1, B2, B3, B6, B9, and C; folic acid; and minerals—calcium, phosphorus, iron, and dietary fiber [92]. However, contamination with potentially pathogenic organisms, notably Escherichia coli, requires caution [93].

Consuming 100 g of fruit per day has been shown to reduce risk of CHD (RR: 0.94; 95% CI: 0.91–0.98) and stroke (RR: 0.84; 95% CI: 0.75–0.91) [28,34]. Avocados, pomegranates, grapes, and other common fruits may prevent CVD by controlling body weight, plasma lipid profile, oxidative stress, and inflammation [90,94]. Fruit intake was associated with a lower risk of elevated blood pressure (OR: 0.52; 95% CI: 0.37–0.73) and elevated TG concentrations (OR: 0.84; 95% CI: 0.73–0.96) in the meta-analysis of observational studies carried out in of Korea [50]. A meta-analysis of RCTs indicated that berries including the juice of barberry, cranberry, grape, pomegranate, powder of blueberry, grape, raspberry, and freeze-dried strawberry significantly reduced systolic blood pressure by 3.68 mmHg (95% CI: 6.79 to −0.58; $P = 0.02$) and diastolic blood pressure by 1.52 mmHg (95% CI: 2.87 to −0.18; $P = 0.04$) [95]. Fruits and vegetable intake reduce risk of CHD (RR: 0.97; 95% CI: 0.96–0.99) and HF (RR: 0.94, 95% CI: 0.90–0.97) [28]. A meta-analysis of observational studies of adults found a lower risk of CHD (RR: 0.88; 95% CI: 0.8–0.98) and stroke (RR: 0.82; 95% CI: 0.72–0.93) for the highest compared with the lowest tertile of lutein intake. Lutein is synthesized in dark green leafy vegetables such as spinach and kale [93]. Several biological mechanisms have been proposed for the potential beneficial effect of lutein on cardiometabolic health, including vascular changes, antioxidant effects, and effects on immune response and inflammation [93,96].

Fruit consumption of 200–300 g/d decreased risk of T2DM by 10%, although no additional benefit for higher intake was observed [30]. Consumption of berries was associated with an 18% reduction in risk (RR: 0.82; 95% CI: 0.76–0.89; $I^2 = 48.6\%$) [97]. A subgroup analysis from this review indicated that this finding is significant in both European and United States populations but NS in male populations. Citrus fruit consumption was not associated with T2DM risk (high compared with lowest analysis) (RR: 1.02; 95% CI: 0.96–1.08; $I^2 = 0.0\%$) [98]. A modest inverse association between fruit intake and risk of T2DM was observed, but not between total vegetable intake and biomarkers of metabolic diseases and incidence of T2DM [30, 99]. Although fruit and vegetable consumption was not associated with T2DM risk, a dose-response meta-analysis indicated a threshold of 2–3 servings of vegetables and 2 servings of fruit per day, after which risk of T2DM did not decrease anymore [100]. Another review also indicated a significant inverse association between fruit and green leafy vegetable intake and risk of T2DM [101,102]. A meta-analysis conducted on 4 cohort studies reported that consumption of cruciferous vegetables was associated with a reduced incidence of T2DM (highest compared with lowest intake) (RR: 0.84; 95% CI: 0.73–0.96; $I^2 = 54.4\%$) [98]. High lutein intake was associated with a lower risk of metabolic syndrome (RR: 0.75; 95% CI: 0.60–0.92), comparing the highest with the lower tertile, and no significant heterogeneity was observed between studies. There was no significant association between lutein intake and risk of T2DM (RR: 0.97; 95% CI: 0.77–1.22) [96].

Regarding fruit juice, a review indicated that whole fruits are preferable to 100% juice, which should be limited to 1 serving/d (1/2 cup) because of its high sugar content [34].

However, there is a modest, long-term weight gain from 100% fruit juice intake in young children and adults [103]. In addition, the intake of sugar-sweetened fruit juice but not 100% fruit juice is associated with an increase in the incidence of T2DM [34].

Sweets and added sugars

All monosaccharides and disaccharides added to foods and beverages by the manufacturer, cooker, or consumer, and sugars naturally present in honey, syrups, unsweetened fruit juices, and fruit juice concentrates are referred to as "added sugars" [104, 105]. Sugar is naturally present in intact fruits and lactose in human, cow, or goat milk, whereas unsweetened milk products do not contain added sugar. To reduce risk of obesity, it was recommended that consumers should limit their intake of added sugar and sugar-sweetened beverages (SSB) to <10% of their total energy [106]. Increased consumption of SSB and added sugar reduces dietary diversity resulting in nutrient deficiency [104]; thus, total sugar should preferably be consumed as part of the main meal and in a natural form as human milk, milk, unsweetened dairy products, and fresh fruits, rather than as SSBs, fruit juices, smoothies, or sweetened milk products. SSB should be replaced by water or unsweetened milk drinks [34].

Sugar-containing beverages/added sugars increase risk of overweight/obesity and dental caries, lead to nutritional deficiency and poor dietary diversity, and may be associated with an increased risk of CVD and T2DM [18,29,30,34,59,107,108]. Risk of obesity increased by 12% (RR: 1.12; 95% CI: 1.05–1.19; $I^2 = 67.7\%$) and 21% (RR: 1.21; 95% CI: 1.09–1.35; $I^2 = 47.2\%$) for every 250 mL/d increase in SSB and artificially sweetened beverages [109]. A positive association between SSB consumption and risk of CHD (RR: 1.17; 95% CI: 1.11–1.23), stroke (RR: 1.07; 95% CI: 1.02–1.12), and HF (RR: 1.08; 95% CI: 1.05–1.12) was observed [28]. T2DM risk increased by 19% (RR: 1.19; 95% CI: 1.13–1.25; $I^2 = 82.4\%$) and 15% (RR: 1.15; 95% CI: 1.05–1.26; $I^2 = 92.6\%$) with each 250 mL/d increase in SSB and artificially sweetened beverages [109]. In contrast, moderate chocolate consumption might have a preventive effect on CVD risk because of the presence of polyphenols [110–112]. With moderate heterogeneity, the total CVD risk ratio for the highest compared with the lowest category of chocolate intake was 0.77 (95% CI: 0.71–0.84) [110]. However, the amount of added sugar and chocolate's energy and fat content should be considered.

Because of the links to long-term weight gain and NCDs, consuming 100% fruit juice (>1 serving/d) is not advisable [34, 103]. A position article review on sugar advised that free sugar consumption should be minimized to below 10% of EI in children and adolescents aged 2–18 y. Water or unsweetened milk drinks should substitute liquid with added sugar to reduce the total sugar intake [104,113].

Fats and oils

Fat-rich foods, consisting of a mixture of FAs, include butter, margarine, and oil. Fat products improve nutritional status, quality of life, and health among the elderly [114]. Fried food consumption was positively associated with a risk of weight gain, although the oil type used may modify this association [115]. On the contrary, high olive oil intake was neither negatively nor positively associated with an increased risk of becoming overweight or obese [115]. Cooking green vegetables with fat increases vitamin A bioavailability because fats aid in absorbing fat-soluble vitamins, including carotenoids, vitamins D, E, and K [114]. A high-quality systematic review showed probable evidence for a moderate direct association between total fat intake and body weight [116]. However, focusing on limiting total fat does not consider the health advantages of high intakes of plant-based fats or risks of processed carbohydrates, which are the alternatives to dietary fat [34]. There was no conclusion in a review on the relationship between dairy fat intake and overweight or obesity [117].

Systematic reviews and meta-analyses of moderate and high quality showed that dairy fat consumption is not associated with CVD or T2DM in cohort studies [116–118]. A low-quality review of large-scale cohort studies in Western countries failed to show a strong association between fat consumption and the development of T2DM [119]. A systematic review by Mozaffarian [34] indicated that butter appears to be neutral for cardiometabolic health and detrimental to long-term weight management. Virgin oils (for example, extra virgin olive oil and virgin soybean oil) may be preferred because of their low-temperature refinement, which may help retain trace phenolic components [34]. Daily 10 g olive oil consumption is associated with a reduced risk of T2DM (RR: 0.91; 95% CI: 0.87–0.9) [120] and prevents CVD, although there have been mixed results regarding its influence on blood biomarkers [120–122]. A cohort and RCT studies review indicated that virgin olive and flaxseed oil considerably decreases the incidence of CVD and T2DM [115,123]. Another meta-analysis also indicated that the highest olive oil intake category showed a 16% reduced risk of T2DM [121]. Consumption of nut oil is associated with a lower risk of CVD [122]. Palm oil contains palmitic acid, a naturally occurring SFA; however, the associated risk of CVD and T2DM is controversial [124,125]. The main reasons are heterogeneity, the difference in selection criteria, the wider age range, and direct confounding were not well controlled [124].

SFAs increase total and LDL cholesterol concentrations in the blood, risk factors for CHD[18,126]. A review of RCTs indicated no effect on the incidence of CAD (RR: 1.0, 95% CI: 0.8–1.2), but a decrease in serum cholesterol among the intervention group, receiving vegetable oil, the substitution of saturated fat with vegetable oil, and an intake of ~20% fat [126]. On the contrary, evidence suggests that saturated fat should account for 7%–10% of daily energy in the dietary recommendations [18]. High-refined-carbohydrate diets are often replaced to reduce total and saturated fat consumption, leading to atherogenic dyslipidemia, increased blood concentrations of small dense LDL particles, decreased HDL cholesterol, and increased TGs are risk factors for CHD [116,127]. In general, vegetable fats and oils contain a modest amount of SFAs, although being a good source of unsaturated FAs. However, the exception of palm oil, coconut fat, and cocoa butter is because of higher SFAs [18,125]. Partially hydrogenated oils are food additives that typically have 30%–60% *trans* FAs with well-documented adverse consequences for public health, notably an increased risk of CHD and sudden death [34,128].

A diet high in unsaturated FA, combined with the Mediterranean diet (Med diet), reduces risk of CVD and T2DM [118, 121]. Risk of CVD is reduced when SFA is partially replaced by PUFAs, especially in men [116]. According to a low-quality review, ω-6 FAs appear protective against T2DM risk [129]. Both

TABLE 1
The most well-known dietary patterns with their distinct features

Dietary pattern	Feature
Mediterranean diet	High consumption of vegetables, fruit, cereals, and olive oil; a moderate to high consumption of fish; a moderate consumption of dairy, wine, eggs, and poultry; and a low consumption of meat and sweets [145].
"Prudent pattern"	High consumption of fruits, vegetables, whole cereal foods, pulses, and fish [154].
"Western pattern"	High consumption of refined grains, processed meat, red meat, butter, high-fat dairy foods, eggs, fried foods, sweetened beverages, and sweets [153].
DASH diet	High consumption of vegetables, fruit, whole cereal foods, fish, poultry, nuts, seeds, vegetable oils, lean meats and low consumption of salt, sweetened beverages, and high-fat dairy foods [59].
The SDA diet	A vegetarian diet includes vegetables, fruit, legumes, whole grains, and nuts [132]. The followers abstain from alcohol intake.
Vegetarian or vegan diet	A vegetarian diet excludes meat, poultry, and seafood and a vegan diet does not contain any animal-source foods [156,157].

n-6 and n-3 PUFAs help lower risk of CVD, though more research is needed to identify the optimal quantities [114,122]. Consumption of flaxseed oil has been suggested to decrease insulin resistance in T2DM and prediabetes [129]. A decrease in T2DM incidence was observed with a high vegetable fat intake and a healthy dietary pattern which is partly characterized by a high ratio of unsaturated FAs to SFAs [29]. On a nutrient concentration, increasing ALA and fatty fish intake lowered risk of T2DM, but this was not observed in all cohorts included in the review [130]. Consumption of n-3 FAs was negatively associated with risk of T2DM in the Asian population but positively associated with risk in the Western population [130].

Dietary patterns

Though intake of specific foods and nutrients may elevate risk of NCDs, dietary guidelines should focus on total dietary consumption rather than particular foods or nutrients [34,131]. The contemporary emphasis on dietary patterns can be viewed as a more holistic approach to studying how long-term consumption of various food combinations affects health. Because it is simpler for individuals to adopt full or adjusted dietary patterns rather than including or excluding single nutrients from their diets, this "dietary pattern" approach lends itself more readily to practical implementation in public health promotion [132,133].

The primary reason for the wide prevalence of iron, zinc, iodine, and vitamin A deficiency is the low dietary intake of these nutrients combined with the poor bioavailability of these micronutrients from plant-based foods because of the presence of dietary inhibitors [134]. Grains, roots, tubers, and pulses are the staples of the Ethiopian diet. These include components that enhance and inhibit mineral bioavailability, of which the latter are predominant [135]. In general, plant-based diets are high in inositol phosphates, which reduce phosphorus, calcium, zinc, and iron bioavailability in humans and monogastric animals by forming low digestible complexes [136]. Indeed, adult vegetarians have considerably lower SF concentrations than nonvegetarian controls, according to a meta-analysis of pooled data from 24 cross-sectional studies (−29.71 mg/L; 95% CI: −39.69 to −19.73). The reduction of SF is more evident in men (−61.9 mg/L; 95% CI: −85.6, −38.2) than in premenopausal women (−17.7 mg/L; 95% CI: −29.8, −5.6) or all women (−13.5 mg/L; 95% CI: −23.0 to −4.04)[137]. For each 10% increase in folate intake, a 6% (95% CI: 4%–9%) increase in RBC and 7% (95% CI: 1%–12%) serum/plasma were found [138]. Potential enhancers of micronutrient bio-accessibility are sulfur compound-rich spices—onion (at the dietary concentration of 15 g/100g of the staple grain) and garlic (2.5 g/100 g of staple grain), which are generally present in the Ethiopian diet [135]. Diet might be carefully prescribed, like other therapies, but it might only be 1 part of preventing and treating malnourished children [139].

In observational studies, a diet high in meat consumption was consistently associated with higher SF concentrations [134]. The beneficial effects of ascorbic acid and meat on iron absorption may be counteracted by simultaneously ingesting inhibitory foods and nutrients. Dietary treatments that include a var. of specific dietary variables to increase iron status tend to be more successful than single-nutrient or single-food approaches [140]. Also, in preventing and treating obesity, the dietary approach is shifting toward the effect of healthy diets and dietary patterns on the complex physiological determinants of long-term weight regulation [34].

Higher intake of plant foods has been associated with a lower likelihood of becoming obese, lower BMI, and smaller waist circumference. A plant-based diet leads to weight loss comparable to conventional low-calorie diets but also better overall weight management [132,141]. Obesity, T2DM, hypertension, stroke, and CHD have all emerged because of the changes in food habits and physical activity patterns, the so-called Westernization of diets [142]. In China, for example, high consumption of meats and edible oil, low consumption of cereals and vegetables, increasing consumption of SSB, increased sedentary time, and growing obesity rates have an inverse influence on the incidence and development of T2DM [143]. The followings are some of the most well-known dietary patterns and their characteristics (Table 1).

The Med diet has been associated with decreased mortality and CVD-related mortality [59]. In addition, recent reviews supported that the Med diet reduces risk of chronic illnesses and related mortality, including T2DM and CVD, inside and outside the Mediterranean region [144–151]. However, a review of 22 RCTs indicated that there is still some uncertainty regarding the effects of a Med diet on CVD prevention; evidence of moderate quality showed prevention, whereas evidence of low quality showed no or little prevention of CVD risk [152].

The "healthy" dietary patterns containing vegetables, fruits, and whole grains were significantly associated with a reduced risk of T2DM (RR: 0.86; 95% CI: 0.82–0.90), whereas the "unhealthy" diets with higher amounts of red and processed meats, high-fat dairy, and refined grains were associated with higher risk (RR: 1.30; 95% CI: 1.18–1.43) [153]. There was a 15% decreased risk of T2DM among individuals with the highest adherence to a Healthy/Prudent pattern as compared with those with the lowest adherence T2DM risk (95% CI: 0.80–0.91) [154]. In the linear dose-response meta-analysis, 6 of the 12 food groups exhibited a significant relationship with T2DM risk; increasing intakes of whole grains, fruits, and dairy were associated with decreased risk, whereas increasing intakes of red meat, processed meat, and SSB were associated with increased risk of T2DM. Compared with nonconsumption, optimal consumption of whole grains, fruits, and dairy resulted in a 42% reduction, whereas consumption of red meat, processed meat, and SSB resulted in a 3-fold increase in T2DM risk [30]. A healthy eating pattern consisting of higher intakes of plant-based foods, low-fat dairy, lower intakes of fried foods, and red and processed meat was consistently associated with an 18%–65% lower risk of CAD [155]. In the Asian cohort, adhering to a Western diet pattern was associated with a 37%–64% higher risk of CHD [155]. High consumption of plant-based foods, moderate consumption of dairy products, fish, and poultry, and low consumption of processed foods are similar characteristics across the 4 "healthy" dietary patterns [the Mediterranean, DASH, Prudent, and SDA] that reduce risk of cardiometabolic health [59,132,156–158].

A vegetarian eating pattern was significantly associated with lower CHD mortality (RR: 0.78; 95% CI: 0.69–0.88) and incidence (RR: 0.72; 95% CI: 0.61–0.85) but not CVD mortality (RR: 0.92; 95% CI: 0.84, 1.02) or stroke mortality [159]. Overall, plant-based dietary patterns were associated with a 20%–25% reduced risk of CVD and a correspondingly lower risk of T2DM [141,156,160–162], although the effect of a vegan diet on CVD prevention was classified as uncertain because of insufficient information to conclude [163]. A review of vegetarian diets in children concluded that the existing evidence, based on a small sample and with high heterogeneity, does not allow for solid conclusions on current vegetarian diets' health benefits or risks on children and adolescents' nutritional or health status [164].

Those who adhere to low carbohydrate and high protein diets have an increased risk of all-cause mortality (HR: 1.06; 95% CI: 1.04–1.09; $I^2 = 8.2\%$). No significant association between low carbohydrate, high protein diets, and risk of CVD was found (HR: 1.01; 95% CI: 0.98–1.03; $I^2 = 24.0\%$) [165]. A meta-analysis of randomly assigned trials showed that compared with usual diets, low carbohydrate and low-fat diets had similar effects on weight loss (4.63 kg compared with 4.37 kg) and reductions in systolic (5.14 mmHg compared with 5.05 mmHg) and diastolic (3.21 mmHg compared with 2.85 mmHg) blood pressure after 6 mo [166]. The optimal macronutrient ratios for preventing and treating T2DM are unclear [167].

Intakes of other foods and food preparation

Tea and coffee

Tea and coffee are Ethiopia's most frequently used nonalcoholic beverages after water. The content of cobalt, copper, iron, manganese, molybdenum, and zinc in tea beverages ranges from 3.04–58.44 μg/g; it may not be possible to predict the nutritional effects of habitual drinking of tea because the bioavailability of micronutrients in tea infusions is low [168]. Three to 4 cups of tea per day lowers risk of CVD and T2DM compared with no tea consumption, with no detrimental effect found on micronutrient status [34,168]. Coffee consumption did appear to have a nonlinear dose-response relationship with hypertension. With each 1 cup/d increase in coffee consumption, risk of hypertension was lowered by 2% [169]. An inverse association was found between coffee intake and CVD (OR: 0.71; 95% CI: 0.52–0.97) and elevated/high TG (OR: 0.84; 95% CI: 0.78–0.90) [50]. Both caffeinated and decaffeinated coffees are associated with a lower incidence of T2DM in a dose-dependent fashion. The lowest risk is seen at 3–4 cups/d [34].

Sodium

Risks of all-cause mortality and CVD events were reduced in usual sodium compared with low sodium intake and increased in high sodium compared with regular sodium intake, consistent with a U-shaped association between sodium intake and health outcomes [170]. In addition, 2 narrative reviews reported that in normotensives, salt reduction resulted in minor decreases in systolic blood pressure and stroke [157,171].

Alcohol

Besides social harm and increased dietary EI, alcohol (3.5%–10% wt/vol) consumers had significantly higher total cholesterol than controls, increased risk of arterial hypertension and AF but no differences in blood pressure or other inflammation biomarkers [59,172,173]. Moderate alcohol intake (10–15 g of alcohol/d) may reduce the incidence of T2DM (HR: 0.75; 95% CI: 0.67–0.83), the incidence of CVD, and overall mortality [29,112,174]. An intervention to reduce alcohol consumption did not affect the overall mortality (RR: 0.72; 95% CI: 0.16–3.17) or CVD events compared with the control group [175]. Risk of CVD, HF, and all causes of mortality was associated with higher alcohol intake (>100 g of alcohol/wk) [173,174].

Water

A meta-analysis of 6 studies indicated that water intake was inversely associated with risk of T2DM (RR: 0.94; 95% CI: 0.91–0.97, $I^2 = 24\%$) [176]. There is no review found on water intake on CVD. The findings support recommendations for water as part of a healthy diet.

GI

Several studies concluded that the optimal macronutrient combination to improve metabolic health needs more research. Diets high in refined dietary carbohydrates (especially those with a high GI), such as those rich in refined dietary carbohydrates (some sugars and rapidly digested starches) may increase risk of T2DM. Foods that contain low-GI carbohydrates (such as pulses, vegetables, and fruits), cereal fiber, and resistant starch should be prioritized to prevent T2DM [177].

Frying

There is strong evidence that when fried foods are consumed more often, there is an increased risk of chronic diseases such as T2DM, HF, obesity, and hypertension [59]. A lack of detailed information on the types of oils used for frying foods, stratification of the different kinds of fried food, temperature and duration of frying, and a lack of consideration of overall dietary patterns are, however, major gaps in the current literature [115,178]. Fried food consumption >2–4 times/wk increased risk of high blood pressure by 18%, T2DM by 27%, and CHD by 23% [59].

Food processing

Heat treatment has been shown to enhance the bioavailability of iron and carotene in plant-based foods. Cooking practices usually adopted for plant-based foods involve boiling in water (approximately 100ºC) or pressure-cooking (approximately 115ºC) at 15 pounds per square inch (p.s.i.) for ~5–15 min depending on the type of food [135]. In addition, the use of sprouting, fermentation, and malting can improve the bioavailability of iron and zinc from food grains and pulses [135,136,179]. Fermented foods are also popular in many nations worldwide, including Ethiopia. Fermentation is an ancient, environmentally friendly, and low-cost method of preserving food, which can enrich fermented food with certain nutrients, such as folate and manganese [179]. However, food additives and neo-formed contaminants formed during processing, such as advanced-glycation end-products, may influence CVD risk [180].

Discussion

This review aims to support the development of Ethiopian FBDG using the most recent evidence from systematic reviews and meta-analyses on foods, food groups, and dietary patterns in improving nutritional status and preventing T2DM and CVD. The current burden of malnutrition, micronutrient deficiencies, and emerging NCDs in Ethiopia is because of dietary and lifestyle changes [181–183]. By implementing dietary interventions on major dietary risk factors and improving diet quality, the adverse health and nutrition conditions that are currently prevalent may be counteracted [184,185]. However, according to our review, systematic reviews and meta-analyses predominantly focus on NCDs rather than diet-related nutritional status (Figure 2), and only a few are available from LMICs.

A key finding is that a predominately plant-based diet, with some animal-source foods, can help prevent malnutrition and diet-related NCDs. For instance, QPM increased weight and height in children. QPM is 1 of the biofortified crops that the Ethiopian government widely introduced to improve nutrition security [186]. Pulses improve protein and iron status, nuts are a good source of minerals, and plant-based fat has favorable health profiles and modest saturated fat content. Milk prevents stunting in young children, and meat improves iron status. Fruits and vegetables are good vitamin A and C sources and other healthy dietary components, such as minerals, antioxidants, and polyphenols.

Regarding animal-source food consumption and its contribution to the overall diet quality, the Ethiopian FBDG technical recommendations encourage consuming meat and dairy foods to prevent prevalent protein, zinc, calcium, vitamin B12, and vitamin A deficiencies [134]. On the contrary, excessive processed meat intake contributes to NCD risk [44], and meat consumption contributes to extensive environmental degradation [187]. Animal-based diets are vital, especially in sub-Saharan Africa, in preventing protein-energy and micronutrient deficiencies [134]. Finding the right balance between plant and animal-source foods is important to prevent diet-related NCDs while fulfilling the daily energy and nutrient requirements. Besides such a review for preventing diet-related health and nutrition problems, diet optimization to fulfill the dietary energy and nutrient requirement is crucial [188].

Our review identifies the foods, food groups, and dietary patterns that are relevant for preventing diet-related NCDs, indicating the optimal amounts to be consumed. For example, 30–90 g of whole grains daily lowers risk of CVD and T2DM. A pulse intake of 400 g/wk reduces risk of CVD and T2DM. Intake of 15–35 g of nuts per day lowers CVD risk; 200–300 g of dairy foods per day lowers risk of T2DM; limiting processed meat intake to below 50 g/d reduces risk of CVD. Moderate fish consumption (2–3 servings/wk) lowers risk of CHD. SSB and added

TABLE 2
The recommended amount of nutrient, food, or food group per day from our review in comparison with global recommendations

Food or food group or nutrients	The recommended amount per day			
	Our review	WHO	GBD optimal intake (range)	EAT-Lancet
Whole grain	≥30–90 g	—	125 g (100–150)	232 g (total gains 0–60% of energy) and tuber or starchy vegetables 50 g (0–100)
Pulse	50–150 g	—	60 g (50–70)	
Nuts and seeds	15–35 g	—	21 g (16–25)	25 g
Milk and dairy foods	200–300 g	—	435 g (350–520)	250 g (0–500)
Red meat		≤350–500 g/wk of unprocessed red meat	23 g (18–27)	7 g (0–14) for beef or pork 29 g (0–58) for chicken 13 g (0–25) for egg
Processed meat	<50 g		2 g (0–4)	
Fruits	200–300 g	400 g	250 g (200–300)	200 (100–300)
Vegetables			360 g (290–430)	300 g (200–600)
Added sugar	10% of total	At most 10% of energy		31 g (0–31)
Sugar-sweetened beverages	energy	<5% energy-free sugar	3 g (0–5)	—
Fiber	—	25 g	24 g (19–28)	—
Sodium	—	—	3 g (1–5)[1]	—
Salt	<5 g	<5 g		—
Fish and seafood	1–5 serving/wk		250 mg (200–300) - ω-3 FAs	28 g (0–100)
Fat and oil	10 g virgin oil	<30% of energy <10% of energy from saturated fat	11% (9–13) total energy from liquid vegetable oil	6.8 g (0–6.8) palm oil 40 g (20–80) unsaturated oil 5 g (0–5) lard

Abbreviation: GBD, global burden of diseases.
[1] Twenty-four-hour urinary sodium measured in grams per day; the energy requirement assumed for WHO and GBD—2000 kcal/d; EAT-Lancet—2500 kcal/d. Our review is based only on priority diet-related diseases and causes of death in Ethiopia with no assumption on EI.

sugar intake of >5% of total energy may raise risk of obesity, nutrient deficiencies, CVD, and T2DM. Despite their low micronutrient bioavailability, plant-based diets reduce risk of obesity and diet-related NCDs. Following a Mediterranean or vegetarian diet lowers risk of CVD and T2DM. Lower than usual sodium intake and consumption of coffee reduced CVD risk. Although no association was found between drinking alcohol and overall CVD, there was an association between alcohol consumption and HF and hypertension.

Most of the dietary recommendations derived from this review, which focused specifically on public health dietary issues of concern in Ethiopia, are aligned with country-specific and global recommendations. This is not unexpected because many dietary recommendations from 90 country-specific FBDG appear nearly universal across countries [13]. The universal dietary recommendations are; to consume a var. of foods; consume some types of foods within a food group in higher proportion than others; consume more fruits and vegetables, legumes, and animal-source foods; and limit the intake of sugar, fat, and salt.

The WHO, GBD, and EAT-Lancet diets include fruits and vegetables, animal-source foods, fat intake, and sugar and sugar-containing products (Table 2). In our review, those food groups are also included but differ in the recommended amounts. For example, the WHO healthy diet fact sheet recommends ≥400 g of fruits and vegetables per day, a little higher than the amount concluded (200–300 g) from this review [189]. WHO has similar recommendations on legumes, nuts, and whole grains, with our review recommending some differences in recommended grams per day of intake. The recommended intake of sugars by the WHO is 10% of dietary energy, equivalent to 25 g/d for a healthy body weight consuming ≥2000 kcal/d, but it is ideally recommended to be <5% of total EI for additional health benefits, which are similar to our review [189].

The dietary recommendations from the GBD studies are based on dietary consumption of key foods and nutrients across 195 nations, primarily from Europe and the United States [190]. The GBD dietary recommendations are within the range of the quantities proposed in our review for different food groups, including fruits (250 g), vegetables (360 g), legumes (60 g), whole grains (125 g), nuts, and seeds (21 g), milk (435 mL). On the contrary, GBD recommendations include fiber (24 g), calcium (1.25 g), ω-3 FAs (250 mg), PUFAs (11%), *trans* FA (0.5%), and sodium (3 g), which are not directly proposed in our review as our review mainly focuses on foods, food group, and dietary patterns. Additionally, GBD recommendations on red meat (23 g), processed meat (2 g), and SSB (3 g) are also addressed in our review.

The EAT-Lancet Commission diet aimed to provide a healthy diet on the basis of a sustainable food system [4]. The EAT-Lancet diet includes a daily intake of 200 (100–300) g of fruits, 300 (200–600) g of vegetables, 232 g of whole grain, 50 (0–100) g of legumes, 25 (0–75) g of nuts, 7 (0–10) g of beef and lamb, 29 (0–58) g of chicken and other poultry, 13 (0–25) g of egg, 28 (0–100) g of fish, 250 (0–500) mL of whole milk, 6.8 (0–6.8) g of palm oil, 40 (20–80) g of unsaturated oil, 31 (0–31) g of all sweeteners, and 5 (0–5) g of lard. Processed meat, a risk factor and thus food to limit, is only included by GBD and our review.

Salt intake is not included in the EAT-Lancet recommendations, whereas we consider it in our review as it is relevant for preventing NCDs. The WHO also recommends consuming <5 g (1 teaspoon) of salt daily and using iodized salt [191]. In addition, WHO member states have agreed to reduce global salt consumption by 30%, halt the rise in diabetes and obesity, and reduce risk of premature death from CVD, diabetes, or chronic respiratory illness by 25% by 2025 [192].

The Ethiopian FBDG technical committee has set 2 main objectives for the Ethiopian FBDG; the first objective is to provide dietary recommendations to the Ethiopian population of 2 y and older for increased diet quality, including diversity and food safety for optimal health. Per the Ethiopian FBDG's first goal, 11 key public messages and tips were developed and accompanied by a graphic illustration. The technical dietary recommendations extracted from this review are very relevant to improve the health and nutrition situation in the country and are used for developing the country-specific FBDG. A qualitative study has evaluated the dietary guidelines, tips, and food graphics for acceptability, cultural appropriateness, understanding, and practicality. According to the feasibility study, implementing FBDG can only be feasible if there is a strong set of actions that take into account the overall context-specific food system challenges [193]. This is addressed in the second objective of the FBDG, which is to promote broad food system actions supporting diet quality and being sensitive to sustainability in the Ethiopian diet [194]. A food systems approach involves multiple sectors, including the agriculture and health sector, to develop a national food system roadmap to support FBDG and the national food and nutrition program [195,196]. Future frontiers in FBDG development include incorporating environmental sustainability and increased attention to sociocultural factors, including changing dietary trends [13]. Besides this review, further adaptation of the technical dietary recommendations was possible using diet optimization of current eating habits to fill the evidence gap for developing a feasible healthy diet that meets the nutrient requirements [188]. The additional separate guidelines on food fortification and micronutrient supplementation will continue based on the needs of the subpopulation [197,198]. For consumers in Ethiopia to have the ability to adhere to Ethiopia's FBDG, it is essential to address the availability, accessibility, affordability, sustainability, and seasonality within the entire food system for both urban and rural consumers [17,199,200].

Strength and limitations

To our knowledge, this is the first review to attempt to synthesize the evidence on how dietary interventions affect the triple burden of malnutrition (underweight, overweight, and micronutrient deficiencies) and diet-related NCDs (CVD and T2DM). Such a review is relevant for Ethiopia and most other LMICs, where the triple burden of malnutrition and diet-related NCDs coexists. The evidence on overweight and obesity was not explicitly searched; however, this review synthesized evidence on overweight and obesity reported as CVD and T2DM risk factors. The priority NCDs in Ethiopia currently only include CVD and T2MD, but in the future, this might change to a wider spectrum of NCDs as also in Ethiopia, the diet transition is ongoing.

This review included systematic reviews and meta-analyses of various dietary interventions and cohorts from different

TABLE 3
The 9 key technical dietary recommendations based on the review

No.	Technical recommendation
1.	Cereals (especially whole-grain cereals), roots, and tubers are good sources of energy and nutrients. Biofortified cereals, including quality protein maize and roots, such as orange flesh sweet potatoes, are good sources of protein and vitamins. Consumption of 30–90 g of whole grains daily reduces risk of CVD and T2DM.
2.	Pulses are good sources of protein and minerals, such as zinc. Pulses consumption of 50–150 g/d or 4 servings (400 g/wk) reduces the incidence of CVD and T2DM.
3.	Consumption of 15–35 g of nuts and seeds daily increases antioxidant blood concentrations such as vitamins E and A, lowers risk of CVD, and lowers blood sugar concentrations.
4.	Milk and dairy foods are good sources of calcium, which improves BMD among adults and prevents stunting in children. Consumption of 200–300 mL dairy products daily does not increase CVD risk. Fermented dairy foods may reduce risk of T2DM.
5.	Meat, fish, and eggs are high-quality protein sources. In addition, meat is high in zinc and vitamin B12. Vitamin D, iodine, selenium, and long-chain PUFAs are all found in fish. Processed meat intake should be limited to 50 g/d, and non–fried fish consumption should be increased by 1–5 servings/wk to reduce CVD risk.
6.	Fruits and vegetables are high in vitamins and minerals. CVD plus T2DM risks are reduced when 200–300 g of vegetables and fruits are consumed daily. Hundred percent fruit juice counts as fruit intake but should be limited to half a cup daily.
7.	Sugar consumption should be $<$10% of total energy daily to lower risk of obesity, CVD, and T2DM.
8.	Fat and oil are energy sources and increase the bioavailability of carotenoids and vitamins D, E, and K during vegetable cooking. Plant-based oil with modest saturated fat will reduce the risk of CAD. Ten-gram daily virgin olive oil intake reduces risk of CVD and T2DM.
9.	Plant-based diets lower risk of obesity and NCDs but also reduce micronutrient bioavailability. Meat-rich diets increase micronutrient statuses such as iron and folate, but processed meat intake increases NCD risk. Overcooking should be avoided, processed foods should be consumed in moderation, and intake of fermented foods, particularly dairy foods, should be encouraged. Other recommendations include limiting alcohol and salt intake and encouraging water intake to affect NCDs prevention positively. Daily 3–4 cups of tea or coffee will lower risk of CVD and T2DM.

Abbreviations: NCD, noncommunicable disease; T2DM, type 2 diabetes mellitus.

countries, mostly from high-income countries. For example, in our selected systematic reviews on grain, roots, and tubers, out of the 22 articles (Figure 2), 12 are from high-income, 6 from high- and middle-income, 1 from middle-income, 1 from low-income, and 2 from all-income level countries. It is important to note that Ethiopians' intakes have traditionally mainly relied on various grains, roots, and tubers, some of which are not commonly consumed elsewhere, including teff and enset, but also common ones such as maize, wheat, sorghum, and barley. Differences in environment and study population may limit the comparability of the dietary impact on the disease status between high- and LMIC. Although this analysis mainly focuses on priority diseases and causes of mortality in Ethiopia, it can also be helpful for many LMICs as the review is based on available international evidence. Countries with similar priorities of health and nutrition problems to Ethiopia are advised to contextualize this review further in consultation with in-country experts and using additional local evidence.

Positive impact studies are more likely to be published than those with null findings, and this publication bias was not directly addressed in our review. We used the AMSTAR tool for a quality check of the papers. The recommended amounts of food intake were derived from a meta-analysis of selected review papers. Thus, the recommended amounts in this review will help determine the recommended amounts for the final FBDG and insight from diet modeling. Regardless, the technical recommendations from our review helped Ethiopia develop key public messages for the Ethiopian FBDG by combining the evidence from this review with local evidence on dietary patterns, food availability, accessibility and seasonality, and determinants of cultural and religious factors related to dietary habits.

In conclusion, based on the review, we conclude the following 9 key dietary recommendations (Table 3) to consider in the Ethiopian FBDG in combination with other local evidence and diet modeling work.

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Author contribution

The authors' responsibilities were as follows—THB, LT, IDB, JHMV, EJMF, and NC: conceptualization; THB, JHMV, and LT: literature searching; THB and JHMV: quality appraisal; THB, LT, IDB, JHMV, NC, GK, DA, and EJMF: synthesizing and writing—original draft preparation; LT, IDB, JHMV, NC, GK, DA, EJMF: review; THB: edit, and all authors: read and approved the final manuscript.

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Appendix A. Supplementary data

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