CLINICAL PRACTICE GUIDELINES FOR HEALTHY EATING FOR THE PREVENTION AND TREATMENT OF METABOLIC AND ENDOCRINE DISEASES IN ADULTS: COSPONSORED BY THE AMERICAN ASSOCIATION OF CLINICAL ENDOCRINOLOGISTS/ THE AMERICAN COLLEGE OF ENDOCRINOLOGY AND THE OBESITY SOCIETY

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American Association of Clinical Endocrinologists Medical Guidelines for Clinical Practice are systematically developed statements to assist health care professionals in medical decision making for specific clinical conditions. Most of the content herein is based on literature reviews. In areas of uncertainty, professional judgment was applied.

These guidelines are a working document that reflects the state of the field at the time of publication. Because rapid changes in this area are expected, periodic revisions are inevitable. We encourage medical professionals to use this information in conjunction with their best clinical judgment. The presented recommendations may not be appropriate in all situations. Any decision by practitioners to apply these guidelines must be made in light of local resources and individual patient circumstances.

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Abbreviations:
1,25(OH)$_2$D = 1,25-dihydroxyvitamin D; **25(OH)D** = 25-hydroxyvitamin D; **A1c** = hemoglobin A1c; **AACE** = American Association of Clinical Endocrinologists; **ADA** = American Diabetes Association; **AHA** = American Heart Association; **AI** = adequate intake; **ALA** = alpha-linoleic acid; **BEE** = basal energy expenditure; **BEL** = "best evidence" rating level; **BMI** = body mass index; **BMR** = basal metabolic rate; **BP** = blood pressure; **CCM** = Chronic Care Model; **CCS** = consecutive case studies; **CHD** = coronary heart disease; **CI** = confidence interval; **CKD** = chronic kidney disease; **CPG** = clinical practice guideline; **CSS** = cross-sectional study; **CV** = cardiovascular; **CVD** = cardiovascular disease; **D$_3$** = cholecalciferol; **DASH** = Dietary Approaches to Stop Hypertension; **DBP** = diastolic blood pressure; **DHA** = docosahexaenoic acid; **DM** = diabetes mellitus; **DRI** = dietary reference intake; **DV** = daily value; **EAA** = essential amino acid; **EFA** = essential fatty acid; **EI** = energy intake; **EL** = evidence level; **EPA** = eicosapentaenoic acid; **ESKD** = end-stage kidney disease; **FDA** = U.S. Food and Drug Administration; **GDM** = gestational diabetes mellitus; **GFR** = glomerular filtration rate; **GI** = glycemic index; **HBV** = high-biological-value; **HDL-C** = high-density-lipoprotein cholesterol; **HFCS** = high fructose corn syrup; **HP/LC** = high-protein/low-carbohydrate; **HR** = hazard ratio; **IOM** = Institute of Medicine; **LCMP** = low-calorie meal plan; **LDL-C** = low-density-lipoprotein cholesterol; **LoBAG** = low biologically available glucose; **MNRCT** = meta-analysis of nonrandomized prospective or case-controlled studies; **MNT** = medical nutrition therapy; **MRCT** = meta-analysis of randomized controlled trials; **MUFA** = monounsaturated fatty acid; **MVI** = multivitamin; **NCEP** = National Cholesterol Education Program; **NE** = no evidence (theory, opinion, consensus, and review); **NIH** = National Institutes of Health; **NHANES** = National Health and Nutrition Examination Survey; **NRCT** = nonrandomized controlled trial; **PCOS** = polycystic ovarian syndrome; **PCS** = prospective cohort study; **PPG** = postprandial glucose; **PNV** = prenatal vitamin; **PTH** = parathyroid hormone; **PUFA** = polyunsaturated fatty acid; **Q** = question; **R** = recommendation; **RCCS** = retrospective case-control study; **RCT** = randomized controlled trial; **RD** = registered dietician; **RDA** = recommended dietary allowance; **REE** = resting energy expenditure; **RMR** = resting metabolic rate; **RR** = relative risk; **RRT** = renal replacement therapy; **RYGB** = Roux-en-Y gastric bypass; **SBP** = systolic blood pressure; **SCR** = single-case report; **SS** = surveillance study (registries, surveys, epidemiologic); **SSB** = sugar-sweetened beverage; **T1DM** = type 1 diabetes mellitus; **T2DM** = type 2 diabetes mellitus; **TC** = total cholesterol; **TEE** = total energy expenditure; **TG** = triglyceride; **TLC** = therapeutic lifestyle changes; **TOS** = The Obesity Society; **TV** = television; **TUL** = tolerable upper limit; **USDA** = United States Department of Agriculture; **VLCMP** = very low-calorie meal plan; **WHO** = World Health Organization

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1. INTRODUCTION

The American Association of Clinical Endocrinologists (AACE) and The Obesity Society (TOS) are professional organizations dedicated to improve the lives of patients with endocrine and metabolic disorders. Chronic diseases demand treatment, but a focus on primary, secondary, and tertiary prevention strategies is important as well. Central to this approach is behavior modification to achieve consistent

healthy eating and physical activity. Yet, to date there is no evidence-based clinical practice guideline (CPG) to define the standards of care for healthy eating in the management and prevention of metabolic and endocrine disorders. This joint effort of AACE and TOS addresses this deficit.

For most clinical endocrinologists, nutrition education is not structured. Many of the endocrinology training programs in the United States lack a dedicated nutrition curriculum. The same problem affects physicians with a focus of practice in bariatric medicine (1 [EL4, NE]; 2 [EL4, NE]). As a result, nutritional counseling and management for our patients is often delegated to other health care professionals.

There are many obstacles that preclude patient access to nutritional education. Federal institutions have not paid for nutrition education except for a limited number of conditions, including medical nutrition therapy (MNT) for diabetes mellitus (DM) and nutrition counseling for chronic kidney disease (CKD) stage 5. Although Medicare has recently approved counseling for obesity, most overweight patients or patients with obesity, dyslipidemia, polycystic ovarian syndrome (PCOS), hypertension, osteopenia and osteoporosis, hyperuricemia, earlier stages of CKD, eating disorders, malnutrition, and prediabetes are marginalized from this important component of health care.

Other obstacles to implementing healthy eating strategies on a large scale include:

- unawareness of the importance of health promotion and wellness care in the general population to prevent disease, including endocrine and metabolic disorders,
- the relative paucity of healthy nutritional principles and eating patterns taught in American schools, higher education institutions, and even workplaces,
- the relative scarcity and increased expense of healthy foods,
- the easy accessibility, low cost, and palatability of less-healthy foods,
- mass-media marketing of foods with low nutritional value,
- lack of oversight of food marketing, and inadequate and/or ineffective food policies,
- the perishability of foods, increased need for preservatives, and decreased awareness of food safety,
- the variability of nutrient-gene interactions (nutrigenomics and nutrigenetics), and
- transcultural factors, including religious, social, ethnic, and economic factors, as well as individual food preferences, culinary styles, and belief systems.

This CPG proposes an evidence-based, standardized context for healthy eating recommendations. Throughout this document, the word "diet" is avoided, and the terms "*meal plan*" (what patients are taught to eat) and "*eating or dietary pattern*" (the structure or composition of the meals) are preferred instead. This CPG does not formally address healthy eating for pediatric or hospitalized patients but makes reference to them when appropriate.

2. METHODS

The AACE Board of Directors mandated a CPG on healthy eating for the prevention and treatment of metabolic and endocrine diseases in adults. The project was approved for co-authorship with TOS by the leadership of both organizations. This CPG was developed in accordance with the AACE Protocol for Standardized Production of Clinical Practice Guidelines – 2010 Update. Reference citations in the text of this document include the reference number, numerical descriptor (evidence level; EL 1-4), and semantic descriptor (see Tables 1-4). Recommendations are assigned Grade levels based on the supporting clinical evidence and subjective factors. The format of this CPG is based on specific and relevant clinical questions. All primary writers have made disclosures regarding multiplicities of interest. In addition, all primary writers are credentialed experts in the fields of nutrition, endocrinology, or both. This CPG has been reviewed and approved by the primary writers, other invited experts, the AACE Publications and Nutrition Committees, and the AACE Board of Directors prior to submission for peer review in *Endocrine Practice*. This CPG has also been approved by selected members of TOS prior to submission for peer review in *Obesity*, The Official Journal of TOS. This CPG expires in 2016.

Clinical questions are labeled "Q" and recommendations are labeled "R". Recommendation grades are based on four intuitive levels: (grades A [strong], B [intermediate], and C [weak]) or expert opinion when there is a lack of conclusive clinical evidence (grade D). The "best evidence" rating level (BEL), which corresponds to the best conclusive evidence found in the discussion section in the appendix, accompanies the recommendation grades in the Executive Summary. There are also four intuitive levels of evidence: 1 = strong, 2 = intermediate, 3 = weak, and 4 = no evidence. Comments may be appended to recommendations regarding relevant subjective factors that may have influenced the grading process. The consensus level of experts for each recommendation may also be explicitly provided in appropriate instances. Thus, the process leading to a final recommendation and grade is not dogmatic but rather incorporates a complex expert integration of objective and subjective factors meant to reflect optimal real-life clinical decision-making to enhance patient care. Where appropriate, cascades of recommendations are provided (settings with limited resources, unique patient attributes, etc. (3) [EL4, NE]).

3. EXECUTIVE SUMMARY

3.Q1. What is Healthy Eating?

3.Q1.1 General Recommendations for Healthy Eating and Disease Prevention

- **R1.** All patients should be instructed on healthy eating and on proper meal planning by qualified health care professionals **(Grade A, BEL 1)**. Essential macronutrients and micronutrients, fiber, and water should be provided by well-chosen foods and beverages that can be enjoyed and constitute a healthy eating pattern. Macronutrients should be recommended in the context of a calorie-controlled meal plan **(Grade A, BEL 1)**. All patients should also be counseled on other ways to achieve a healthy lifestyle, including regular physical activity (150 minutes or more per week), ways to avoid a sedentary lifestyle, appropriate sleep time (6 or more hours every night), and budgeting time for recreation or play, stress reduction, and happiness **(Grade A, BEL 1)**.

3.Q1.2 Healthy Macronutrient Intake

- **R2.** In a healthy eating meal plan, carbohydrates should provide 45 to 65% of ingested energy, with due diligence to limit simple sugars or foods that have a high glycemic index (GI). Regardless of the macronutrient mix, total caloric intake must be appropriate for individual weight management goals. Patients should consume 6 to 8 servings of carbohydrates (one serving is 15 grams of carbohydrate) per day with at least half (3 to 4 servings) being from high-fiber, whole-grain products **(Grade A, BEL 1)**. Consumption of fruits (especially berries) and vegetables (especially raw) (≥4.5 cups per day) will increase fiber, increase phytonutrient intake, and facilitate calorie control **(Grade B, BEL 2)**. Patients should be instructed to consume whole grains in place of refined grains, which will add fiber and micronutrients to meals and help lower blood pressure (BP) **(Grade A, BEL 1)**.
- **R3.** Protein from both plant and animal sources (15 to 35% of calories depending on total intake) can replace a portion of saturated fat and/or refined carbohydrates in the meal plan to help improve blood lipids and BP **(Grade A, BEL1)**. The meal plan should include a maximum of 6 ounces per day of reduced-fat animal protein to increase the nutrient-to-calorie ratio **(Grade B, BEL 1)**. Reduced-fat dairy (2 to 3 servings per day) should be recommended as a source of high-quality protein for patients who are not intolerant or allergic to lactose because it lowers BP and helps reduce weight while also providing important micronutrients **(Grade A, BEL 1)**. Plant protein (e.g., pulses, including beans, lentils, and some nuts; and certain vegetables, including broccoli, kale, and spinach) should be emphasized in meal planning, as it is not commonly consumed in Western meals; plant proteins confer many health benefits, including improved blood lipid levels and BP **(Grade B, BEL 2)**.
- **R4.** Patients should be counseled to consume unsaturated fats from liquid vegetable oils, seeds, nuts, and fish (including omega-3 fatty acids) in place of high-saturated fat foods (butter and animal fats), providing 25 to 35% of daily calories to reduce the risk for cardiovascular disease (CVD)

Table 1
2010 AACE Protocol for Production of Clinical Practice Guidelines.
Step I: Evidence Rating

1	Meta-analysis of randomized controlled trials (MRCT)
1	Randomized controlled trials (RCT)
2	Meta-analysis of nonrandomized prospective or case-controlled trials (MNRCT)
2	Nonrandomized controlled trial (NRCT)
2	Prospective cohort study (PCS)
2	Retrospective case-control study (RCCS)
3	Cross-sectional study (CSS)
3	Surveillance study (registries, surveys, epidemiologic study, retrospective chart review, mathematical modeling of database) (SS)
3	Consecutive case series (CSS)
3	Single case reports (SCR)
4	No evidence (theory, opinion, consensus, or review) (NE)

Abbreviations: AACE = American Association of Clinical Endocrinologists.
1 = strong evidence; 2 = intermediate evidence; 3 = weak evidence; 4 = no evidence.
Adapted from Mechanick et al. *Endocr Pract*. 2010;16:270-283.

(Grade A, BEL 1). It should be recommended that patients consume natural foods high in monounsaturated fat, such as olive oil in the Mediterranean dietary pattern, since this is strongly associated with improved health outcomes **(Grade A, BEL 1)**. It should be recommended that patients eat at least 2 servings of cold-water, fatty fish (such as salmon or mackerel) every week because they contain greater amounts of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) **(Grade B, BEL 2)**.

3.Q1.3 Healthy Micronutrient Intake

- **R5.** With the exception of proven therapies for documented specific vitamin deficiency states or diseases, or pregnancy, there are insufficient data to recommend supplemental vitamin intake above the recommended dietary allowances (RDA) **(Grade D, BEL 4)**. Vitamin E supplementation to decrease cardiovascular (CV) events or cancer is not recommended **(Grade B, BEL 2)**. Lifelong regular follow-up and individualized therapy are recommended in diseases known to cause intestinal malabsorption (e.g., after malabsorptive bariatric surgery, ileo-colic resection, short bowel syndrome, celiac disease, inflammatory bowel disease, exocrine pancreatic insufficiency, CKD, and chronic liver disease) to detect and treat vitamin and mineral deficiencies **(Grade B, BEL 2)**.
- **R6.** Vitamin B_{12} levels should be checked periodically in older adults and patients on metformin therapy **(Grade A, BEL 1)**. With the exception of early treatment of patients with neurologic symptoms, pernicious anemia, or malabsorptive bariatric surgery requiring parenteral (intramuscular or subcutaneous) vitamin B_{12} replacement, patients with vitamin B_{12} deficiency can generally be treated with oral vitamin B_{12} (1,000 μg per day of oral crystalline cobalamin) and may benefit from increasing the intake of vitamin B_{12} in food **(Grade A, BEL 1)**.
- **R7.** The prevalence of vitamin D deficiency and insufficiency warrants case finding by measurement of 25-hydroxyvitamin D (25[OH]D) levels in populations at risk, including institutionalized elderly patients, people with hyperpigmented skin, and people with obesity **(Grade B BEL 2)**. Older adults, people with increased skin pigmentation, and those exposed to insufficient sunlight should increase vitamin D intake from vitamin D-fortified foods and/or supplements to at least 800 to 1,000 international units (IU) daily **(Grade A, BEL 1)**.

3.Q2. What Nutritional Recommendations are Appropriate for Weight Management?

3.Q2.1 Approach to Overweight and Obesity

- **R8.** Overweight and obesity should be managed as a long-term chronic disease **(Grade A, BEL 1)**. Overweight and obesity should be managed using a multidisciplinary team approach **(Grade A, BEL 1)**. Nutrition counseling for overweight and obesity should be aimed to decrease fat mass and also to correct adipose tissue dysfunction (adiposopathy) **(Grade A, BEL 1)**. Adult feeding behavior is solidly rooted from childhood, so it is important to counsel adult patients to include their families, especially their children, in healthy eating behavior changes **(Grade B, BEL 2)**. Nutrition counseling should be culturally, linguistically, and educationally provided to meet individual patient needs **(Grade D, BEL 4)**.
- **R9.** The weight-loss goal for overweight or obese patients is 5 to 10% of current body weight over the ensuing 6 to 12 months. This goal is perennial

Table 2
2010 AACE Protocol for Production of Clinical Practice Guidelines.
Step II: Evidence Analysis and Subjective Factors

Study design	Data analysis	Interpretation of results
Premise correctness	Intent-to-treat	Generalizability
Allocation concealment (randomization)	Appropriate statistics	Logical
Selection bias		Incompleteness
Appropriate blinding		Validity
Using surrogate end points (especially in "first in class" intervention)		
Sample size (beta error)		
Null hypothesis versus Bayesian statistics		

Abbreviation: AACE = American Association of Clinical Endocrinologists.
Adapted from Mechanick et al. *Endocr Pract*. 2010;16:270-283.

Table 3
2010 AACE Protocol for Production of Clinical Practice Guidelines.
Step III: Grading of Recommendations – How Different Evidence Levels Can be Mapped to the Same Recommendation Grade[a]

BEL	Subjective factor impact	Two-thirds consensus	Mapping	Recommendation grade
1	None	Yes	Direct	A
2	Positive	Yes	Adjust up	A
2	None	Yes	Direct	B
1	Negative	Yes	Adjust down	B
3	Positive	Yes	Adjust up	B
3	None	Yes	Direct	C
2	Negative	Yes	Adjust down	C
4	Positive	Yes	Adjust up	C
4	None	Yes	Direct	D
3	Negative	Yes	Adjust down	D
1, 2, 3, 4	NA	No	Adjust down	D

Abbreviations: AACE = American Association of Clinical Endocrinologists; BEL = best evidence level; NA = not applicable.
[a] Starting with the left column, BEL, subjective factors, and consensus map to recommendation grades in the right column. When subjective factors have little or no impact ("none"), then the BEL is directly mapped to recommendation grades. When subjective factors have a strong impact, then recommendation grades may be adjusted up ("positive" impact) or down ("negative" impact). If a two-thirds consensus cannot be reached, then the recommendation grade is D. NA regardless of the presence or absence of strong subjective factors, the absence of a two-thirds consensus mandates a recommendation grade D.
Adapted from Mechanick et al. *Endocr Pract*. 2010;16:270-283.

until an acceptable body mass index (BMI) is achieved **(Grade A, BEL 1)**. Combined therapy utilizing a low-calorie meal plan (LCMP), increased physical activity, behavior therapy, and appropriate pharmacotherapy provides the most successful intervention for weight loss and weight maintenance and is also recommended as an adjunct to bariatric surgery **(Grade A, BEL2. Expert panel experience and consensus)**.

3.Q2.2 Behavior Modification

- **R10.** Sustained behavior modification must be achieved for long-term success with weight management. Food and activity recordkeeping should be recommended to help patients achieve the best results **(Grade A, BEL 1)**. Behavioral group therapy is a cost-effective way of providing nutrition counseling to patients and should be incorporated into weight management treatment programs **(Grade B, BEL 2)**. Use of portion-controlled prepackaged meals should be considered as a way to achieve a lower caloric intake **(Grade A, BEL 1)**.

3.Q2.3 Low-Calorie Meal Plans

- **R11.** When first treating a patient with overweight or obesity, emphasis should be placed on maintaining a healthy meal plan and avoiding fad diets while including food choices from all major food groups **(Grade A, BEL 2)**. A healthy, LCMP with a deficit of 500 to 1,000 kcal/day should be an integral part of any program aimed at achieving a total weight-loss rate of 1 to 2 pounds/week (which may include lean muscle mass as well as fat mass weight loss) **(Grade A, BEL 1)**. All meal plans of <1,200 kcal/day should be carefully selected so that nutrient requirements are met. When particular food groups are severely restricted or omitted, the use of dietary supplements to meet nutrient requirements should be implemented **(Grade D, EL 4)**.

3.Q2.4 Very Low-Calorie Meal Plans

- **R12.** Very low-calorie meal plans (VLCMPs) (≤800 kcal/day or ~6 to 10 kcal/kg), which can produce weight losses up to 1.5 to 2.5 kg/week and up to 20 kg in 12 to 16 weeks, may be recommended for patients with a BMI >30 kg/m^2 who have significant comorbidities or who have failed other nutritional approaches to weight loss **(Grade B, BEL 2)**. VLCMP treatment requires nutritional supplementation and medical monitoring for complications, including electrolyte

Table 4
2010 American Association of Clinical Endocrinologists Protocol for Production of Clinical Practice Guidelines.
Step IV: Examples of Qualifiers that may be Appended to Recommendations

Cost effectiveness
Risk-benefit analysis
Evidence gaps
Alternative physician preferences (dissenting opinions)
Alternative recommendations ("cascades")
Resource availability
Cultural factors
Relevance (patient-oriented evidence that matters)

Adapted from Mechanick et al. *Endocr Pract*. 2010;16:270-283.

imbalances, hepatic transaminase elevation, and gallstone formation, and the duration of treatment should not exceed 12 to 16 weeks **(Grade A, BEL 1)**.

3.Q3. What Nutritional Recommendations are Appropriate for Cardiovascular Health?

3.Q3.1 Nutritional Strategies for Excess Fat Mass and Adiposopathy

- **R13.** All patients at risk for CVD should implement healthy eating patterns, which provide calorie control, adequate nutrients, beneficial bioactive compounds, and result in weight loss or weight maintenance **(Grade D, BEL 4)**. To help control calorie intake, patients should eat meals that are low in energy density **(Grade A, BEL1)**. All patients should also be advised to increase caloric expenditure to at least 150 minutes of moderate-intensity activity every week (e.g., walking) or 75 minutes of vigorous-intensity activity every week (e.g., running) **(Grade A, BEL 1)**. Successful weight loss and maintenance to decrease CV risk must include both a change in meal plan as well as frequent physical activity **(Grade A, BEL 1)**.

3.Q3.2 Nutritional Strategies for Dyslipidemia

- **R14.** The therapeutic lifestyle changes (TLC) meal plan with viscous fiber and plant sterols and stanols is recommended for individuals with elevated low-density-lipoprotein cholesterol (LDL-C) **(Grade A, BEL 1)**. The Mediterranean meal plan (or a TLC meal plan that provides 30 to 35% of calories from total fat with an emphasis on mono- and polyunsaturated fatty acids [PUFAs]) is recommended for individuals who have abnormal non-LDL-C lipid values **(Grade A, BEL 1)**.

3.Q3.3 Nutritional Strategies for Hypertension

- **R15.** Attaining and maintaining a healthy body weight is recommended to prevent and treat hypertension. Obese and overweight individuals should accomplish a 10% weight loss to decrease their BP **(Grade A, BEL 1)**. All patients should be counseled to adhere to the Dietary Approaches to Stop Hypertension (DASH) meal plan, which is high in fruits, vegetables, whole grains, and reduced-fat dairy **(Grade A, BEL 1)**. Sodium intake should be reduced to <2,300 mg/day, and potassium intake should be increased to >4,700 mg/day with implementation of a DASH-type meal plan **(Grade A, BEL 1)**. Sodium intake should be further reduced (<1,500 mg/day; or 3,800 mg/day of table salt) for people age 51 years and above, all people who are African American, regardless of age, and for patients who have hypertension, DM, or CKD **(Grade A, BEL 1)**.

3.Q4. What Nutrient Sources Should be *Limited* for Cardiovascular Health?

- **R16.** Added sugars should be limited to <100 calories per day for women and <150 calories per day for men **(Grade A, BEL 1)**. Sugar-sweetened beverage (SSB) intake should be reduced as an effective way to reduce added sugar intake **(Grade B, BEL 2)**. Saturated fat intake should be limited to <7% for reduction of CVD risk **(Grade A, BEL 1)**. It is recommended that processed red meat intake be limited to less than 2 servings per week and that

lean or very lean red meat cuts be consumed while controlling for saturated fat intake **(Grade B, BEL 2)**. Whole grain products should be substituted for refined grain products when possible, such that at least one-half of daily servings of grains are from whole grains **(Grade B, BEL 2)**.

3.Q5. What Nutritional Recommendations are Appropriate for Diabetes Mellitus?

3.Q5.1 Patient Nutrition Education

- **R17.** Medical nutrition therapy provided by a physician, physician extender, registered dietician (RD), and/or certified diabetes educator (CDE) is recommended for all patients with DM **(Grade A, BEL 1)**. Patients with DM who experience difficulty achieving glycemic targets should keep a personal food diary **(Grade D, BEL 4)**.

3.Q5.2 Caloric and Protein Intake

- **R18.** Patients with DM should consume total daily calories at amounts sufficient to attain or maintain a normal BMI of 18.5 to 24.9 kg/m^2, which is generally in the 15 to 30 kcal/kg/day range, depending on level of physical activity **(Grade A, BEL 1)**. Patients with DM should consume protein in the 0.8 to 1.0 g/kg/day range, and protein should account for about 15 to 35% of the total calorie consumption for the day **(Grade C, BEL 3)**.

3.Q5.3 Carbohydrate Intake

- **R19.** Medical nutrition therapy should be implemented to control the glycemic response to meals and to achieve hemoglobin A1c (A1c) and blood glucose levels as close to the target range as possible without risk to the individual patient **(Grade A, BEL 1)**. Carbohydrates should account for about 45 to 65% of the total calorie consumption for the day, including low-fat dairy products and sucrose **(Grade C, BEL 3)**. Patients with DM should consume carbohydrate primarily from unprocessed carbohydrates, which are provided by a target of 8 to 10 servings per day of vegetables (particularly raw), fruits, and legumes, with due diligence to limit simple sugars or foods that have a high GI **(Grade A, BEL 1)**. Regardless of the macronutrient mix, total caloric intake must be appropriate for individual weight management goals. Patients with DM should consume 20 to 35 g of fiber from raw vegetables and unprocessed grains (or about 14 g of fiber per 1,000 kcal ingested) per day (the same as the general population) **(Grade B, BEL 2)**. Patients with type 1 DM (T1DM), or insulin-treated type 2 DM (T2DM) should synchronize insulin dosing with carbohydrate intake **(Grade A, BEL 1)**. Patients with T2DM treated with short-acting oral hypoglycemic agents (nateglinide, repaglinide) should also synchronize carbohydrate intake with administration of these medications **(Grade A, BEL 1)**. Patients with DM may safely consume artificial sweeteners within the guidelines of the U.S. Food and Drug Administration (FDA) **(Grade D, BEL 4)**.

3.Q5.4 Fat Intake

- **R20.** For patients with DM, total fat intake should account for about 30% of the total daily calories **(Grade B, BEL 2)**. Consumption of saturated fat should be less than 7% of total daily calories regardless of the serum total cholesterol level, and PUFAs should be up to 10% of the total daily calories (examples of food sources include vegetable oils high in n-6 PUFA, soft margarine, salad dressings, mayonnaise, and some nuts and seeds) **(Grade B, BEL 2)**. The n-3 PUFAs are most desirable, and dietary recommendations for EPA and DHA can be achieved with two or more servings of fresh fish per week **(Grade B, BEL 2)**. In patients with DM, monounsaturated fatty acids (MUFAs) should be up to 15 to 20% of the total daily calories **(Grade B, BEL 2)**. Dietary cholesterol should be less than 200 mg/day **(Grade A, BEL 1)**. Patients with DM should avoid consumption of *trans* fats **(Grade C, BEL 3)**.

3.Q5.5 Other Nutritional Recommendations

- **R21.** There is insufficient evidence to specifically recommend a "low-GI" meal plan in patients with DM **(Grade D, BEL 4)**. There is insufficient evidence to support the routine use of antioxidants, chromium, magnesium, and/or vanadium in patients with DM **(Grade C, BEL 3)**.
- **R22.** Patients with DM who choose to drink alcohol should ingest it with food and limit intake to 2 servings per day for men or 1 serving per day for women. Alcohol intake should not be increased for any purported beneficial effect **(Grade D, BEL 4)**. There is insufficient evidence, based on long-term risks and benefits, to support the use of fad diets in patients with DM **(Grade D, BEL 4)**.

3.Q5.6 Diabetes Mellitus Prevention

- **R23.** There is insufficient evidence to support nutrition changes to specifically prevent T1DM **(Grade D, BEL 4)**. However, women with a personal or family history of T1DM who may be HLA-DR3 and DR4 carriers should be counseled on the medical evidence suggesting that the use

of infant formula derived from cow's milk in the first 6 months of life increases a baby's risk of T1DM by stimulating antibody formation to the beta-cells **(Grade B, BEL2)**. Patients at high risk for the development of T2DM should implement lifestyle interventions to achieve a minimum of 7% weight loss followed by weight maintenance, and a minimum of 150 minutes of weekly physical activity, similar in intensity to brisk walking **(Grade A, BEL 1)**.

3.Q6. What Nutritional Recommendations are Appropriate for Chronic Kidney Disease?

3.Q6.1 General Approach

- **R24.** Patients with CKD should have a meal plan low in protein, sodium, potassium, and phosphorus, which slows the progression of kidney disease **(Grade A, BEL1)**. All patients with CKD should receive nutrition education by qualified health care professionals **(Grade A, BEL 1)**.

3.Q6.2 Protein Requirements

- **R25.** In CKD stages 1, 2, or 3, protein intake should be limited to 12 to 15% of daily calorie intake or 0.8 g of high-biological-value (HBV) protein/kg body weight/day **(Grade A, BEL 1)**. In CKD stage 4, protein intake should be reduced to 10% of daily calorie intake or 0.6 g of high-quality protein/kg body weight/day, provided an essential amino acid (EAA) deficiency does not occur **(Grade A, BEL 1)**. For nondialyzed CKD patients with a glomerular filtration rate (GFR) <25 mL/min, 0.6 g of protein/kg body weight/day should be prescribed, with at least 50% of the protein intake from HBV sources to ensure a sufficient amount of EAAs **(Grade A, BEL 1)**. For patients with CKD stage 5 or patients on renal replacement therapy (RRT), protein intake should be 1.3 g/kg/day (peritoneal dialysis) or 1.2 g/kg/day (hemodialysis) **(Grade A, BEL 1)**. Urinary protein losses in the nephrotic syndrome should be replaced, and a low-normal protein dietary reference intake (DRI) of 0.8 to 1.0 g/kg body weight/day should be recommended **(Grade C, BEL 3)**.
- **R26.** Patients with CKD stages 1, 2, or 3 should ingest 35 kcal/kg body weight/day in order to maintain neutral nitrogen balance and to prevent catabolism of stored proteins for energy needs **(Grade B, BEL 2)**. Patients with CKD and a GFR <25 mL/min should ingest 35 kcal/kg body weight/day if they are younger than age 60 years or 30 to 35 kcal/kg body weight/day if they are age 60 years or above **(Grade B, BEL 2)**.

3.Q6.3 Electrolytes

- **R27.** All patients with CKD, regardless of CKD stage, should limit sodium intake to 2.0 g/day **(Grade A, BEL 1)**. When potassium levels are elevated, potassium intake (including salt substitutes) should be limited to 2 to 3 g/day **(Grade A, BEL 1)**. When diarrhea or vomiting is present, potassium intake should be liberalized and provided with meals that include a variety of fruits, vegetables, and grains **(Grade D, BEL 4)**.
- **R28.** Phosphate intake should be limited to 800 mg/day for patients with stage 3, 4, or 5 CKD **(Grade A, BEL 1)**. All patients with CKD and hyperphosphatemia should get 2,000 mg/day of total calcium intake (binders plus calcium in meals) **(Grade A, BEL 1)**.
- **R29.** All patients with CKD who have hyperphosphatemia and secondary hyperparathyroidism should be treated with oral vitamin D to bring the total serum 25(OH)D level to greater than 30 ng/mL (**Grade A, BEL 1)**. If the intact parathyroid hormone (PTH) level remains elevated above treatment goal despite a serum 25(OH)D level higher than 30 ng/mL, treatment with an active form of vitamin D is indicated **(Grade A, BEL 1)**.
- **R30.** Patients with stage 3, 4, or 5 CKD should receive oral ferrous sulfate, 325 mg three times a day, in order to maintain transferrin saturation >20% and serum ferritin >100 ng/mL **(Grade A, BEL 1)**.

3.Q6.4 Renal Replacement Therapy

- **R31.** For patients with end-stage kidney disease (ESKD) on RRT, potassium intake should be limited to 3 to 4 g/day (peritoneal dialysis) or 2 to 3 g/day (hemodialysis) **(Grade A, BEL 1)**. Patients with DM and ESKD who are on RRT should be routinely queried regarding their eating habits, home glucose monitoring, and frequency and severity of hypoglycemia **(Grade C, BEL 3)**.

3.Q7. What Nutritional Recommendations are Appropriate for Bone Health?

3.Q7.1 Calcium

- **R32.** Total elemental calcium intake should be 1,000 mg/day for premenopausal women and men and 1,200 to 1,500 mg/day for postmenopausal women, preferentially from food sources **(Grade A, BEL 1)**. Excessive amounts of elemental calcium intake, in the range of 2,000 mg/day, may increase the risk of kidney stones and other side effects and should therefore be actively discouraged **(Grade A, BEL 1)**. A calcium intake greater

than 1,500 mg/day is associated with an increased risk of advanced prostate cancer and should be discouraged **(Grade B, BEL 2)**. Calcium supplements should be used if a patient's meal plan does not provide adequate calcium intake **(Grade A, BEL 1)**. Calcium citrate should be recommended instead of calcium carbonate for patients with achlorhydria, history of gastric surgery, and those being treated with proton-pump inhibitors or H2-receptor blockers **(Grade B, BEL 2)**. For best absorption, calcium supplements should be limited to no more than 500 mg of elemental calcium per dose, since there is decreasing absorption with increasing doses **(Grade A, BEL 1)**. A 24-hour urine calcium collection should be measured in patients with osteoporosis or patients at risk for bone loss in order to check calcium adequacy and test for hypercalciuria or malabsorption **(Grade B, BEL 2)**.

3.Q7.2 Vitamin D

- **R33.** Serum 25(OH)D should be measured in individuals at risk for vitamin D deficiency (e.g., elderly, institutionalized, or malnourished patients) and in those with known osteopenia or osteoporosis **(Grade A, BEL 1)**. Vitamin D should be supplemented to keep the plasma 25(OH)D level greater than 30 ng/mL **(Grade A, BEL 1)**. For most patients, a daily intake of at least 1,000 to 2,000 IU of ergocalciferol (D_2) or cholecalciferol (D_3) should be adequate **(Grade A, BEL 1)**. For patients with advanced renal failure in whom renal activation of vitamin D is impaired, calcitriol should be dosed to allow for adequate intestinal absorption of calcium **(Grade A, BEL 1)**.

3.Q8. What Nutritional Recommendations are Appropriate for Pregnancy and Lactation?

3.Q8.1 Pregnancy Planning

- **R34.** Prior to pregnancy, women should be encouraged to achieve a normal BMI **(Grade A, BEL 1)**. Elevated fasting blood glucose prior to pregnancy should prompt screening for DM and initiation of a healthy eating meal plan and lifestyle modification **(Grade A, BEL 1)**. Any chronic diseases, including DM, thyroid disorders, and rheumatologic disorders should be optimally controlled prior to conception with a focus on appropriate nutrition and physical activity **(Grade D, BEL 4)**.

3.Q8.2 Pregnancy

- **R35.** The appropriate individual caloric intake should be calculated based on prepregnancy and current (pregnant) BMI **(Grade D, BEL 4)**. Pregnant women who are vegetarian or vegan must be referred to a RD specializing in pregnancy to assist in meal planning and appropriate use of dietary supplements **(Grade D, BEL 4)**. Women who are pregnant should consume 1.1 g/kg of protein per day in the second and third trimesters **(Grade B, BEL 2)**. During pregnancy, less than 10% of calories should be derived from saturated fats and less than 10% should be derived from PUFAs, with the remainder from MUFAs **(Grade D, BEL 4)**. *Trans* fatty acids should be avoided during a pregnancy since they may have adverse effects on fetal development **(Grade B, BEL 2)**.
- **R36.** Daily ingestion of a prenatal vitamin (PNV) is recommended for all women during pregnancy **(Grade A, BEL 1)**. All women in their childbearing years should consume 400 μg/day of folic acid, and once pregnancy is confirmed, the intake should be adjusted to 600 μg/day **(Grade B, BEL 2)**. Intake of vitamin A over 10,000 IU a day is teratogenic, so women should be advised against excessive supplementation **(Grade B, BEL 2)**. All pregnant women should ingest a minimum of 250 μg of iodine daily **(Grade B, BEL 2)**.
- **R37.** Women who have DM and/or are insulin resistant should adjust the percentage of ingested carbohydrate during pregnancy to obtain proper glycemic control **(Grade B, BEL 2)**. Women with gestational DM (GDM) should: (*1*) adhere to the recommendations for healthy eating for all pregnant women, (*2*) allow for appropriate weight gain during pregnancy (i.e., 2 to 5 pounds in the first trimester and 0.5 to 1 pound per week thereafter), (*3*) avoid concentrated sweets and "fast foods," and (*4*) eat small, frequent meals with protein, having only one starch with breakfast and choosing high-fiber foods with lower fat content **(Grade C, BEL 3)**.
- **R38.** Patients should be instructed to consume less than 300 mg of caffeine (3 cups of coffee) per day during pregnancy, since caffeine can increase the incidence of miscarriage and stillbirth when consumed in larger quantities **(Grade B, BEL 2)**.

3.Q8.3 Lactation

- **R39.** Whenever possible, exclusive breastfeeding is recommended for at least the first 6 months of life **(Grade A, BEL 1)**. All women should be instructed on breastfeeding, made aware of community resources about breast feeding, and counseled to adjust their meal plans to meet nutritional needs during lactation **(Grade A, BEL 1)**. All pregnant and lactating women should ingest a minimum of 250 μg of iodine daily **(Grade B, BEL 2)**. During breastfeeding, basal insulin

requirements decrease. Women who breastfeed should be advised to either lower their basal insulin dose (or basal insulin infusion rate if on an insulin pump) or eat a carbohydrate-containing snack prior to breastfeeding **(Grade D, BEL 4)**.

3.Q9. What Nutritional Recommendations are Appropriate for the Elderly?

3.Q9.1 Healthy Eating for Energy Balance and Toward an Ideal Body Weight

- **R40.** As people age, they should implement healthy eating to maintain an ideal body weight, since both overweight and underweight lead to increased morbidity and mortality **(Grade A, BEL 1)**. In the elderly with sarcopenia and decreased basal metabolic rate, formulating a meal plan should include caloric reduction to maintain energy balance and to prevent fat-weight gain **(Grade B, BEL 2)**. To constrain caloric overconsumption in the elderly while also ensuring micronutrient adequacy, quality foods low in calories and containing adequate amounts of HBV protein sources to provide EAAs and essential fatty acids (EFAs) and rich in micronutrients and fiber should be ingested routinely **(Grade B, BEL 2)**. Quality food high in proteins, minerals, and vitamins but low in saturated fat, cholesterol, and *trans* fat (such as lean meat, fish, poultry, eggs, and dry beans and nuts) should be recommended for overweight or obese elderly patients to provide adequate protein intake without carrying a high risk for CVD **(Grade A, BEL 1)**. Older adults should consume more of the nutrient-dense whole-grain foods, such as brown rice, whole-wheat breads, and whole-grain and fortified cereals to meet carbohydrate needs. Conversely, the consumption of refined starch-based foods such as processed potato, white bread, pasta, and other commercial products made of refined wheat flour should be limited to decrease the risk of obesity and DM **(Grade B, BEL 2)**. Dehydration is a more prevalent condition in the elderly, and thirst sensation may be compromised with aging, therefore habitual fluid intake (about 2 quarts per day or eight 8-ounce glasses) is recommended **(Grade B, BEL 2)**.
- **R41.** On an individual basis, ingestion of nutrition supplements between meals should be recommended for undernourished elderly patients **(Grade B, BEL 2)**. Energy and nutrient-dense foods, or manipulation of energy and nutrient density of the meal plan, should be recommended for the frail elderly to promote weight gain and improve clinical outcomes **(Grade A, BEL 1)**. Food safety, including the prevention of food spoilage, should be provided for all elderly patients **(Grade D, BEL 4)**.

3.Q9.2 Healthy Eating to Prevent Micronutrient Deficiency in Older Adults

- **R42.** To ensure adequacy of a wide variety of micronutrients, a daily mix of nutrient-dense foods, including fruits and vegetables, should be recommended **(Grade B, BEL 2)**. In the elderly, pills should not be used as a substitute for meals **(Grade D, BEL 4)**. The elderly should consume at least 3 daily servings of calcium-rich foods **(Grade A, BEL 1)**. In the elderly, case finding for vitamin D and vitamin B_{12} deficiencies is reasonable given their high prevalence with advancing age **(Grade B, BEL 2)**. It is appropriate to recommend a daily multivitamin (MVI) to complement food intake in older adults who cannot achieve adequate micronutrient intake otherwise **(Grade B, BEL 2)**. Surveillance to prevent toxicity from excess ingestion of vitamin pills is appropriate for the elderly **(Grade C, BEL 3)**.

3.Q9.3 Healthy Eating for the Frail Elderly

- **R43.** Community nutrition assistance programs that provide individuals with home-delivered meals should be recommended for frail elderly patients still living independently **(Grade A, BEL 1)**. Barriers to healthy eating in the elderly should be actively found and addressed, including provision of direct feeding assistance where self-feeding is not adequate, treatment of depression, group meals for institutionalized patients, correcting oral and dental problems leading to difficulties with eating, chewing or swallowing, addressing social isolation, rectifying polypharmacy, and treating underlying diseases **(Grade B, BEL2)**. Physicians treating geriatric patients should make every effort to reduce the number of medications to achieve better medication adherence and to allow for better nutritional care **(Grade D, BEL 4)**.

You are what you eat ~ Victor Lindlahr

4. APPENDIX: EVIDENCE BASE

4.Q1. What are Healthy Eating and a Healthy Lifestyle?

4.Q1.1 General Recommendations for Healthy Eating and Disease Prevention

Healthy eating includes the adequate provision of macro- and micronutrients to sustain normal physiology and to avoid nutritional deficiencies. It also includes avoidance of excessive amounts of foods and beverages that may have a negative impact on health. Healthy eating

must be maintained over a long time and should clearly be separated from fad diets, which are usually short lived and often unhealthy. Instead of applying the term "diet," patients should be instructed on proper meal planning and the application of eating patterns (or meal patterns). The ability to read and understand nutrition fact labels should be an important component of patient nutrition education. These learned skills may be modified as needed and provide life-long durability.

Similarly, the term "exercise" is stigmatized and can be an obstacle for most patients. The term "physical activity" should be used instead. Whereas it is extremely desirable to achieve CV fitness through regular, structured, continuous physical activity, this is not practical for most people most of the time. Two-thirds of patients are overweight or obese and may incur orthopedic or overuse injuries. Strenuous activity may also precipitate vascular events in people with unrecognized vascular disease. The simple concept that caloric expenditure is achieved by moving body mass over distance, or against gravity, translates into a myriad of opportunities when the focus is taken away from exercise. For example, a 2-minute walk every hour on the hour during the waking hours of the day achieves the same caloric expenditure as a 30-minute walk once (assuming the same velocity) (4 [EL2, NRCT]; 5 [EL4, NE]; 6 [EL1, RCT]).

Healthy eating and physical activity must be accompanied by proper sleep (ideally 7 to 8 hours a night; less than 6 hours a day is associated with metabolic derangements and cognitive impairment) and adequate time for recreation and play and for stress reduction and happiness (7 [EL3, SS]; 8 [EL3, CCS]). The implementation of this knowledge into effective nutrition and regular physical activity by individual patients requires a team approach (9 [EL4, NE]; 10 [EL4, NE]). It takes individualized care to achieve success.

The United States Preventive Services Task Force recommends that individuals limit total and saturated dietary fat and cholesterol, maintain caloric balance, and increase fiber intake (11 [EL2, MNRCT]). These guidelines are especially pertinent for our population's health, as T2DM is becoming increasingly common, primarily due to an increase in the rising prevalence of obesity.

The Finnish Diabetes Prevention study authors concluded that T2DM could be prevented by changes in the lifestyles of high-risk patients (12 [EL1, RCT]). This study randomly assigned 522 middle-aged, overweight men and women (mean age, 55 years; mean BMI, 31 kg/m^2) with impaired glucose tolerance to either an intervention or control group. The intervention group received counseling to reduce weight via nutritional intervention (lower fat intake, higher fiber intake) and increased daily physical activity. After 4 years, the cumulative incidence of DM defined by oral glucose tolerance testing (OGTT) was 11% in the intervention group and 23% in the control subjects.

The Diabetes Prevention Program (DPP) randomized 3,234 adults (mean age, 51 years; mean BMI, 34 kg/m^2) who had impaired fasting glucose and were at high risk for the development of T2DM into placebo, metformin, or lifestyle modification groups. The intensive lifestyle intervention was intended to help subjects lose and maintain a 7% weight loss through a healthy (low fat, reduced calorie) meal plan, 150 minutes of exercise per week, and 16 sessions of support and close follow-up in the first 6 months (13 [EL1, RCT]). After an average follow-up of 2.8 years, lifestyle intervention resulted in more weight loss (5.6 kg) than either metformin (2.1 kg) or placebo (0.1 kg). The incidence of DM was reduced by 58% with lifestyle modification and by 31% with metformin, compared with placebo. The incidence of DM was 11.0, 7.8, and 4.8 cases per 100 person-years in the placebo, metformin, and lifestyle groups, respectively. Lifestyle modification was significantly more effective than metformin in preventing progression to DM.

Healthy lifestyle also has beneficial effects on CV health. CV events were reduced by 35% and all-cause mortality by 40% over 6 years in a prospective cohort study of 15,708 middle-aged adults (ages 45 to 64 years) who adopted four healthy lifestyle habits to include no tobacco smoking, regular physical activity (at least walking) 150 minutes or more per week, maintaining a normal BMI <25 kg/m^2, and eating at least five fruits and vegetables daily (14 [EL2, PCS]).

The most common cancers in the United States are breast, lung, and colorectal cancer in women and prostate, lung, and colorectal cancer in men. The American Cancer Society (ACS) recommends eating at least 5 servings of fruits and vegetables daily (15 [EL4, NE]). Fruits, vegetables, and whole-grain foods contain vitamins and antioxidants that may lower the risk of lung and gastrointestinal (esophagus, stomach, colon) cancers (Table 5).

Unfortunately, few individuals meet national recommendations for healthy eating. In an evaluation of healthy eating habits of more than 153,000 individuals using the Behavioral Risk Factor Surveillance System (BRFSS) in 2000, only 23% reported consuming at least five fruits and vegetable servings daily (16 [EL3, SS]). A similar finding was reported in Olmsted County, Minnesota, where only 16% of 732 individuals reported meeting standard nutrition recommendations for consuming both five or more servings of fruits and/or vegetables per day, and no more than 30% of calories from fat (17 [EL3, SS]).

Early nutrition guidelines have been based on treatment of clinical nutrient deficiencies. Prospective epidemiologic studies and randomized trials of nutrition and nutrient supplements have advanced our understanding of the contribution of nutrition to health maintenance and disease prevention and treatment. Growing evidence suggests that fruit and vegetable consumption is inversely related to the

risk of coronary heart disease (CHD) and stroke (18 [EL2, PCS]; 19 [EL2, PCS]). Observational studies have consistently shown that meal plans high in antioxidant vitamins from ingestion of fruits and vegetables are associated with a lower risk of CVD (20 [EL4, NE]). A review and meta-analysis of prospective cohort data concluded that intake of fruits and vegetables at the 90th percentile reduced the risk of CHD by a median of 15% compared with the 10th percentile of consumption (21 [EL2, MNRCT]). A meta-analysis of cohort studies also found that a higher intake of fruits and vegetables is associated with a lower risk of stroke. The risk was reduced with only 3 to 5 servings of fruits and vegetables daily, with further stroke risk reduction if more than 5 servings were consumed daily (relative risk [RR], 0.89 and 0.74, respectively) (22 [EL2, MNRCT]). One study found the lowest risk of stroke was associated with a high consumption of cruciferous vegetables (e.g., broccoli, cabbage, cauliflower, Brussels sprouts), green leafy vegetables, citrus fruits, and vitamin C-rich fruits and vegetables (18 [EL2, PCS]). A meta-analysis of 9 cohort studies including 221,080 men and women found that fruit and vegetable intake was inversely related to CHD. There was a 4% decline in CHD for each daily portion of additional fruit and vegetable consumed and a 7% decline for fruit intake (23 [EL2, MNRCT]). Thus, daily ingestion of at least 8 servings of fresh fruits and vegetables should be recommended for everyone.

Natural compounds found in food may work individually or in combination and confer health benefits beyond those of dietary supplements and nutraceuticals (Table 5) (24 [EL4, NE]). A large number of potentially anticarcinogenic and antioxidant agents are found in fish, fruits, vegetables, fiber, and plant compounds (e.g., flavonoids, phenols, protease inhibitors, sterols, allium compounds, and limonene) (25 [EL4, NE]). The antioxidant vitamins include vitamins E, C, and A (to include carotenoids such as beta-carotene). A number of studies have examined the hypothesis that antioxidants may prevent cancer and CVD by augmenting the body's ability to dispose of toxic free radicals, thereby limiting oxidative damage (26 [EL4, NE]). Retrospective and small prospective studies have suggested a direct relationship between fruit and vegetable intake and the prevention of cancers (27 [EL2, MNRCT]; 28 [EL2, PCS]). However, caution must be used

Table 5
Natural Compounds in Food Important in Maintaining Health

Greater nutrition
- Whole foods contain a variety of compounds important to health. As an example, an orange provides vitamin C, beta carotene, calcium, and other nutrients, whereas a vitamin C supplement does not.
  - Fortified foods: means that 1 or more nutrients have been added that were originally absent from the food.
  - Enriched foods: means that nutrients lost during the preparation of foods for consumption have been added back to the food.

Essential fiber
- Fiber is important in digestion and may play a role in disease prevention.
  - Soluble fiber sources: beans, fruits, and vegetables and some grains.
  - Insoluble fiber sources: whole grains and some fruits and vegetables.

Phytochemicals/Flavonoids
- A nonnutrient compound synthesized by plants. Flavonoid is a common name for a phytochemical that may function as an antioxidant.
  - May play a role in the prevention of disease by enhancing protective enzymes in the body, detoxifying carcinogens in foods, and preventing cell damage that can lead to cancer.
  - Found in many plant foods, including whole grains, legumes, nuts, fruits (berries) and cruciferous vegetables (broccoli, cabbage, cauliflower, Brussels sprouts, etc.).

Antioxidants
- A compound that can protect the body against free radicals, which are unstable molecules that can form anywhere in the body leading to cell damage and have been linked to both cardiovascular disease and cancer.
  - Examples of antioxidants include lycopene, beta-carotene, carotenoids, and vitamins A, C, and E.
  - Foods (containing antioxidants): tomatoes (lycopene), berries to include strawberries/blueberries/blackberries/raspberries/cranberries (vitamin C, ellagic acid, anthocyanin), carrots (beta-carotene), spinach (carotenoids, lutein, and zeaxanthin) and other dark leafy vegetables, whole grains (ligans, saponins) to include breads, flax, and sesame seeds.

in interpreting these studies, as the outcomes noted may be due to effects of the antioxidants themselves, other food-related compounds, or the possibility that people who consume healthier meals (e.g., more fruit and vegetables and less fat) live healthier lives.

The relationship between fiber intake and colorectal cancer risk is unclear. Large observational studies have reported that high fiber intake reduces the risk of colorectal adenomas (29 [EL2, RCCS]) and cancer (30 [EL1, RCT]). In contrast, no relationship was noted between a high-fiber meal plan and the recurrence rate of colorectal adenomas in the large observational Nurses' Health Study (31 [EL2, PCS]) or in a randomized secondary prevention trial (32 [EL1, RCT]). A systematic review of 5 studies involving 4,349 patients followed for 2 to 4 years found no definitive evidence that increased dietary fiber reduced the incidence or recurrence of adenomatous colorectal polyps (33 [EL1, MRCT]). There is no apparent reason for the conflicting results seen in these large observational studies. Of note, a pooled analysis of 13 prospective cohort studies involving 725,628 men and women followed for 6 to 20 years found that fiber intake was inversely associated with the risk of colorectal cancer, but the association was no longer apparent after accounting for other nutritional risk factors (34 [EL2, MNRCT]). Thus, increasing fiber intake should not be recommended to lower the risk of colorectal neoplasia.

The strongest evidence for beneficial health effects of a plant-based meal plan comes from mortality studies and the Mediterranean dietary pattern. A study of older Americans (American Association of Retired Persons cohort) was scored for adherence to the Mediterranean dietary pattern according to higher intake of foods considered to be healthy (vegetables, fruits, nuts, legumes, grains, fish, and monounsaturated fats) and for lower intakes for those foods considered to be unhealthy (high-fat dairy products, meat, and saturated fats). Mortality was reduced among individuals who adhered to the healthier Mediterranean dietary pattern. During 5 years of follow-up, a 20% reduction in total mortality and CV and cancer mortality was seen in men. Similar reductions in total mortality but smaller benefits for cancer mortality were seen in women (35 [EL2, PCS]). The Lyon Diet Heart Study assessed dietary changes to include 20% increases in consumption of vitamin C-rich fruits and bread, decreases in processed and red meat, and use of a margarine based on rapeseed (canola) oil. This meal plan led to a 70% reduction in all-cause mortality (36 [EL4, NE]; 37 [EL1, RCT]). A meta-analysis of 12 studies involving 8 cohorts found that individuals strictly adhering to the Mediterranean diet had a reduced risk of dying from cancer and CVD, reporting 6, 9, and 9% reductions in cancer, CVD, and overall mortality, respectively (38 [EL2, MNRCT]). The Mediterranean dietary pattern has also been shown to provide protection against T2DM (39 [EL2, PCS]). In a study of graduates from the University of Navarra, in Spain, 13,000 subjects with no prior history of DM were followed a median of 4.4 years for dietary habits and overall health. Researchers found that persons who adhered closely to the Mediterranean dietary pattern had an 83% reduction in the RR of developing DM. The European Prospective Investigation into Cancer and Nutrition study followed 23,000 Greek men and women for 8.5 years to assess the Mediterranean diet and mortality. The authors reported that consuming a diet high in vegetables and low in meat and meat products was more significantly associated with lower mortality than was eating cereal and fish. Moderate alcohol intake and increased fruit, nut, and legume consumption were also associated with a lower mortality risk in this study (40 [EL2, PCS]).

There is strength in the world literature to claim that healthy eating, especially the Mediterranean dietary pattern, contributes significantly to human health maintenance and disease prevention. It is worth noting that healthy eating requires a healthy food supply, and implicit in this is the role of government and public health organizations.

4.Q1.2 Healthy Macronutrient Intake

Studies have shown that one macronutrient profile may not be appropriate for all individuals irrespective of their CVD risk status. The Optimal Macronutrient Intake Trial to Prevent Heart Disease (Omni-Heart) compared meal plans that emphasized the three different macronutrients in isocaloric trial groups: complex carbohydrates (CARB meal plan) similar to the DASH meal plan (58% carbohydrate, 15% protein, 27% fat), protein (PROT) meal plan, of which half was from plant sources (48% carbohydrate, 25% protein, 27% fat), and fat (UNSAT meal plan) meal plan, of which unsaturated fats, such as olive oil, canola oil, and nuts and seeds were emphasized (48% carbohydrate, 15% protein, 37% fat) (41 [EL1, RCT]). Participants (n = 164) were generally healthy with prehypertension or stage 1 hypertension with uncontrolled but relatively normal blood lipid levels (i.e., baseline LDL-C was 129.2 mg/L). All results were compared to the BP and lipid levels obtained after the CARB meal plan. After 6 weeks of controlled feeding, the PROT meal plan lowered systolic BP (SBP) and diastolic BP (DBP) by 1.4 and 3.5 mm Hg, respectively, and the UNSAT meal plan lowered SBP and DBP by 1.3 and 2.9 mm Hg, respectively, in those with hypertension. The PROT meal plan lowered LDL-C by 3.3 mg/dL, high-density-lipoprotein cholesterol (HDL-C) by 1.3 mg/dL, and triglycerides (TGs) by 15.7 mg/dL, while the UNSAT meal plan increased HDL-C by 1.1 mg/dL, lowered TG by 9.6 mg/dL, and did not have an effect on LDL-C. In sum, the DASH-type meal plan decreases CVD risk by 16.1% according to the Framingham risk equation; however, substituting ~10% of total calories from carbohydrate with either protein or unsaturated fat further decreases CVD risk (PROT, –21.0%; UNSAT, –19.6%) by improving both BP and lipid values.

The macronutrient profile of meals has remarkably diverse effects on different CVD risk factors. The recommended meal plan should complement personal tastes of individuals within the guidelines for calories and macronutrient distributions. Both macronutrient distribution and quality of macronutrients (i.e., sugar versus starch or fiber, saturated versus unsaturated fats, etc.) are important in improving CVD risk factors and outcomes.

Carbohydrates and Fiber

Healthy carbohydrates are high in fiber (both soluble and insoluble), sterols, and stanols, low in energy density, and contain bioavailable micronutrients. Viscous or soluble fiber, specifically beta-glucan or pectin, decreases total cholesterol (TC) by numerous mechanisms, including increasing bile acid secretion and decreasing endogenous cholesterol production (42 [EL4, NE]). Insoluble fiber, often thought of as the "roughage" in vegetables or the hull of a grain, creates a bulky stool, allowing the food to pass through the intestine more quickly, which decreases absorption of calories and nutrients. In addition, fiber may delay gastric emptying, which affects satiety and absorption of carbohydrates (42 [EL4, NE]). Sterols and stanols are cholesterol derivatives from plants that block the absorption of cholesterol in the intestine and increase bile production, both of which decrease serum cholesterol (43 [EL4, NE]).

Complex carbohydrates are naturally high in fiber and simple carbohydrates generally are not. For those "counting carbs," the grams of fiber and sugar alcohols must be subtracted from total grams of carbohydrates, resulting in the gram amount of available carbohydrates in the product. Therefore, it is possible to eat a plant-based meal that is low in carbohydrate (sugars and starches) due to the high fiber content of fruits, vegetables, and whole grains (44 [EL4, NE]).

Fruits and Vegetables

Fruit and vegetable intake should be ≥4.5 cups (45 [EL4, NE]). Adults should have 2.5 to 3 cups of vegetables and 1.5 to 2 cups of fruit daily in a 2,000 calorie meal plan, for health promotion and prevention of chronic disease (46 [EL4, NE]). These recommendations are similar to the 4 to 5 servings of fruit and 4 to 5 servings of vegetables recommended by TLC and DASH meal plans (1 serving = 0.5 cup of cooked vegetables) (Table 6). Frozen, canned, dried, and fresh options allow for flexibility in the meal plan and help with the cost of buying fresh produce.

Fruits and vegetables are an excellent source of total fiber intake but are diverse in their fiber composition (i.e., insoluble or soluble [viscous]) (47 [EL2, MNRCT]). The concentration of plant sterol and stanol esters in fruits and vegetables is relatively low; therefore, to attain effective levels of sterols and stanols, foods with concentrated amounts of these compounds, such as fortified margarines, juices, yogurts, milk, salad dressings, and snack bars, are recommended (48 [EL4, NE]). Fruits and vegetables are naturally low in sodium and high in potassium, which contribute to the decreases in BP (49 [El4, NE]). An observational study showed that increasing fruit and vegetable intake by 1 serving per day was associated with a 4% decreased risk of CHD (18 [EL2, PCS]). The evidence from randomized controlled trials (RCTs) on CVD endpoints is less clear (50 [EL4, NE]).

Whole Grains

High-fiber whole grain (≥1.1 gram of fiber per 10 g of carbohydrate) intake should be more than three 1-ounce equivalent servings per day (45 [EL4, NE]). Current recommendations by the United States Department of Agriculture (USDA) for servings of grains are 5 to 8 ounces of grains per day for adults on a 2,000 calorie meal plan, with at least half from whole grain sources (46 [EL4, NE]). The DASH and TLC meal plans recommend similar amounts of grain per day but emphasize only whole grains.

Many epidemiological studies have reported that higher intakes of whole grains are associated with a lower BMI, percent fat mass, waist circumference, and CVD risk (51 [EL2, NRCT]; 52 [EL3, SS]; 53 [EL2, MNRCT]). Increased intake of cereal fiber specifically is associated with lower body weight and waist circumference over time (54 [EL2, PCS]). However, RCTs have not demonstrated that eating whole grains improves weight loss outcomes (55 [EL1, RCT]). Whole grains, such as oats, whole wheat, barley, rye, and brown and wild rice vary in their fiber and phytochemical content (47 [EL2, MNRCT]). For example, the soluble fiber content is high in oats and barley, while insoluble fiber is found in the bran of whole wheat. Knowing the different nutritional profiles of whole grains is important with regards to health claims. For example, 3 grams of beta-glucan soluble fiber per day from oats and barley or 7 grams per day of soluble fiber from psyllium reduces risk for CVD by lowering LDL-C (47 [EL2, MNRCT]; 56 [EL4, NE]).

A meta-analysis of 20 studies showed that increasing fiber to ~14 g/day decreased SBP by 1.6 mm Hg and DBP by 2.0 mm Hg (57 [EL2, MNRCT]). A prospective cohort study demonstrated that those with the highest intake of whole grain per day were 19% less likely to develop hypertension (RR, 0.81; $P<.0001$) than those who ate the least amount of whole grains per day (58 [EL2, PCS]). Inclusion of whole grains in place of refined grains will add fiber and micronutrients to meals that aid in BP lowering. However, whole grains are not fortified with micronutrients like refined grains, thus the availability of some micronutrients typically is less. The food industry has increased the amount of whole grain products available, which facilitates meeting the whole-grain intake recommendation.

Reduced-Fat Dairy: Milk and Yogurt

Yogurt and milk are composed primarily of carbohydrates but also are a good source of high-quality protein. The USDA recommends 3 cups of reduced-fat dairy per day for all age groups, although the dairy product must contain a high amount of calcium to be included (46 [EL4, NE]). The DASH and TLC meal plans align with the USDA recommendations. However, the Mediterranean meal plan focuses mainly on cheese and yogurt as dairy sources (reduced-fat cheese, discussed in the "Animal Protein" section). Full-fat dairy products such as whole milk and full-fat yogurt contribute significant amounts of saturated fat to meals, which can increase serum LDL-C. However, saturated fat from milk may increase only the number of larger, less atherogenic LDL-C particles (59 [EL3, CSS]). Regardless, consuming reduced-fat milk and yogurt will not adversely affect the lipid profile, as the saturated fat has been decreased or removed. Of note, reduced-fat yogurts sometimes have added sugars as a substitute for fat and may not be lower in calories than the full-fat option; it is important to compare labels to determine whether the reduced-fat formulation is healthier.

Reduced-fat milk, low-fat cottage cheese, and yogurt are low-calorie sources of highly bioavailable micronutrients, such as calcium, potassium, and magnesium, which are associated with lower BP. Increasing the number of daily servings of reduced-fat milk and yogurt (3.4 servings/day vs. 0.4 servings/day) in a meal plan high in fruits and vegetables favorably alters the intracellular micronutrient content (i.e., decreases calcium and increases magnesium), which is shown to affect an individual's BP response to a dairy-rich meal plan (60 [EL1, RCT]). The DASH dietary pattern lowers SBP by 5.0 mm Hg and DBP by 3.0 mm Hg more than a control meal plan. Fifty percent of the reduction in BP is ascribed to reduced-fat dairy intake (61 [EL1, RCT]). In addition to the effects of micronutrients, fermented dairy peptides (2.5 to 5.6 mg/day) also decrease SBP by 4.8 mm Hg and DBP by 2.2 mm Hg over 4 weeks

Table 6
Examples of Meal Patterns Consistent with AHA Nutrition Guidelines

Food group	TLC	DASH	Mediterranean	Examples of Servings
Vegetables	4-5 servings/day	5 servings/day	Eat daily	1 c raw leafy vegetables, 1/2 c cut-up raw or cooked vegetables, 1/2 c vegetable juice
Fruits	4-5 servings/day	4 servings/day	Eat daily	1 med. fruit, 1/4 c dried fruit, 1/2 c fresh, frozen canned fruit, 1/2 c fruit juice
Grains	6-8 servings/day	7 servings/day	Eat daily	1 slice bread, 1 oz. dry cereal, 1/2 c cooked rice or pasta
Fat-free or low-fat milk products	2-3 servings/day	2-3 servings/day	Eat daily (Specifically, cheese and yogurt in low to moderate amounts)	1 c milk, 1 c yogurt, 1/5 oz. cheese
Lean meats, poultry, fish	<6 oz. per day	≤5 oz. per day	Eat fish and poultry twice weekly ≤7 eggs /week	1 oz. cooked Serve – 3 oz. cooked
Nuts, seeds, legumes, pulses	4-5 servings/day	Counted in vegetable servings	Eat daily	1/3 c, 2 TBSP peanut butter or seeds, 1/2 c dry beans or peas
Fats and oils	2-3 servings/day	Amount depends on daily calorie level	Use olive oil daily in cooking	1 tsp. soft margarine, 1 TBSP mayonnaise, 1 tsp. vegetable oil, 2 TBSP salad dressing
Sweets and added sugars	≤5 servings/week	No recommendation	≤2 sweets/week	1 TBSP sugar, jelly or jam; 1/2 c sorbet, 1 c lemonade

Abbreviations: AHA = American Heart Association; c = cup; DASH = Dietary Approaches to Stop Hypertension; oz. = ounce; TBSP = tablespoon; TLC = therapeutic lifestyle changes; tsp. = teaspoon.
Mediterranean dietary pattern adapted with permission from Oldways Mediterranean Pyramid (Copyright of Oldways Preservation and Exchange Trust; Accessed at: http://www.oldwayspt.org).
Adapted with permission from: Lichtenstein AH, et al. Diet and lifestyle recommendations, revision 2006: A scientific statement from the American Heart Association Nutrition Committee. *Circulation*. 2006;114:82-96.

(62 [EL1, MRCT]). Replacing high-fat dairy products with lower fat versions has beneficial effects on BP and lowers TC and LDL-C.

Protein Sources

Higher intake of protein (24% vs. 14.7% of total calories), from either plant or animal sources, is associated with a reduced risk of CVD events (RR, 0.75; 95% confidence interval [CI], 0.61-0.92), specifically ischemic heart disease in women (63 [EL2, PCS]). Manipulating protein intake at the expense of carbohydrate or fat can lower CVD risk. Replacing 10% of calories from carbohydrates in the DASH meal plan with protein from both plant and animal sources (25% of total calories) resulted in lower LDL-C, TG, and HDL-C, as well as lowered SBP when compared to the unmodified DASH meal plan (41 [EL1, RCT]).

The Food Guide Pyramid recommended 5.5 to 6 ounces of protein food sources per day for adults eating a 2,000 calorie meal plan and emphasizes variety for health benefits (46 [EL4, NE]). More recently, the FDA has introduced My Plate as a nutrition aid, calling for one-fourth of a medium sized plate to be a source of protein (64 [EL4, NE]). The TLC and DASH meal plans recommend <6 ounces or ≤5 ounces per day of lean meats, respectively. The Mediterranean Diet Pyramid specifies increased plant compared to animal protein, and recommends daily servings of beans, legumes, and nuts and weekly servings of poultry and fish (Table 6). The Acceptable Macronutrient Distribution Range for protein is 10 to 35% of total calories to prevent chronic disease (44 [EL4, NE]).

Animal Protein Sources: Lean Meat Cuts, Skinless Poultry, Lean Fish, Reduced-Fat Cheese

Animal sources of protein can be sources of saturated fat and cholesterol as well. Reduced-fat animal protein sources are recommended. Lean meat cuts, reduced-fat cheese, egg whites, fish, and skinless poultry are all heart-healthy animal protein options. In the PREMIER trial, a free-living study assessing weight loss strategies, 66% of the protein consumed was animal protein, namely poultry, dairy, and beef (65 [EL1, RCT]). Both lean red meat and white meat have been shown to be equally efficacious in improving lipid profiles in hypercholesterolemic participants when incorporated into the TLC meal plan. When lean red or white meat makes up 80% of protein intake for 36 weeks, this lowers LDL-C by 1 to 3%, raises HDL-C by 2%, and TGs are unchanged (66 [EL1, RCT]). Intake of lean white fish (low in omega-3 fatty acids) lowers BP as compared to lean meat or fatty fish (high in omega-3 fatty acids) in a population at high risk for CVD. While omega-3 fatty acids have a slight antihypertensive effect at higher doses (see "Omega-3 Fatty Acids" section), one study reported that fish proteins had angiotensin-converting enzyme inhibitor (ACEI) effects (67 [EL1, RCT]).

Cheeses that are lower in fat content include part-skim mozzarella, some goat cheeses, string cheese, and some soft cheeses, due to their high water content. Many common cheeses are available as reduced- or no-fat versions, such as mozzarella, cheddar, Monterey Jack, brie, Swiss, and Muenster. Cheese intake often has been a proxy for meal plans that are high in saturated fat and of lower quality dietary patterns; however, the type of cheese reportedly eaten may mediate the associations between cheese intake and CVD risk factors (68 [EL2, PCS]). For example, compared to those who eat cheese less frequently (zero servings per month), men who eat cheese more frequently (15 to 30 times per month) have worse lipid and BP profiles. On the other hand, women who eat cheese less frequently have slightly improved lipid profiles compared to those who eat cheese more frequently (69 [EL2, CSS]). The type of cheese and processing determines saturated fat and sodium levels. However, all cheese contains bioactive compounds such as calcium, conjugated linoleic acid, and dairy peptides. Fermentation of dairy peptides by bacteria in the gut or in the processing procedure produces other bioactive compounds that improve CVD risk profiles by lowering BP, improving lipids, and decreasing inflammation (70 [EL4, NE]). Similar to dairy products, food sources of animal proteins are an excellent source of micronutrients.

Plant Protein Sources: Legumes (Beans and Lentils), Soy Products

The percentage of protein intake from plants was 34% in the PREMIER trial, primarily from grains (both refined and whole), fruits, vegetables, and nuts and seeds (65 [EL1, RCT]). Nuts, fruits, vegetables, and grains are discussed in either the carbohydrate or fats sections. Although less commonly eaten in the American meal plan, pulses and legumes (which include beans and lentils), are good sources of protein, soluble fiber, and micronutrients. Consumption of legumes more than four times per week as compared to less than once per week is associated with an 11% decrease in CVD risk (19 [EL2, PCS]). Bean consumption, analyzed as a separate food from legumes, was associated with lower BMI, waist circumference, SBP, and higher nutrient intake in a cross-section of a nationally representative sample (71 [EL3, SS]).

Soybean products, such as tofu and soy milk, have attracted attention due to their effects on LDL-C. Isolated soy protein with isoflavones lowered LDL-C by 3% in RCTs when compared to milk or other proteins (72 [EL4, NE]). The replacement of animal protein sources high in saturated fat with soy products, such as a soy burger in place of a hamburger, may have an additive effect on lowering of LDL-C. The average soy protein consumption in the RCTs was 25 to 50 g/day, which was about half of the total protein intake. Soybeans are high in protein, fiber, PUFAs, vitamins, and minerals. Soy foods can be incorporated into

meals in place of animal protein foods; they may also be included as a substitute for carbohydrate and fat calories to increase the total (and plant) protein content of meals.

Phytoestrogens are present in soybeans and can act as endocrine disruptors. A discussion on this subject is beyond the scope of this guideline, but it is worth noting that the long-term health effects of the phytoestrogens in soybeans are unknown (73 [EL4, NE]). Soy protein in concentrated forms (such as supplements) should be used with caution due to its potential estrogenic effects.

Fats

The American Heart Association (AHA) and National Cholesterol Education Program (NCEP)-Adult Treatment Panel (ATP) III guidelines recommend that saturated fat be <7% of total calories for lowering LDL-C. *Trans* fat should be <1% of total calories, and total cholesterol intake should be <200 to 300 mg/day (NCEP and AHA guidelines, respectively). Unsaturated fats should make up the rest of the recommended 25 to 35% of calories from fat (44 [EL4, NE]). MUFAs can provide up to 20% of total calories, whereas the recommendation for PUFAs is 5 to 10% of calories (48 [EL4, NE]; 74 [EL2, NRCT]). Increased intake of unsaturated fats as compared to saturated fats is associated with better CHD outcomes (63 [EL2, PCS]).

The focus on markedly decreasing fat ingestion in the 1990s may have contributed to some of the increase in the common chronic diseases such as obesity, DM, and dysmetabolic syndrome. This is because the decrease in fat intake was accompanied by an increase in the ingestion of carbohydrates (principally from refined sources and added sugars) and calories. Clearly, reducing fat intake can be an effective weight-maintenance strategy for some individuals, but fat intake from healthy sources can contribute to CVD risk reduction.

Omega-3 Fatty Acids: Fish, Flax, Walnuts

Omega-3 fatty acids are PUFAs that are derived from plant or animal sources. The marine-derived omega-3 fatty acids EPA and DHA have been shown to be cardioprotective (75 [EL1, RCT]). The evidence for a plant-derived omega-3 fatty acid, alpha-linoleic acid (ALA), is less convincing (76 [EL4, NE]). Therefore, the source is important when recommending increased intake of omega-3 fatty acids. Increasing intake of omega-3 fatty acids can be achieved via foods or supplements.

EPA+DHA intake for the prevention of CVD should be at least 500 mg/day, which can be achieved by consuming 2 servings (3.5 ounces) of fatty, cold-water fish (such as salmon or mackerel) per week. Alternatively, this intake may be met with fish oil capsules (45 [EL4, NE]; 77 [EL2, MNRCT]). Patients with CHD should ingest 1 g/day of EPA+DHA, preferably from fatty fish. The intake should be 2 to 4 g/day of EPA+DHA for individuals with elevated TG levels (Table 7) (78 [EL4, NE]). However, the USDA Dietary Guidelines Advisory Committee has concluded that "moderate evidence shows that consumption of 2 servings (4 oz.) of seafood per week, resulting in an average of 250 mg/d of long-chain omega-3 fatty acids [due to the lack of emphasis on oily fish], is associated with reduced cardiac mortality from CHD or sudden cardiac death in persons with or without CVD" (79 [EL4, NE]).

High-dose EPA+DHA (2 to 4 g/day) is a treatment for TG >500 mg/dL. TG may be lowered through inhibition of TG production in the liver and by affecting genes that control lipolysis and oxidation of fats (80 [EL4, NE]). In addition, there is some evidence, although not conclusive, that EPA+DHA increases HDL-C (81 [EL4, NE]). Some evidence suggests that EPA+DHA increases LDL-C in response to significant TG lowering, which is thought to be due to the increased conversion of very

Table 7
Recommended Intakes for Marine-derived Omega-3 Fatty Acids, EPA and DHA for CVD Prevention

Population	Recommendation
Patients without documented CHD	Eat a variety of (preferably oily) fish at least twice per week, resulting in an average of ~500 mg/d EPA+DHA. Include oils and foods rich in α-linoleic acid (flaxseed, canola, and soybean oils; flaxseed and walnuts).
Patients with documented CHD	Consume ~1 g EPA + DHA per day, preferably from oily fish. EPA + DHA supplements could be considered in consultation with the physician.
Patients needing to lower TG (TG>500 mg/dL)	2-4 g EPA + DHA per day provided as capsules under a physician's care.

Abbreviations: CHD = coronary heart disease; CVD = cardiovascular disease; DHA = docosahexaenoic acid; EPA = eicosapentaenoic acid; TG = triglycerides.
Adapted from Kris-Etherton et al. Fish consumption, fish oil, omega-3 fatty acids, and cardiovascular disease. *Circulation*. 2002;106:2747-2757.

low-density-lipoprotein cholesterol (VLDL-C) to LDL-C (80 [EL4, NE]). Overall, increasing EPA+DHA intake has a favorable effect on the lipid profile.

Consumption of ~600 mg/day of EPA+DHA decreases SBP and DBP by about 2 mm Hg (81 [EL4, NE]). Omega-3 fatty acids produce eicosanoids that are vasodilatory and improve endothelial function. The slight BP improvements together with other benefits of EPA+DHA reduce CVD risk.

The plant-derived omega-3 fatty acid ALA may have anti-arrhythmic and anticoagulation properties (82 [EL2, NRCT]; 83 [EL2, NRCT]). The Mediterranean meal plan often is higher in ALA due to the emphasis on nuts and seeds as compared to the TLC and DASH meal plans. ALA has been shown to beneficially affect CVD risk factors (see "Nuts" and "Liquid Vegetable Oils" sections below); however, the evidence for EPA+DHA in primary and secondary CVD prevention is stronger (76 [EL4, NE]).

Liquid Vegetable Oils

Liquid vegetable oils are the primary source of PUFAs in the Western meal plan. Corn, safflower, sunflower, and soybean oils (the predominant vegetable oils in the meal plan) are all high in linoleic acid, which is an essential omega-6 fatty acid; flaxseed and canola (rapeseed) oils have appreciable amounts of ALA. Olive oil is high in MUFAs and is encouraged in the Mediterranean dietary pattern.

Substituting PUFAs, mainly omega-6 fatty acids, for carbohydrates, improved the ratio of TC to HDL-C in a meta-analysis of large epidemiologic studies (84 [EL2, MNRCT]). The LDL-lowering effects of omega-6 fatty acids were demonstrated by substituting 10% of calories from saturated fat for omega-6 fatty acids, resulting in a decrease of LDL-C by 18 mg/dL (85 [EL1, MRCT]). Omega-6 PUFA intake should be 5 to 10% of total calories per day for prevention of CVD (86 [EL4, NE]).

Regular ingestion of MUFAs, by replacing 5% of energy from saturated fats, is associated with improved CVD risk (79 [EL4, NE]). MUFAs are most often consumed in the form of olive oil and nuts, such as walnuts, macadamia nuts, and almonds (74 [EL2, NRCT]; 87 [EL2, NRCT]; 88 [EL2, PCS]; 89 [EL4, NE]; 90 [EL4, NE]; 91 [EL2, PCS]; 92 [EL2, PCS]). Olive oil and nuts have other beneficial components, such as polyphenols. Many high-MUFA oils are entering the food supply as a substitute for *trans* fatty acids, including canola, safflower, sunflower, and soybean oils. A study comparing ingestion of virgin olive oil to refined olive oil found decreased LDL-C oxidation in subjects consuming the virgin but not the refined olive oil (93 [EL1, RCT]). The polyphenols present in virgin olive oil but absent in refined olive oil are thought to be responsible for this effect.

The controversy about the benefits of MUFAs originated from primate studies. A meal plan emphasizing MUFAs resulted in atherosclerotic progression similar to that observed in primates consuming meals high in saturated fat (94 [EL1, RCT]). Primates on the high-PUFA meal plan had the least atherosclerotic progression. Assessing atherosclerotic progression in humans is more difficult, and these results have not been replicated in humans.

In summary, vegetable food sources of MUFAs are cardioprotective.

Nuts

Nuts contain unsaturated fats, protein, fiber, and micronutrients but are also high in energy. When tree nuts are incorporated into the meal plan, the LDL-C–lowering effects are 25% greater than would be expected based on blood-cholesterol predictive equations (95 [EL4, NE]). A review of large epidemiologic studies showed a 35% decrease in the RR of CHD incidence in individuals who consumed nuts five or more times per week (96 [EL4, NE]). A pooled analysis of 25 intervention trials investigating the effects of nut consumption on blood lipid levels found that daily nut consumption of 67 g (2.36 ounces) caused a 5.1% decrease in TC (10.9 mg/dL), 7.4% decrease in LDL-C (10.2 mg/dL), 8.3% decrease in the LDL-C:HDL-C ratio (0.22), and 5.6% decrease in the TC:HDL-C ratio (0.24) (97 [EL2, MNRCT]). The effects were greater in those with higher baseline LDL-C values, lower BMI, and in those eating Western meals. The Portfolio Study emphasized foods or nutrients that decrease TC, including almonds (14 g/1,000 calories), soluble fiber (9.8 g/1,000 calories), soy protein (21.4 g/1,000 calories), and plant sterols (1.0 g/1,000 calories). This meal plan lowered LDL-C by 30%, which is similar to the efficacy of first-generation statins (98 [EL1, RCT]). Endothelial function, related to BP, is improved when the meal plan includes walnuts, which are high in plant-derived omega-3 fatty acids, antioxidants, and L-arginine (99 [EL1, RCT]). Types of nuts that decrease CVD risk factors include hazelnuts, peanuts, pecans, some pine nuts, pistachio nuts, macadamia nuts, and walnuts (100 [EL4, NE]). Almonds, which are seeds, also decrease CVD risk (100 [EL4, NE]). The current FDA qualified health claim for nuts and CVD states that "scientific evidence suggests but does not prove that eating 1.5 ounces per day of most nuts (such as those specified above) as part of a meal plan low in saturated fat and cholesterol may reduce risk of heart disease" (100 [EL4, NE]). Nuts, legumes, pulses, and seeds should amount to ≥4 servings per week for CVD prevention (45 [EL4, NE]).

4.Q1.3 Healthy Micronutrient Intake

Vitamins are organic compounds that are essential in small amounts for normal metabolism. With the exception of vitamin D, vitamins are not synthesized by the body and need to be ingested to prevent certain metabolic disorders. Lack of adequate vitamin intake can lead to obvious clinical vitamin deficiency syndromes but can also lead to

subtle effects in otherwise healthy patients or those with chronic disease. Gross vitamin deficiency still occurs in populated areas of the world where meals are poor in nutritional value. Vitamin deficiency is rarely seen in industrialized societies but may occur in the very elderly, vegans, immigrants, the very poor, alcoholism, malabsorption, malabsorptive bariatric surgery, hemodialysis, and inborn errors of metabolism.

Vitamin B_{12} deficiency has been reported to be present in 10 to 20% of older adults and is more prevalent in people who follow a vegetarian or vegan meal plan since the major source is meat (101 [EL3, CCS]). Some persons with low-normal serum vitamin B_{12} levels may in fact be deficient and manifest neurologic, psychologic, or hematologic symptoms or disease (102 [EL3, CCS]). If vitamin B_{12} deficiency is suspected, even in the presence of low-normal vitamin B_{12} levels, the diagnosis can be confirmed with measurement of methyl malonic acid. Methyl malonic acid is elevated in the presence of vitamin B_{12} deficiency. Vitamin B_{12} deficiency can result from lack of the intrinsic factor needed to bind vitamin B_{12} for gut absorption. Vitamin B_{12} deficiency is also found in approximately 15% of adults over 60 years of age due to poorly absorbed protein-bound vitamin B_{12} (103 [EL3, CCS]). Malabsorption of the food-protein-B_{12} complex is related to gastric achlorhydria and is often associated with atrophic gastritis. In addition, a RCT involving persons with T2DM treated with metformin or placebo over 4 years revealed an increased risk of vitamin B_{12} deficiency. In this trial, the absolute risks for vitamin B_{12} deficiency and low vitamin B_{12} levels were 7 and 11%, respectively (104 [EL1, RCT]). Folate fortification of foods does not seem to mask macrocytic anemia in patients with vitamin B_{12} deficiency, although this may be possible with high folate supplement use. The National Health and Nutrition Examination Survey (NHANES) data for adults in the post-folate food fortification era found that patients with vitamin B_{12} deficiency had higher folate levels, were more likely to be anemic, and had more cognitive impairment than those with normal serum folate levels (105 [EL2, PCS]). Given the high prevalence of vitamin B_{12} deficiency and the ease and safety of treatment, some have advocated routinely screening adults over the age of 65 for vitamin B_{12} deficiency. This policy has not been endorsed in formal guidelines. Whether or not individuals over 50 years of age should take vitamin B_{12} supplements is unclear. It is prudent to recommend an intake of at least 10 to 15 μg of vitamin B_{12} daily for older individuals (106 [EL4, NE]). With the exception of malabsorptive bariatric surgery (Roux-en-Y gastric bypass [RYGB] and biliopancreatic diversion with duodenal switch [BPD-DS]) and pernicious anemia requiring parenteral (IM, SQ, or intranasal) vitamin B_{12} treatment, patients with vitamin B_{12} deficiency can generally be treated with oral vitamin B_{12} (1,000 μg/day of oral crystalline cobalamin). Patients with vitamin B_{12} deficiency also benefit from increasing the intake of foods rich in vitamin B_{12}, including turkey, pork, eggs, liver, and corned beef (107 [EL2, NRCT]; 108 [EL1, RCT]).

Vitamin D deficiency is more common than previously believed, especially among adolescents, individuals of increased pigmentation, postmenopausal women, and the elderly. Persons at risk for vitamin D deficiency include those with inadequate sun exposure or oral intake, those who have decreased gut absorption due to malabsorption, and those who have decreased conversion of vitamin D to either 25(OH)D in the liver or subsequent conversion to 1,25-dihydroxyvitamin D ($1,25(OH)_2D$) in the kidney (Table 8; see also discussion on bone health) (109 [EL4,

Table 8
Risk Factors for Vitamin D Deficiency

- Decreased intake
  - Malnutrition (inadequate oral intake)
  - Decreased sun exposure
  - Increased adiposity
  - Gastrointestinal malabsorption (short bowel syndrome, pancreatitis, inflammatory bowel disease, amyloidosis, celiac sprue, malabsorptive bariatric surgery procedures)
- Hepatic
  - Some anti-epileptic medications (increased catabolism of 25(OH)D)
  - Severe liver disease or failure (decreased 25-hydroxylase activity)
- Renal
  - Aging (decreased 1-alpha hydroxylase activity and decreased 7-dehydrocholesterol in skin – precursor to vitamin D)
  - Renal insufficiency, GFR<60% (decreased 1-alpha hydroxylase activity)
  - Nephrotic syndrome (decreased levels of vitamin D-binding hormone)

NE]). Inadequate body stores of vitamin D have been associated with muscle weakness, functional impairment, and increased risk of falls and fractures (110 [EL1, MRCT]; 111 [EL2, PCS]). Lower serum total 25(OH)D concentrations in older persons have also been associated with a greater risk of future nursing home admission (112 [EL2, PCS]), and up to 50% of the institutionalized elderly have inadequate levels of vitamin D (113 [EL3, CSS]). The Control and Prevention has recently reported that the percentage of adults achieving 25(OH)D levels greater than 30 ng/mL has declined to only 30% in Caucasians and only 5% in African Americans since 1980. During this same time, more individuals have been found to be severely vitamin D deficient (25[OH]D <10 ng/mL) (114 [EL3, SS]), including children (115 [EL3, SS]).

At present, there are no guidelines for vitamin D testing, nor are there guidelines for when that testing should occur. However, it should be noted that vitamin D supplementation has been shown to reduce fall frequency by half (116 [EL1, RCT]) and to reduce all types of skeletal fracture (117 [EL1, RCT]; 118 [EL1, MRCT]). Higher serum total 25(OH)D concentrations (e.g., 34 ng/mL versus 20 ng/mL) have been associated with greater calcium absorptive efficiency (119 [EL1, RCT]), and several studies suggest that a minimum level of 30 ng/mL (i.e., 75 nmol/L; 1 ng/mL = 2.5 nmol/L) is needed to prevent secondary hyperparathyroidism, a known cause of bone loss (113 [EL3, CSS]; 120 [EL3, CCS]; 121 [EL3, CSS]). Based on bone health, where there is strength of data, the Institute of Medicine (IOM) recommendations for vitamin D RDAs are 600 IU/day for ages 1 to 70 years and 800 IU/day for ages 71 years and older (Table 9), corresponding to a serum 25(OH)D level of at least 20 ng/mL (50 nmol/L). RDA recommendations meet the requirements of at least 97.5% of the population (122 [EL1, MRCT]). On the other hand, PTH plasma levels begin to rise at a total vitamin D level of 78 nmol/L (31.2 ng/mL) (121 [EL3, CSS]). Thus, endocrinology specialty societies recommend raising total vitamin D levels to over 30 ng/mL, which requires 600 to 2,000 IU/day of vitamin D (123 [EL4, NE]; 124 [EL4, NE]).

With the exception of fatty fish, the vitamin D content of most foods is low to nonexistent. Foods fortified with vitamin D, including dairy products, represent the major source of vitamin D. Regardless, for individuals to reach a level of 30 ng/mL, vitamin D intake needs to be greater than the current IOM recommendations. This will often require the use of vitamin D supplements.

The 2005 Dietary Guidelines for Americans recommend that older adults, people with increased skin pigmentation, and those exposed to insufficient sunlight increase vitamin D intake from vitamin D-fortified foods and/or supplements (46 [EL4, NE]). These recommendations were updated in 2010 (64 [EL4, NE]). Individuals in these high-risk groups should consume at least 1,000 IU (or 25 μg; 1 μg = 40 IU) of vitamin D daily to maintain adequate blood concentrations of 25(OH)D. 25(OH)D is

Table 9
Dietary Reference Intakes for Calcium and Vitamin D

	Calcium			Vitamin D		
Life stage group	**Estimated average requirement (mg/day)**	**RDA (mg/day)**	**UL Intake (mg/day)**	**Estimated Average Requirement (IU/day)**	**RDA (IU/day)**	**UL Intake (IU/day)**
Infants 0 to 6 months	a	a	1,000	b	b	1,000
Infants 6 to 12 months	a	a	1,500	b	b	1,500
1-3 years old	500	700	2,500	400	600	2,500
4-8 years old	800	1,000	2,500	400	600	3,000
9-18 years old	1,100	1,300	3,000	400	600	4,000
19-50 years old	800	1,000	2,500	400	600	4,000
51-70 year old males	800	1,000	2,000	400	600	4,000
51-70 year old females	1,000	1,200	2,000	400	600	4,000
>70 years old	1,000	1,200	2,000	400	800	4,000
14-18 years old, pregnant or lactating	1,100	1,300	3,000	400	600	4,000
19-50 years old, pregnant or lactating	800	1,000	2,500	400	600	4,000

Abbreviations: RDA = recommended daily allowance; UL = upper limit.
[a] For infants, Adequate Intake is 200 mg/day for 0-6 months of age and 260 mg/day for 6-12 months of age.
[b] For infants, Adequate Intake is 400 IU/day for 0-6 months of age and 400 IU/day for 6-12 months of age.
Adopted from: IOM, Food and Nutrition Board. Dietary Reference Intakes: Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride. Washington, DC: National Academy Press, 2011.

the best laboratory indicator of vitamin D body stores. Routine monitoring of serum total 25(OH)D levels in high-risk individuals is recommended, with the goal of achieving levels of about 30 ng/mL, depending on the individual patient's clinical status (123 [EL4, NE]; 124 [EL4, NE]).

Evidence-Based Recommendations for Daily Allowances

DRIs represent four concepts (Table 10): the RDA, adequate intake (AI), estimated average requirement, and tolerable upper limit (TUL). DRIs are established in the United States by the National Academy of Sciences, National Research Council, and the IOM (Table 11). For practical clinical purposes, the RDA reflects the average daily intake that is sufficient to meet the dietary requirement of nearly all healthy people. The AI is used when the RDA cannot be determined, as is the case for vitamin D and vitamin K. The Daily Value (DV) is set by the FDA and is used on food and supplement labels. The FDA DVs for food labels are based on a 2,000 calorie per day meal plan. However, an individual's DRI for any nutrient may be higher or lower depending upon the calorie intake needed above or below a 2,000 calorie per day meal plan. A better estimate for any given individual's DRI nutrient needs can be assessed with the use of a government web site that takes into consideration a person's gender, age, height, weight, and activity level to estimate the daily DRI and TUL for vitamins and minerals (125 [EL4, NE]). This can be a helpful aide for use by the population at large to provide nutrient education and to help insure that otherwise healthy individuals taking supplements are within their estimated bodily need.

With the exception of vitamin D intake and specific use for vitamin deficient states or disease, there is little evidence that supplemental vitamin intake above the RDA/AI is beneficial for otherwise healthy adults consuming healthy meals. However, it is important to note that many Americans, at least 20 to 30% in some surveys, take over-the-counter herbal or nutritional supplements (126 [EL3, SS]; 127 [EL3, SS]). A readily accessible web site to help physicians, other health care providers, and patients learn the benefits, risks, and nutrient-drug interactions of dietary supplements is the Natural Medicines Comprehensive Database (128 [EL4, NE]). This database is a complete and reliable natural medicine resource to provide available health information on all herbal and nonherbal supplements.

Evidence-Based Use of Multivitamins

Natural foods such as whole grains, dairy products, fruits, and vegetables contain a variety of nutrients and compounds that provide benefits not available in supplements and which may act synergistically to support health (Table 5). Of concern is the report from The Dietary Guidelines for Americans that the American populace consumes insufficient amounts of green leafy vegetables, fresh fruits, whole grains, and fiber and eats excessive amounts of refined carbohydrates, saturated fat, and sodium (64 [EL4, NE]). The intake of unbalanced meals raises concern

Table 10
Terms Used for the Intake of Food and Supplement Vitamins and Minerals

Recommended Dietary Allowance (RDA): The amount of each vitamin and mineral needed to meet the daily needs of nearly all healthy people as determined by the Food and Nutrition Board of the IOM. RDAs for vitamins and minerals are based on gender, age, and physical condition (e.g., pregnancy, lactation, etc.)

Adequate Intake (AI): An AI is a recommended intake level of certain nutrients based on estimates of how much healthy people need. It is used when there is not enough data to establish an RDA for a vitamin or mineral (e.g., vitamins D and K).

Daily Value (DV): The DV is set by the FDA and is used on food and supplement labels. DVs for food labels are based on a 2,000 calorie/day diet. An individual's DV may be higher or lower depending upon calorie intake need above or below a 2,000 calorie/day diet.

- ***USP Verified***: The initials USP on a label ensure that the food or supplement meets the standards for strength, quality and purity established by the testing organization U.S. Pharmacopeia or other third party verification services. The FDA Good Manufacturing Practices regulation is intended to ensure the quality and purity of all dietary supplements in the U.S. by 2010.
- ***Percent Daily Value***: The percent DV is the percentage of the DV that 1 serving of food or supplement provides to meet the RDA/AI for a given calorie/day diet.

Tolerable Upper Limit (TUL), to caution against excessive intake of nutrients (like vitamin A) that can be harmful in large amounts. This is the highest level of daily consumption that current data have shown to cause no side effects in humans when used indefinitely without medical supervision.

Table 11
Recommended Daily Allowance (RDA), Adequate Intake (AI), and Tolerable Upper Limit (TUL) of Selected Vitamins for Adults >18 Years of Age[a]

Vitamin (measured unit)	RDA/AI Men	RDA/AI Women	TUL	Selected Food Sources [Examples]	Function (F) and Increased Need (N)	Adverse Effects (AE), & AE Risk (R)
Vitamin A (international units)	3000	2330	9990	Liver, egg yolk, yellow-green vegetables [6000 IU in a small 5 inch carrot], milk	F: vision, immune function, bone and tissue growth. N: BPD-DS bariatric surgery, malabsorption	AE: Liver toxicity R: alcoholism, tobacco smokers, liver disease
Vitamin D (international units)	400-600	400-600	2000	Fortified dairy-foods [100 IU in 8 oz milk], fish oils	F: bone-muscle health. N: bone loss, pigmentation, CKD, RYGB, malabsorption, aging, steroids	AE: renal stones, hypercalciuria, hypercalcemia (rare)
Vitamin E (milligrams)	15	15	1000	Vegetable oils, unprocessed cereals, grains, nuts [7 mg/oz almonds], fruit, meat	F: antioxidant., rbc and immune function N: malabsorption	AE: cancer risk, possible bleeding
Vitamin C (milligrams)	90	75	2000	Citrus juice, fruits [70 mg in 1 orange], tomatoes, broccoli	F: antioxidant, iron absorption, wound healing. N: smokers	AE: renal stones, GI upset
B1-thiamine (milligrams)	1.2	1.1	(ND)	Fortified-enriched-whole grains [breads, cereals], pork	F: muscle, heart, nerve function N: RYGB, malabsorption, dialysis, alcohol >1/day	AE: none known
B2-riboflavin (milligrams)	1.3	1.1	(ND)	Dairy, eggs, grains, nuts, spinach	F: skin, eye, nerve function; coenzyme for redox reactions	AE: none known
B3-niacin (milligrams)	16	14	35	Lean & organ meats, poultry, fish [11 mg in in 3 oz tuna], peanuts, brewers yeast	F: gut, skin, hair, eye, nerve function; coenzyme for redox energy metabolism. N: dialysis	AE: flushing, rash, GI upset
B5-pantothenic acid (milligrams)	5	5	(ND)	Whole grains, oats, cereals, organ meats, egg yolk, yeast	F: coenzyme in fatty acid metabolism	AE: none known
B6-pyridoxine (milligrams)	1.3-1.7	1.3-1.5	100	Fortified-enriched-whole grains, nuts, peas, bananas [0.4 mg in 1 banana], fish	F: rbc and brain function, protein metabolism. N: tobacco smokers, alcohol >1/day	AE; sensory neuropaty, skin lesions
B9-folic acid (micrograms)	400	400	1000	Fortified grains, spinach, legumes, avocados, fruits	F: rbc metabolism, cell growth N: pregnancy, alcohol >1/day	AE: may mask vitamin B12 deficiency
B12-cobalamin (micrograms)	2.4	2.4	(ND)	Meats, fish [5 mcg in 3 oz salmon], poultry, fortified foods (cereals)	F: rbc, nerve and brain function. N: achlorhydria, aging, vegans, alcohol >1/day, RYGB	AE: none known
Biotin (micrograms)	30	30	(ND)	Liver; less in other meats and fruits	F: coenzyme for synthesis of glycogen, fat, protein	AE: none known

The table provides selected food sources for vitamins, vitamin functions, patients who may be in need (N) of more intake than the stated RDA/AI, adverse effects (AE) of excess vitamin supplementation (there are no AE noted from food intake only), and clinical settings of increased risk (R) for vitamin deficiency.
[a] More detailed information can be obtained at The National Academies web site http://www.nap.edu/topics.php?topic=287.
Four organizations comprise The National Academies: the *National Academy of Sciences*, the *National Academy of Engineering*, the *IOM*, and the *National Research Council*. The goal of these organizations is to produce reports to help shape sound policies, inform public opinion, and advance the pursuit of science, engineering, and medicine.

for inadequate intake of healthy micronutrient vitamins and minerals necessary for bodily health. MVI supplements are widely used in the United States, often in the hope of maintaining health, increasing energy, and reducing the risk of cancer, CVD, and other chronic diseases (Table 12). In fact, MVIs are the most common supplements used in America, with one in three adults taking an MVI regularly. MVI use is responsible for $23 billion in annual sales in the United States (129 [EL4, NE]). Of note however, is that no supplement trial in otherwise healthy adults has ever been able to reproduce the health benefits of eating adequate amounts of fresh fruits and vegetables. In addition, the results of both observational and randomized controlled studies to date are not compelling to support a role for either most individual vitamin supplements studied or for a single MVI in the prevention of CV events or mortality from CVD or cancer.

There is substantial observational and RCT data for the benefit of calcium and vitamin D use in reducing fractures (130 [EL1, RCT]) and colorectal cancer (131 [EL1, RCT]), selenium supplementation in reducing the risk of skin and other cancers (132 [EL1, RCT]; 133 [EL1, MRCT]; 134 [EL1, MRCT]), folate intake in relation to CVD (135 [EL4, NE]), and fetal neural tube defects with both food fortification (136 [EL3, SS]) and oral folate supplements (137 [EL1, RCT]). Other vitamin studies report evidence of harm and it seems unwise to extrapolate dietary nutrient associations to possible effects from isolated supplements or MVI use. A recent National Institutes of Health (NIH) state-of-the-science conference on MVIs and mineral

Table 12
Vitamin Content of Commonly Available Multivitamins

	A units	D units	E units	K units	C mg	B1 mg	B2 mg	B3 mg	B5 mg	B6 mg	B9 mcg	B12 mcg	Bio-tin mcg	Fe mg	Zn mg	Cu mg	Misc. Notes
Centrum®	3500	400	30	25	60	1.5	1.7	20	10	2	400	6	30	18	11	0.5	Ca 200 mg, I 150 mcg, Mg 50 mg, Se 55 mcg, Cr 35 mcg
Centrum Silver®	2500	500	50	30	60	1.5	1.7	20	10	3	400	25	30	--	11	0.5	Ca 220 mg, I 150 mcg, Mg 50 mg, Se 55 mcg, Cr 45 mcg
One A Day® Womens	2500	800	30	25	60	1.5	1.7	10	5	2	400	6	30	18	15	2	Ca 450 mg, Mg 50 mg, Se 20 mcg, Cr 120 mcg
One A Day® Men's Health	3500	400	45	20	90	1.2	1.7	16	5	3	400	18	30	--	15	2	Ca 210 mg, Mg 120 mg, Se 105 mcg, Cr 120 mcg, Lycopene 600 mcg
Therapeutic-M® Theragran-M®	5000	400	60	28	90	3	3.4	20	10	6	400	12	30	9	15	2	Ca 40-66 mg, I 150 mcg, Cr 50 mcg, Se 70 mcg
Flintstones Complete®	3000	400	30	--	60	1.5	1.7	15	10	2	400	6	40	18	12	2	Ca 100 mg, I 150 mcg, Mg 20 mg
Prenatal (Natal Care Plus®)	4000	400	22	--	120	1.8	3	20	--	10	1000	12	--	27	25	2	Ca 200 mg
ADEKs High Potency	9000	400	150	150	60	1.2	1.3	10	10	1.5	200	12	50	--	7.5	--	Contents reflect adult dose as 2/day
Dialyvite®	--	--	--	--	100	1.5	1.7	20	10	10	1000	6	300	--	--	--	Ca 100 mg, I 150 mcg, Mg 20 mg

Key: Ca: calcium, I: iodine, Mg: magnesium, Se: selenium, Cr: chromium, B1: thiamine, B2: riboflavin, B3: niacin, B5: pantothenic acid, B6: pyridoxine, B9: folic acid, B12: cobalamin, Fe: iron, Zn: zinc, Cu: copper

Note: Flintstones Complete® now has 600 IU vitamin D.

supplements concluded that there is no consistent evidence that any single vitamin supplement or MVI helps prevent a wide range of diseases (138 [EL1, MRCT]). In addition, supplement trials have had to be stopped prematurely due to unexpected adverse events (139 [EL4, NE]).

Several large early cohort studies have reported decreased CVD rates among individuals who self-selected for higher intakes of vitamin E though meals and/or supplements. In addition, several observational and case-control studies have reported reduced rates of cancer among persons who self-selected for higher antioxidant use. However, in a randomized trial of 39,876 women (≥45 years of age) provided vitamin E (600 IU on alternate days), there was no overall benefit for major CV events (RR, 0.93 for any of nonfatal myocardial infarction, nonfatal stroke, or CV death) or cancer after 10 years of follow-up (140 [EL1, RCT]). A follow-up Selenium and Vitamin E Cancer Prevention Trial (SELECT) to evaluate supplement use for prostate cancer prevention was stopped early because of (nonsignificant) increases in prostate cancer and DM versus control subjects (141 [EL1, RCT]). A meta-analysis of vitamin E trials reported a mild increase in all-cause mortality with vitamin E use (142 [EL1, MRCT]).

Three intervention trials have studied the use of β-carotene for lung cancer prevention. The Alpha-Tocopherol, Beta-Carotene Cancer Prevention Study randomly assigned 29,133 Finnish male smokers to supplemental β-carotene (20 mg/day) or α-tocopherol (vitamin E) versus placebo (143 [EL1, RCT]). After 5 to 8 years of follow-up, β-carotene use increased the RR of lung cancer (1.18) and total mortality (RR, 1.08) without any reduction in cancer. A second large study was the Carotene and Retinol Efficacy Trial (CARET), which involved random assignment of 18,314 smokers, former smokers, and asbestos-exposed patients to a combination of β-carotene (30 mg/day) plus retinol (25,000 IU/day) versus placebo. The trial was stopped after 4 years due to a significant increased risk in the β-carotene plus retinol group for lung cancer (RR, 1.28), CVD mortality (RR, 1.26), and total mortality (RR, 1.17), without any significant decline in lung cancer

(144 [EL1, RCT]). In the Physicians' Health Study, 22,071 American male physicians (age 40 to 84 years, 11% smokers and 39% former smokers) were randomly assigned to receive β-carotene (50 mg) or aspirin compared to placebo. After 12 years, there were no differences between the β-carotene and placebo groups for risk of any cancer, CVD, or total mortality (145 [EL1, RCT]).

Table 11 summarizes the RDA, AI, and upper limit (UL) of vitamins for adults. It is important to note that nutritional deficiencies are very common after malabsorptive bariatric surgery (RYGB less so than very long-limb RYGB and BPD-DS) and often occur despite supplementation with a standard MVI (146 [EL4, NE]). The reported incidence of specific deficiencies after RYGB varies widely in the literature, between 10 to 50% for vitamin B_{12} and iron (147 [EL4, NE]; 148 [EL4, NE]; 149 [EL3, CSS]) and 0 to 40% for folic acid (150 [EL4, NE]). Hypovitaminosis D with secondary hyperparathyroidism has been reported in up to 80% of patients both before and after gastric bypass (151 [EL3, CSS]). In a 2-year retrospective study after RYGB surgery, 137 patients were given a standardized MVI and followed with laboratory testing at 3, 6, 9, 12, 18, and 24 months for vitamin and mineral deficiencies. Three months after RYGB, 34% of these patients required at least 1 specific supplement in addition to the MVI, and at 6 and 24 months this proportion increased to 59 and 98%, respectively. Two years after RYGB, a mean of 3 specific supplements were required for each patient, to include vitamin B_{12}, iron, calcium, vitamin D, and folic acid (152 [EL2, PCS]). Lifelong regular follow-up is needed after malabsorptive bariatric surgery to detect and treat vitamin and mineral deficiencies (153 [EL4, NE]).

4.Q2. What Nutritional Recommendations are Appropriate for Weight Management?

Eat little, sleep sound. ~Iranian Proverb
He that eats till he is sick must fast till he is well. ~ English Proverb

4.Q2.1 Approach to Overweight and Obesity

Fat mass (adiposity), as measured by BMI, is strongly associated with an increased risk of hypertension, dyslipidemia, and hyperglycemia. Primary disturbances in adipose tissue anatomy and function adiposopathy are etiologic in the development of these metabolic derangements (154 [EL4, NE]; 155 [EL4, NE]; 156 [EL4, NE]). The disturbances in adipocyte tissue anatomy and function include adipose tissue hypertrophy and inflammation and altered adipokine activity (156 [EL4, NE]). Thus, obesity is viewed as a primary, chronic disease by the World Health Organization (WHO) (157 [EL4, NE]; 158 [EL4, NE]), a position long held by TOS and recently officially taken by AACE (159 [EL4, NE]). People with overweight or obesity who after a thorough history and physical examination, including appropriate laboratory testing, do not have any documentable complications of the disease, are at very high risk for eventually developing them. This tenet is central to a preventive medicine approach to metabolic diseases.

There is an increased risk of mortality once BMI increases to more than 25 kg/m^2 in the United States Caucasian population. Expected life span is reduced by 9 years in a person with a BMI >30 kg/m^2 compared to someone with a BMI of 20 to 22 kg/m^2 (160 [EL4, NE]). These BMI cutoff points are not generalizable to different racial and ethno-cultural groups. In particular, in Southeast Asian, Chinese, and Asian Indian populations, CV risk increases at a BMI cutoff level of 23 to 24 kg/m^2 (157 [EL4, NE]).

Healthy eating plays a major role in helping individuals lose excess fat mass, and traditionally this has been the goal of treatment. The concept that adipose tissue dysfunction plays a major role in the genesis of metabolic disorders is now well established in the literature (154 [EL4, NE]; 155 [EL4, NE]; 156 [EL4, NE]; 161 [EL4, NE]; 162 [EL4, NE]; 163 [EL2, NRCT]; 164 [EL1, RCT]; 165 [EL4, NE]; 166 [EL4, NE]; 167 [EL4, NE]; 168 [EL4, NE]; 169 [EL4, NE]; 170 [EL4, NE]; 171 [EL2, NRCT]; 172 [EL4, NE]; 173 [EL4, NE]; 174 [EL4, NE]; 175 [EL4, NE]; 176 [EL2, PCS]; 177 [EL4, NE]). Thus, moving forward, a major focus of nutrition counseling for overweight or obesity is to correct adiposopathy. This evidence base supports the critical role of healthy eating in risk reduction for various disease states. Table 13 outlines weight-loss therapies appropriate for use at different BMI levels, with different comorbidities, for the largely Caucasian American population (178 [EL4, NE]; 179 [EL4, NE]).

Adult feeding behavior is rooted from childhood experiences. Therefore, it is important to consider the role that adults play in rearing children, since a number of factors within the home environment have been associated with healthy eating. Both household food availability (foods present in the house) and accessibility (whether available food is in a form or location that facilitates their consumption, such as fruit on the counter) have been positively associated with healthful meal intake in youth (180 [EL3, SS]). Home availability and taste preferences are the strongest correlates of fruit and vegetable intake among adolescents (181 [EL3, SS]). On the other hand, availability of less healthy options, such as soft drinks in the home, is associated with increased soft drink consumption among children (182 [EL3, SS]).

Social environmental influences within the home, such as modeling of healthful dietary intake by parents and more frequent family meals, may promote healthy eating among children and adolescents. Parental food and vegetable intake has been associated with fruit and vegetable intake among youth (183 [EL3, CSS]; 184 [EL3, SS]; 185 [EL3, CSS]). Parental feeding style may also have a

Table 13
Therapies Appropriate for Use at Different BMI Levels with Different Comorbidities

BMI → Classification →	18.5-24.9 Normal	25-29.9 Overweight	30-34.9 Obesity class I	35-39.9 Obesity class II	≥40 Obesity class III
Risk of complications →	**Very low**	**Mild**	**Moderate**	**High**	**Extreme**
Medical nutrition therapy	X	X	X	X	X
Physical activity	X	X	X	X	X
Behavior modification	X	X	X	X	X
Pharmacotherapy		X	X	X	X
Surgery			X (gastric banding only)	X	X

Abbreviation: BMI = body mass index.
Adapted from: US Department of Health and Human Services, Public Health Services, National Institutes of Health, National Heart, Lung and Blood Institute and North American Association for the Study of Obesity. The practical guide. Identification, evaluation and treatment of overweight and obesity in adults. NIH Publication No. 00-4084, October 2000.

bearing on children's food intake. Parental practices, such as restricting foods, pressuring children to eat, or using foods as rewards, may inadvertently promote behaviors contrary to their intentions (186 [EL4, NE]). Furthermore, there is evidence that family socioeconomic and demographic factors may contribute to obesity in youth. These factors include single-parent status (187 [EL2, PCS]), poor living conditions (188 [EL2, PCS]; 189 [EL2, PCS]), lower family household income (190 [EL4, NE]), parental education (188 [EL2, PCS]), and neighborhood safety (189 [EL2, PCS]; 191 [EL3, CSS]).

Restaurant and fast food consumption (192 [EL3, CSS]; 193 [EL3, SS]), large portion sizes (194 [EL2, NRCT]; 195 [EL2, NRCT]), and consumption of beverages with added sugar (196 [EL2, PCS]; 197 [EL2, NRCT]) all increase energy intake (EI) and are associated with overweight and obesity. On the other hand, consumption of low-energy-dense foods (i.e., fruits and vegetables) decreases EI, which helps in losing or maintaining weight (198 [EL2, NRCT]; 199 [EL4, NE]).

Additional behaviors associated with obesity in adults include night eating, snacking, and alcohol consumption. Night eating has been associated with a definite psychiatric disorder, night eating syndrome (nocturnal hyperphagia, insomnia, and morning anorexia) (200 [EL2, PCS]). Snacking between meals has also been associated with excessive weight. Conversely, routinely eating a healthy breakfast is associated with energy balance and weight control (201 [EL3, SS]). Each of these behaviors may be readily identifiable and amenable to counseling and intervention.

Child-care facilities, schools, after school and summer school programs, and work sites provide a valuable opportunity to promote healthy eating in children, adolescents, and adults. With the exception of 2 states, the remaining 48 do not require that meals and snacks served in child-care facilities follow the Dietary Guidelines for Americans (202 [EL4, NE]). This is a missed opportunity, since the majority of children under age 5 years (60%) spend an average of 29 hours per week in some form of child-care setting and 41% spend 35 or more hours per week (203 [EL3, SS]). Up to 2 meals and a snack are eaten at school every day (204 [EL4, NE]). Therefore, the school food environment can have a large impact on meal intake in children and adolescents.

Meals served in the National School Lunch and Breakfast Program must meet federally defined nutrition standards and the recommendations of the Dietary Guidelines for Americans. However, federal requirements currently do little to limit the sale of "competitive foods" (so called because they compete with school meal programs). Nine out of ten schools sell competitive foods, and the majority of offerings are high in fats and concentrated sugars (205 [EL4, NE]). Federal, state, and local authorities need to implement stronger regulations for competitive foods in schools. Nutrition should also be a part of the curriculum to enhance student's skills for adopting a healthier lifestyle.

Nutrition behaviors can be positively influenced by work site health promotion programs, such as reducing the price of healthful foods in work site cafeterias and vending machines and sending nutrition education email messages.

The presence of food stores and the availability of healthful products in those stores are important contributors to healthy eating patterns among neighborhood residents. Increased access to chain supermarkets is associated with lower adolescent BMI (206 [EL3, SS]). Greater availability of convenience stores, on the other hand, is associated with higher BMI (207 [EL3, SS]). Low-income and minority neighborhoods have fewer chain supermarkets than do middle- and upper-income neighborhoods (208 [EL3, SS]). In general, population groups that suffer the worst

health status, including nutritional health and obesity, are also those that have the highest poverty rates (208 [EL3, SS]). Among the important opportunities to reduce disparities are initiatives to encourage the development of grocery retail investments in low-income communities. Thus, retail food environments at both the community level (presence of supermarkets) and the consumer level (healthful, affordable foods in food stores) are promising venues for positive change (209 [EL3, CSS]; 210 [EL3, CSS]; 211 [EL3, SS]).

Cultural Ethnocentric Considerations

Poor nutrition is one of the major modifiable determinants of chronic diseases. Eating behavior studies have shown that both individual factors such as taste preferences, nutrition knowledge, attitudes, and intentions, as well as environment-based factors (food supply, food availability, and food safety) are of crucial importance in shaping and maintaining nutrition and eating habits. Determinants of eating behavior include the social, physical, and macrolevel environments we live in. The social environment includes interactions with family, friends, peers, and others in the community and may impact food choices through mechanisms such as role modeling, social support, and social norms. Many of these factors require transculturalization in order to optimize implementation for individuals of different backgrounds.

Knowledge of cultural food preferences is essential in nutritional interventions and counseling for minority populations. Reinforcement of positive traditional habits, adaptation of healthy Western food items, and development of strategies that will effectively correct likely deficiencies in meal planning are important intervention goals. Understanding common religious and ethnic food practices is important in nutritional planning and education. Examples of this include:

- prohibition of pork for Muslims, Jews, and Seventh Day Adventists
- prohibition of beef for Hindus
- food restrictions such as eggs, dairy products, and fish for Eastern orthodox populations
- fasting practices and other ceremonial activities
- the use of herbs and botanicals as part of meal patterns, rituals, and celebrations, and
- the belief among Hispanics that chubby children are healthy and being fat is a sign of wealth (the family has food to eat).

Culturally appropriate nutrition counseling and awareness of religious practices are important for improving health issues such as obesity.

Macroenvironment

Federal agricultural policies have a large impact on the U.S. food supply and consequently, public health. United States farm policy for commodity crops has made sugar and fat some of the most inexpensive foods to produce. This has indirectly influenced food processors and manufacturers to expand their product lines to include more fats and sweeteners. High fructose corn syrup (HFCS) and hydrogenated vegetable oil (high in *trans* fats) are prevalent in foods, likely owing to the availability of inexpensive corn and soybeans. In the American food supply, per capita daily supply of added fats and oils increased 38% from 1970 to 2000. A strong correlation exists between the increased use of HFCS and the obesity epidemic, and therefore, the Center for Food, Nutrition, and Agriculture Policy convened an expert panel to examine this issue. The expert panel concluded that HFCS does not appear to contribute to overweight and obesity any differently than do other energy sources (212 [EL4, NE]).

The cost of food is second only to taste as the most important factor affecting food decisions. Low-income families spend less on fruits and vegetables than do higher income families (213 [EL3, SS]). This is because the current structure of food prices is that high-sugar and high-fat foods provide calories at the lowest cost. Thus, low-income families may select energy-dense (albeit low-cost) foods as a way to save money.

Television (TV) food advertising is one factor in our current obesogenic environment warranting public health intervention. Over the past few decades, children and adolescents have increasingly been targeted with aggressive forms of food marketing, with an emphasis on advertisements for candy, snacks, sugared cereals, and fast foods. These ads frequently employ lively youth-oriented animation and themes of fun and adventure, compelling kids to request parents to purchase the advertised foods (214 [EL3, CSS and EL2, NRCT]). The challenge then is to shift the advertising and marketing emphasis to healthier child- and youth-oriented foods and beverages. Ads should be developed with practical nutrition messages that are scientifically precise yet also acknowledge the essential factors that drive feeding behaviors. Besides advertising, TV viewing itself has been linked to the obesity epidemic (214 [EL3, CSS and EL2, NRCT]). TV viewing is negatively associated with engagement in physical activity, and having a TV in a child's bedroom is a significant risk factor for obesity (215 [EL4, NE]). With the advent of computers and video games, "screen time" has increased in American society. Decreasing "screen time" effectively helps lower BMI (216 [EL1, MRCT]).

Microenvironment—Physiology and Molecular Definition

The control of eating behavior is not restricted to cognitive, behavioral, and environmental factors. The control of food intake is based on a network of interactions forming part of a psychobiological system (156 [EL4, NE]). There are peripheral sensors (gut, adipose tissue, liver, and skeletal muscle) that provide signals to the brain about the fed state and energy stores. The brain translates this feedback

into peptide signals that help control hunger, appetite, satiety, food seeking, and other behaviors. In simple terms, the expression of food intake is controlled by inhibitory and excitatory signaling systems (217 [EL4, NE]). Any defect within the inhibitory signals that mediate satiety leads to individuals being vulnerable to overconsumption through increases in meal size or the frequency of eating. Gut peptides, including cholecystokinin, glucagon-like peptide-1, oxytomodulin, peptide YY, insulin, and amylin are of particular significance. The complexity of this system has been described in several recent reviews (156 [EL4, NE]; 218 [EL4, NE]).

Team Approach to Obesity Care

The Chronic Care Model (CCM), developed by Edward Wagner and associates, recognizes the changes needed to organize health services for people with chronic conditions (e.g., obesity) and offers a chronic care guide to improvements (219 [EL3, SCR]). The key components of the CCM are self-management support, practice redesign, decision support, clinical information systems, health care organization, and community resources. The CCM focuses on relationship-centered communication and creating informed, active patients with improved self-management skills (220 [EL4, NE]).

Currently, there are only limited evidence-based interventions shown to specifically improve health professionals' management of obesity (221 [EL4, NE]; 222 [EL4, NE]; 223 [EL4, NE]; 224 [EL1, RCT]). How practices operate on a day-to-day basis is extremely important for the provision of chronic disease management. Establishing an integrative team approach is one such strategy (225 [EL4, NE]; 226 [EL4, NE]). A patient-care team is defined as "a group of clinicians who communicate with each other regularly about the care of a defined group of patients and participate in that care" (227 [EL4, NE]). Effective chronic illness interventions generally rely on multidisciplinary teams (10 [EL4, NE]). Teamwork entails coordination and delegation of tasks between providers and staff (228 [EL4, NE]). According to the CCM, at the time of the patient visit, an optimal team has the information, decision support, people, equipment, and time required to deliver evidence-based clinical management and self-management support (219 [EL3, SCR]). Because of limited time, physicians are generally unable to provide all of the care necessary for treatment. Teams ensure that key elements of care that doctors may not have the training or time to do well are competently performed (10 [EL4, NE]). Moreover, other personnel are often better qualified to deliver the nutritional, physical activity, and behavioral counseling.

4.Q2.2 Behavior Modification

Behavioral modification for healthy eating, also referred to as lifestyle modification, is the cornerstone of weight management (178 [EL4, NE]; 179 [EL4, NE]; 229 [EL4, NE]). Behavioral modification refers to a set of principles and techniques to help patients adopt new eating and activity habits to replace the maladaptive habits that likely contributed to the development of excess body weight (230 [EL4, NE]; 231 [EL4, NE]; 232 [EL4, NE]). It is typically used in combination with MNT and physical activity interventions for both weight loss and weight maintenance. Behavioral modification also is used in conjunction with pharmacotherapy and bariatric surgery.

Many of the tenets of behavioral modification are drawn from social cognitive theory (232 [EL4, NE]; 233 [EL4, NE]). Social cognitive theory emphasizes that self-efficacy—the belief that an individual can engage in a behavior—is a crucial determinant of both the initiation and eventual successful maintenance of an adaptive behavior (233 [EL4, NE]; 234 [EL4, NE]). Central to this is the successful implantation of self-regulation strategies believed to be important for the management of chronic illness (235 [EL4, NE]; 236 [EL4, NE]). As applied to behavioral modification for healthy eating, these strategies include self-monitoring of food intake, setting of specific nutrition-related goals (such as decreasing the intake of sugar or fat), modification of the food environment, increasing physical activity, development of coping skills in response to stress, and the use of social support.

Self-monitoring involves observing and recording caloric intake as well as other related aspects of eating behavior (times, places, emotions, etc.). Self-monitoring can help patients identify maladaptive aspects of their eating behavior that are often the byproduct of a number of environmental stimuli. For example, through self-monitoring, a patient may identify a habit of overeating snack foods while watching TV in the evening. A resulting behavioral modification strategy to develop a healthier eating behavior would be to eliminate eating in front of the TV. More cognitive interventional strategies—which target a patient's maladaptive thoughts about food and eating behavior—are often used to deal with other behavioral and emotional challenges.

Behavioral modification approaches typically encourage patients to eat self-selected, conventional foods but reduce their EI by 500 to 1,000 kcal/day. This is typically accomplished through smaller portion sizes and a high-carbohydrate, low-fat diet (i.e., fewer than 30% of calories from fat) that emphasizes consumption of fruits, vegetables, and whole grains (237 [EL4, NE]; 238 [EL4, NE]). Behavioral modification, however, can be combined with a variety of other dietary approaches, which are reviewed below.

The regular use of portion-controlled servings of conventional foods improves the induction of weight loss in behavior-based approaches. In at least one study, individuals who were prescribed a meal plan of 1,000 kcal/day and were provided the actual foods for 5 breakfasts and 5 dinners a week lost significantly more weight at 6, 12, and 18

months than those who were prescribed the same number of calories but consumed meals of self-selected table foods (239 [EL1, RCT]). Several other studies have shown the benefits of using prepackaged, portion-controlled meals, such as frozen-food entrees (230 [EL4, NE]; 240 [EL4, NE]; 241 [EL1, RCT]; 242 [EL1, RCT]; 243 [EL1, RCT]; 244 [EL1, RCT]).

Behavioral modification treatment, as practiced in academic medical centers, is typically provided on a weekly basis for an initial period of 16 to 26 weeks (240 [EL4, NE]; 245 [EL4, NE]). Treatment is usually delivered to groups of 10 to 20 individuals (often in 60-minute sessions) by RDs, behavioral psychologists, exercise physiologists, or other health professionals. There are pros and cons to group as compared to individual treatment. At least one study found that group treatment induced a significantly larger initial weight loss as compared to individual treatment (246 [EL1, RCT]). In addition to being more cost-effective, group sessions provide a combination of empathy, social support, and healthy competition. In contrast, some individuals report a strong preference for individual treatment or may have related mental or physical health concerns that warrant individualized attention.

Treatment visits follow a structured curriculum that begins with a review of participants' food and activity records. The health care provider helps participants identify strategies to cope with problems identified and thus increase their adherence to the prescribed eating and activity plans. Weekly homework assignments are a critical component of lifestyle modification. Patients' completion of daily food records is a consistent predictor of initial weight loss (247 [EL1, RCT]; 248 [EL1, RCT]; 249 [EL1, RCT]; 250 [EL1, RCT]).

The results of a number of randomized controlled trials and observational studies indicate that persons treated by a comprehensive behavioral approach lose approximately 10.7 kg, equal to 10% of initial weight (251 [EL1, RCT]; 252 [EL1, RCT]; 253 [EL1, RCT]; 254 [EL1, RCT]; 255 [EL1, RCT]; 256 [EL1, RCT]). Approximately 80% of patients who begin treatment complete it, suggesting the acceptability of lifestyle modification to the vast majority of patients. Thus, lifestyle modification yields favorable results as judged by the criteria for success (i.e., a 5 to 10% reduction in initial weight) proposed by the WHO (229 [EL4, NE]), the NIH (178 [EL4, NE]), and the Dietary Guidelines for Americans (46 [EL4, NE]; 64 [EL4, NE]).

Perhaps the strongest evidence of the benefits of modest weight losses comes from the DPP, as discussed above (13 [EL1, RCT]). The Look Action for Health in Diabetes (LookAHEAD) study also provides strong evidence for the efficacy of behavioral modification for weight reduction (257 [EL1, RCT]). In this long-term, prospective, RCT, 5,145 individuals with T2DM were studied to see whether weight loss reduced CV morbidity and mortality. Participants were randomly assigned to an intensive lifestyle intervention, including meal replacement strategies, or to a diabetes support and education condition. At the end of the first year of the study, participants in the intensive lifestyle intervention lost 8.6% of their initial weight as compared to 0.7% for those in the support and education condition. LookAHEAD has shown important health benefits associated with lifestyle intervention, including decreasing sleep apnea, reducing the need for DM medications, helping to maintain physical mobility, and improving quality of life. In September 2012, the NIH stopped the intervention arm, acting on the recommendation of the study's data and safety monitoring board, which ruled that the intensive lifestyle did no harm but did not decrease occurrence of CV events. At the time, participants had been in the intervention for up to 11 years (256 [EL4, NE]). Nonetheless, LookAHEAD and other studies provide strong evidence of the health benefits of a 5 to 10% reduction in initial weight (12 [EL1, RCT]; 13 [EL1, RCT]; 257 [EL1, RCT]; 258 [EL1, RCT]; 259 [EL1, MRCT]).

4.Q2.3 Low-Calorie Meal Plans

Energy Balance Assessment

In the past, guidelines were general and stated that a meal plan containing 1,000 to 1,200 kcal/day should be selected for women and plans containing between 1,200 to 1,600 kcal/day should be chosen for most men (178 [EL4, NE]). However, a more exact approach considers energy balance when formulating appropriate caloric goals for a LCMP. This personalized nutrition assessment takes into consideration the two trends which have caused the current epidemic of obesity: increased caloric intake and decreased energy expenditure. This imbalance between EI and output yields excess energy that is stored as adipose tissue.

Estimated energy needs should be based on resting metabolic rate (RMR). If possible, the RMR should be measured (e.g., indirect calorimetry). However, if it cannot be measured, then the Mifflin-St. Jeor Equation (MSJE) using actual weight is the most accurate means for estimating RMR for overweight and obese individuals (260 [EL4, NE]; 261 [EL4, NE]):

Men: 10 × weight (kg) + 6.25 × height (cm) – 5 × age (years) + 5

Women: 10 × weight (kg) + 6.25 × height (cm) – 5 × age (years) – 161

The authors of this equation recommend applying a physical activity level (PAL) multiplier of 1.2 for sedentary (~20% above RMR), 1.4 for low-active to moderate (~40% above RMR), and 1.6 for active (~60% above RMR) individuals as assessed through clinical judgment. The MSJE will predict actual or measured RMR within ± 10% in 82% of nonobese individuals and 70% of obese individuals ages 20 to 82 years (262 [EL2, NRCT]; 263 [EL4, NE]; 264 [EL4, NE]).

A meal plan prescription should be appropriate for the individual's metabolism (264 [EL4, NE]). The first step in determining caloric goals for a LCMP is to quantify energy balance:

Energy balance = EI – total energy expenditure (TEE).

Energy balance assessment was often a difficult task in the past and required cumbersome surveys and laboratory evaluations. Intake can now be measured by validated surveys, and energy expenditure can be estimated with equations or measured directly with devices that can be used in the medical office setting.

The first task is to determine the patient's baseline EI. The patient can keep a 3- or 7-day "usual" food record prior to the visit. The 7-day food record has been shown to be representative of overall intake over 28 days (r = 0.89) (265 [EL2, NRCT]). This can be combined with a 7-day activity record that will be used to quantify intentional activity for the energy expenditure component of the evaluation. There are also other tools available that have been designed to encourage health care professional and patient dialogue. These tools provide a brief assessment of nutrition and physical activity, along with a Physician's Key to guide the assessment and counseling. The Rapid Eating and Activity Assessment for Patients (REAP) and Weight, Activity, Variety and Excess (WAVE) questionnaires are two examples of tools to assess nutrition and physical activity (266 [EL4, NE]). There are also numerous computer programs and internet web sites available to both professionals and consumers that assist in assessing patient caloric intake and overall nutrient adequacy to speed the evaluation. A practitioner then reviews this information and the average daily caloric intake is used for the patient's energy balance calculation.

TEE quantifies calories as energy expended by:

1. Physical activity: accounts for approximately 20 to 30% of TEE.
2. The body's basal energy requirements at rest: basal metabolic rate (BMR). The BMR or the RMR (approximately 10% higher than the BMR) can be calculated or measured by indirect calorimetry. BMR accounts for 65 to 75% of TEE (262 [EL2, NRCT]).
3. Thermogenesis: the energy expended by the body processing ingested food (accounts for 10 to 15% of TEE).

Resting energy expenditure (REE) measurements are now also possible and practical via an office-based portable medical device. The REE (or RMR) is defined as the number of calories an individual burns resting all day. REE can be measured using hand-held oxygen-consumption monitors (Med Gem® [Microlife USA, Inc, Dunedine, FL]). In a study of 63 adults, RMR correlated (r = 0.91) with measurements using the Douglas Bag technique (267 [EL2, NRCT]). Optimum testing conditions are under steady state, in the morning while the patient is rested. Prior to testing, the person should refrain from food or beverage (other than water for 4 hours), have no intense physical activity for 4 hours, and use no tobacco for 1 hour before the test. The person should be seated and rested 10 minutes prior to the test. The test result will yield the RMR or REE that is generally 10% above the basal energy expenditure (BEE). BEE is the amount of oxygen consumed while resting, extrapolated to a 25-hour period. This measure can then be used to calculate the patient's TEE (TEE = BEE + physical activity factor [PAF] + 10% for thermogenesis or specific dynamic action [SDA] for food). Thus, we recommend that TEE be simply calculated using RMR × 1.2 PAL for sedentary individuals as a starting point (× 1.6 PAL for active individuals). In this equation, the 10% for the SDA is accommodated by the increase of 10% using RMR in lieu of BMR. An additional estimate for intentional physical activity is averaged for the week and added to estimate the total kcal/day expenditure or average TEE, which is used in the assessment of energy balance.

A helpful tool for estimating intentional physical activity is the Physical Activity Recall (PAR) (268 [EL1, RCT]). PAR is an interviewer-administered survey used to determine level of activity and energy expenditure in the previous 7 days. Validity and reliability have been demonstrated. In addition, several new medical devices have facilitated measurement of physical activity and BEE. Activity monitors conveniently quantify physical activity. Pedometers (Accusplit, CA) are about the size of a pager and can be worn by a patient to determine the number of steps that are taken per day (269 [EL2, NRCT]). From this information, an estimate of total calories can be calculated. Although stride length varies from person to person, approximately 2,000 to 2,500 steps generally is equivalent to 1 mile. Furthermore, 1 mile walked burns approximately 100 kcal. Thus, if the patient uses a pedometer and records readings daily for 1 week prior to assessment, then the average for that week can be used for a baseline measure and interpreted into kcal/day (i.e., 2,000 to 2,500 steps ~100 kcal).

Since weight gain and obesity reflect food intake greater than energy needs, a LCMP should be individualized to each person's total energy requirement. Individual need is the amount of food (kcal/day) that can either sustain energy balance to prevent weight gain or produce healthy weight losses equivalent to 0.5 to 3 pounds/week, depending on initial weight, gender, and age (178 [EL4, NE]; 179 [EL4, NE]). Table 14 gives a calorie range for individuals for each age/sex group based on physical activity levels ranging from sedentary to active (270 [EL4, NE]).

LCMPs may have different nutrient compositions, so care must be used to assure nutrient adequacy. At the lower kcal/day recommended levels (1,000 kcal/day), it becomes more important that careful food choices are made and

Table 14
Calorie Range for Individuals for each Age/Sex Group Based on Physical Activity Levels

	Calorie Range	
	Sedentary	**Active**
Children		
2-3 years	1,000	1,400
Females		
4-8 years	1,200	1,800
9-13 years	1,600	2,200
14-18 years	1,800	2,400
19-30 years	2,000	2,400
31-50 years	1,800	2,200
51+ years	1,600	2,200
Males		
4-8 years	1,400	2,000
9-13 years	1,800	2,600
14-18 years	2,200	3,200
19-30 years	2,400	3,000
31-50 years	2,200	3,000
51+ years	2,000	2,800

Sedentary means a lifestyle that includes only the light physical activity associated with day-to-day life.
Active means a lifestyle that includes physical activity equivalent to walking more than 3 miles per day at 3 to 4 miles per hour, in addition to the light physical activity associated with typical day-to-day life.
Adapted from: U.S. Department of Agriculture, Center for Nutrition Policy and Promotion. www.mypyramid.gov/professionals/index.html

the use of supplements to meet nutrient requirements is implemented (271 [EL4, NE]). Particular attention should be paid to maintaining an adequate intake of vitamins and minerals. For example, maintenance of the recommended calcium intakes of 1,000 to 1,500 mg/day is especially important for women who may be at risk for osteoporosis. And adequate intake of folate in foods as well as folic acid (400 μg/day) from fortified foods and/or supplements is necessary for women of childbearing age to avoid the risk of neural tube defects (178 [EL4, NE]; 270 [EL4, NE]; 272 [EL4, NE]). The USDA Food Guide can be used to recommend the amounts of food to consume from the basic food groups to meet recommended nutrient intakes (Table 15) (270 [EL4, NE]; 272 [EL4, NE]). The aim of the 2010 U.S. Dietary Guidelines is achieving and maintaining a healthy body weight (46 [EL4, NE]).

LCMPs have been defined as meal plans that provide approximately a 500 to 1,000 kcal/day reduction from usual intake and usually will provide a weight loss of approximately 1 to 2 pounds/week (178 [EL4, NE]). LCMPs usually begin at ~1,200+ kcal/day, but 1,000 kcal/day LCMPs have been used with care in older, smaller, and inactive individuals. LCMPs of 800 kcal/day severely compromise food intake, and should only be used with special individuals and be closely monitored for nutrient adequacy and other problems. LCMPs usually support ~5 to10% weight loss in 6 months. Beyond 6 months it becomes harder to maintain ongoing weight loss. Energy requirements generally decrease with the achieved weight loss, also making it difficult to maintain a negative energy balance. Thus, emphasis should be placed on the prevention of weight regain or on the maintenance of energy balance at this point, if weight loss cannot be sustained (178 [EL4, NE]; 179 [EL4, NE]).

4.Q2.4 Very Low-Calorie Meal Plans

VLCMPs are meal plans or liquid formulations that provide an energy level between 200 and 800 kcal/day (178 [EL4, NE]; 273 [EL4, NE]). These meal plans are designed to produce rapid weight loss in patients with BMI >30 kg/m^2 who have other significant comorbidities or have failed other approaches (274 [EL4, NE]). Patients adhering to VLCMPs can achieve larger weight losses (average of 1.5 to 2.5 kg/week, and up to 20 kg in 12 to 16 weeks) (275 [EL4, NE]). Several meta-analyses have evaluated the efficacy of VLCMPs on long-term weight loss or weight maintenance, but the results are inconsistent. One meta-analysis evaluated results from 29 long-term U.S. studies (2 to 5 years) and concluded that VLCMPs were associated with greater long-term reductions compared to LCMPs (276 [EL1, MRCT]). A recent meta-analysis involving 6 RCTs comparing VLCMPs with LCMPs did not produce similar results. While short-term (mean, 12.7 weeks) weight loss was greater with VLCMPs (16.1 pounds vs. 9.7 pounds) compared to LCMPs, there was no difference in long-term (mean, 1.9 years) weight loss (6.3 pounds vs. 5.0 pounds) between the 2 groups at up to 5 years after randomization (277 [EL1, MRCT]). Weight regain and attrition rates were higher for the VLCMP group (178 [EL4, NE]; 273 [EL4, NE]; 275 [EL4, NE]; 276 [EL1, MRCT]; 277 [EL1, MRCT]; 278 [EL1, RCT]).

Risks and Health Concerns of Low- and Very Low-Calorie Meal Plans

In clinical trials, LCMPs have been shown to reduce total body weight by an average of 8% (13 to 17 pounds) over a period of 6 months, accompanied by a reduction in waist circumference of 1.5 to 9.5 cm (178 [EL4, NE]; 273 [EL4, NE]). Behavioral therapy in conjunction with nutritional intervention can result in additional short-term weight loss (178 [EL4, NE]). After successful weight loss, a weight-maintenance program consisting of medical nutrition therapy, physical activity, behavioral strategy,

Table 15
Daily Amount of Food from Each Group

Calorie Level	1,000	1,200	1,400	1,600	1,800	2,000	2,200	2,400	2,600	2,800	3,000	3,200
Fruits	1 cup	1 cup	1.5 cups	1.5 cups	1.5 cups	2 cups	2 cups	2 cups	2 cups	2.5 cups	2.5 cups	2.5 cups
Vegetables	1 cup	1.5 cups	1.5 cups	2 cups	2.5 cups	2.5 cups	3 cups	3 cups	3.5 cups	3.5 cups	4 cups	4 cups
Grains	3 oz-eq	4 oz-eq	5 oz-eq	5 oz-eq	6 oz-eq	6 oz-eq	7 oz-eq	8 oz-eq	9 oz-eq	10 oz-eq	10 oz-eq	10 oz-eq
Meat and beans	2 oz-eq	3 oz-eq	4 oz-eq	5 oz-eq	5 oz-eq	5.5 oz-eq	6 oz-eq	6.5 oz-eq	6.5 oz-eq	7 oz-eq	7 oz-eq	7 oz-eq
Milk	2 cup	2 cup	2 cups	3 cups	3 cups	3 cups	3 cups	3 cups	3 cups	3 cups	3 cups	3 cups
Oils	3 tsp.	4 tsp.	4 tsp.	5 tsp.	5 tsp.	6 tsp.	6 tsp.	7 tsp.	8 tsp.	8 tsp.	10 tsp.	11 tsp.
Discretionary calorie allowance	165	171	171	132	195	267	290	362	410	426	512	648

Calorie Levels are set across a wide range to accommodate the needs of different individuals.
Fruit Group includes all fresh, frozen, canned, and dried fruits and fruit juices. In general, 1 cup of fruit or 100% fruit juice, or 1/2 cup of dried fruit can be considered as 1 cup from the fruit group.
Vegetable Group includes all fresh, frozen, canned, and dried vegetables and vegetable juices. In general, 1 cup of raw or cooked vegetables or vegetable juice, or 2 cups of raw leafy greens can be considered as 1 cup from the vegetable group.
Grains Group includes all foods made from wheat, rice, oats, cornmeal, or barley, such as bread, pasta, oatmeal, breakfast cereals, tortillas, and grits. In general, 1 slice of bread, 1 cup of ready-to-eat cereal, or 1/2 cup of cooked rice, pasta, or cooked cereal can be considered as 1 oz. equivalent from the grains group. At least half of all grains consumed should be whole grains.
Meat & Beans Group in general, 1 oz. of lean meat, poultry, or fish, 1 egg, 1 Tbsp. peanut butter, 1/4 cup cooked dry beans, or 1/2 oz. of nuts or seeds can be considered as 1 oz. equivalent from the meat and beans group.
Milk Group includes all fluid milk products and foods made from milk that retain their calcium content, such as yogurt and cheese. Foods made from milk that have little to no calcium, such as cream cheese, cream, and butter, are not part of the group. Most milk group choices should be fatfree or lowfat. In general, 1 cup of milk or yogurt, 1 1/2 oz. of natural cheese, or 2 oz. of processed cheese can be considered as 1 cup from the milk group.
Oils include fats from many different plants and from fish that are liquid at room temperature, such as canola, corn, olive, soybean, and sunflower oils. Some foods are naturally high in oils, like nuts, olives, some fish, and avocados. Foods that are mainly oil include mayonnaise, certain salad dressings, and soft margarine.
Discretionary Calorie Allowance is the remaining amount of calories in a food intake pattern after accounting for the calories needed for all food groups—using forms of foods that are fatfree or lowfat and with no added sugars.
Adapted from: MyPyramid U.S. Department of Agriculture, Center for Nutrition Policy and Promotion, April 2005.

and appropriate pharmacotherapy should continue indefinitely to prevent weight regain. Attention should be given to maintain an adequate intake of vitamins and minerals.

Despite its many potential benefits, LCMPs are not appropriate for all patients. Pregnant or lactating women, those with serious or unstable psychiatric illness (bulimia nervosa, anorexia nervosa, poly-substance abusers, etc.), or patients who have a variety of serious diseases in whom caloric restriction might exacerbate their illnesses (active malignancy, unstable angina, or recent cardiac events, recent or recurrent cerebrovascular accidents, etc.) should be excluded from weight-loss programs (178 [EL4, NE]; 273 [EL4, NE]). Extreme caution and experienced medical supervision are needed for any weight-loss program involving children. Behavioral techniques and family involvement are keys in successful management of childhood obesity.

For those who can follow low-calorie restrictions, side effects or complications may develop that warrant close follow-up (279 [EL4, NE]; 280 [EL4, NE]). The following possible side effects should be discussed with patients and expected when entering a weight-loss process: constipation (281 [EL4, NE]), hypotension (282 [EL2, RCCS]), loss of muscle mass (279 [EL4, NE]; 280 [EL4, NE]), cold intolerance (283 [EL2, NRCT]), poor wound healing (284 [EL2, NRCT]), and psychological symptoms such as depression and irritability (285 [EL4, NE]).

Body fat is necessary for the production of many hormones, including adrenocortical and sex hormones. Rapid weight loss can lead to a reduction in sex steroids that in turn results in loss of libido and menstrual irregularity (286 [EL3, CCS]). For females, the reduction in estrogen can

also be detrimental to bone health (287 [EL2, PCS]).

As BMI increases, the risk for developing gallstones rises. This risk is further increased with weight loss and is dependent on the rate of weight reduction (288 [EL3, CSS]; 289 [EL2, NRCT]). In one study, the BMI-adjusted RR for cholecystectomy was 1.27 to 1.66 for those losing 5 to 9.9 kg and 1.57 to 2.4 for those losing 10 kg or more in the previous 2 years (290 [EL2, PCS]). To minimize the rate of gallstone formation, a slow but progressive weight-loss strategy is preferred. A reasonable time line is to achieve a 10% reduction in total weight over 6 to 12 months. This can be accomplished by a decrease in caloric intake of 300 to 500 kcal/day (0.5 to 1 pound/week) for a patient with a BMI in the range of 27 to 35 kg/m^2 and a deficit of 500 to 1,000 kcal/day (1 to 2 pounds/week) for those with a higher BMI. A greater rate of weight loss does not yield better results at the end of 1 year (291 [EL1, RCT]).

Because VLCMPs result in rapid weight loss they can be associated with a number of side effects and complications. Minor side effects include headache, fatigue, dizziness, constipation, nausea, diarrhea, hair loss, and cold intolerance. Serious complications include volume depletion and cholelithiasis (178 [EL4, NE]; 273 [EL4, NE]; 275 [EL4, NE]; 276 [EL1, MRCT]). Studies have shown that 10 to 25% of people on VLCMPs will develop gallstones, and some will eventually require surgery (178 [EL4, NE]; 292 [EL3, CCS]).

Due to the side effect profile, lack of superiority data, and need for special monitoring and supplementation, an expert panel convened by the National Heart, Lung, and Blood Institute (NHLBI) did not recommend the use of VLCMPs over LCMPs (178 [EL4, NE]; 273 [EL4, NE]). In the limited circumstances where VLCMPs are needed, the duration of treatment should not exceed 12 to 16 weeks (178 [EL4, NE]; 273 [EL4, NE]).

Medical Nutrition Therapy for Long-Term Weight Management

The ideal macronutrient composition of the meal plan for weight loss and weight maintenance is still being debated. Although consensus was seemingly established around the efficacy and desirability of a low-fat meal plan, the growing epidemic of obesity has caused considerable concern and interest (229 [EL4, NE]; 293 [EL3, SS]). Additionally, inherent advantages of different diets, such as the Mediterranean diet (rich in MUFAs), Asian diets (rich in vegetable proteins), European diets (including alcohol and saturated fat), and the America Diet (lower in fat) are being considered. In the longer term, healthy eating should focus on weight maintenance and the prevention of weight gain (or regain). This focus allows for health maintenance and prevention of exacerbation of obesity.

In an analysis of the PREMIER trial, a large, multicenter weight-loss study utilizing the DASH meal plan and behavioral interventions, those participants in the highest tertile of meal plan energy density change (i.e., greatest energy density reduction) lost more weight than those in the middle and lowest tertiles of energy density change (5.9 kg vs. 4.0 and 2.4 kg, respectively) at 6 months (294 [EL1, RCT]). Lowering the energy density of the meal plans corresponded with an increased intake of fruits, vegetables, minerals, and vitamins in the highest energy density change tertile (294 [EL1, RCT]). Compared to a typical low-fat meal plan (<30% calories from fat), incorporating more fruits and vegetables into a low-fat meal plan resulted in a more rapid weight loss after 6 months (6.7 ± 0.7 kg vs. 8.9 ± 0.8 kg) and more weight loss at 12 months (6.4 ± 0.9 kg vs. 7.9 ± 0.9 kg) in a free-living study (295 [EL1, RCT]).

During the active weight-reduction phase, the greatest impact of a meal plan is the total energy deficit (kcal/day). During the longer-term weight maintenance phase, the macronutrient composition of meals (particularly low fat and high carbohydrate) may provide extra benefits. Small cumulative effects (~30 kcal/day) of calories by such subtle changes as the thermic effect of food eaten will have a significant impact on weight maintenance over time (296 [EL4, NE]).

Sustaining weight loss for over 1 year has proven to be difficult in many large weight-loss trials. According to a meta-analysis of 80 trials of at least 1 year in duration, participants lost an average of 5 to 8.5 kg in the first 6 months and then reached a weight plateau (304 [EL1, MRCT]). At 48 months, an average of 3 to 6 kg of weight lost was maintained. Strategies focusing on food intake, such as a LCMP and meal replacements, increased physical activity, and medications with nutrient changes (i.e., orlistat) were the most successful strategies for losing weight and maintaining the weight loss (304 [EL1, MRCT]).

The American Dietetic Association recently published the 2009 Weight Management Position Paper, which reviewed the current evidence on weight-management interventions (261 [EL4, NE]). The position paper used an "Evidence Analysis Process" to identify effective nutritional strategies for weight management. Because there is much confusion regarding which strategies are most effective, they are discussed below:

- Having patients focus on reducing carbohydrates rather than reducing calories and/or fat may be a successful short-term strategy for some individuals. Reducing carbohydrate intake to <35% of kcal consumed results in reduced energy intake and is associated with a greater weight- and fat-loss during the first 6 months. These results were not significant after 1 year (260 [EL4, NE]; 261 [EL4, NE]). The use of low-carbohydrate meal plans should be evaluated in patients with osteoporosis, kidney disease, and patients with increased LDL-C (261 [EL4, NE]).
- A low-GI meal plan is not recommended for

weight loss or weight maintenance (260 [EL4, NE]; 261 [EL4, NE]). However, the overarching recommendations to eat more fresh fruits and vegetables and less processed foods, mainly starches and sugars, is effectively a recommendation to consume lower GI carbohydrates in the meal plan.

- 3 to 4 servings of low-fat dairy foods should be included to meet daily nutritional needs (261 [EL4, NE]).
- Portion control should be included as part of a comprehensive weight-management program (261 [EL4, NE]).
- Total caloric intake should be distributed throughout the day, with the consumption of 4 to 5 meals/snacks per day, including breakfast. Greater energy intake during the day is preferable to evening overconsumption and night grazing behaviors (261 [EL4, NE]).
- For people who have difficulty with self-selection and/or portion control, meal replacements (e.g., liquid meals, meal bars, or calorie-controlled packaged meals) may be used as part of the meal planning in a comprehensive weight-management program. Substituting 1 or 2 daily meals or snacks with meal replacements is a successful weight-loss and weight-maintenance strategy (261 [EL4, NE]; 297 [EL1, RCT]; 298 [EL1, RCT]; 299 [EL1, RCT]).
- Healthy eating, which includes an approach involving small changes to prevent weight gain or regain and achieve long-term weight maintenance, is recommended (300 [EL4, NE]).

As American adults continue to steadily gain small amounts of weight over time (1 to 2 pounds or ~0.6 kg/year), health consequences and medical costs associated with obesity steadily rise (301 [EL4, NE]). The emphasis on the prevention of weight gain offers new challenges for patients with overweight and obesity (302 [EL4, NE]). Meal planning is an effort to prevent the progression to obesity and/or exacerbation of the obese state. It was evident from the follow-up on 2,788 subjects in the CARDIA study identified as weight maintainers (able to maintain their weight within 5 pounds over 15 years) that baseline weight status did not appear to influence the size or direction of the risk factor changes (303 [EL2, PCS]; 304 [EL3, CSS]).

4.Q3. What Nutritional Recommendations are Appropriate for Cardiovascular Health?

Poor nutrition plays a role in the progression of CVD, while healthy eating decreases CVD risk. Nutritional intervention to prevent CVD targets multiple risk factors. In contrast, pharmaceutical interventions typically target a single risk factor (305 [EL4, NE]).

4.Q3.1 Nutritional Strategies for Excess Fat Mass and Adiposopathy

Overweight and obesity (defined as a BMI of 25 to 29.9 kg/m^2 and >29.9 kg/m^2, respectively) are major risk factors for CVD and the development of dyslipidemia and hypertension (178 [EL4, NE]). The RR of overweight and obese individuals developing CVD within the next 10 years is increased by 70 and 120%, respectively, as compared to a normal-weight individual. However, the 1999-2002 NHANES data document that at a BMI of 40 kg/m^2 or higher, 72.7% of patients do not have DM, 48.7% of patients do not have hypertension, and 37.5% of patients do not have dyslipidemia. On the other hand, at a BMI between 18.5 and 25 kg/m^2, defined as normal-lean, 4.2% of patients have DM, 17.6% have hypertension, and 38.2% have measurable dyslipidemia (306 [EL4, NE]; 307 [EL3, SS]). Intra-abdominal or visceral fat accumulation, defined as a waist circumference ≥102 cm for men and ≥88 cm for women, is a component of adiposopathy, is more strongly associated with metabolic dysregulation than BMI, and is a criterion for diagnosing dysmetabolic syndrome (Tables 16 and 17) (48 [EL4, NE]). Due to the severity of the obesity epidemic and its subsequent effects on CVD risk, the U.S. Department of Health and Human Services declared that one of the top national health goals of the next decade is to "increase the proportion of adults who are at a healthy weight" (308 [EL4, NE]).

Decreasing body weight by 10% improves risk factors for CVD and other chronic diseases (178 [EL4, NE]). Every kilogram of reduction in body weight results in a 2.28 mg/dL decrease in TC, a 0.91 mg/dL decrease in LDL-C, and a 1.54 mg/dL decrease in TGs, according to a meta-analysis of 70 trials (259 [EL1, MRCT]; 309 [EL4, NE]). In a meta-analysis of 25 trials, a loss of 5.1 kg resulted in reductions in average SBP of 4.4 mm Hg and DBP of 3.6 mm Hg (310 [EL1, MRCT]). In addition, 5 to 10% weight loss improves fasting glucose and A1c (309 [EL4, NE]) and markers of inflammation (specifically interleukin [IL]-6, IL-18, and C-reactive protein) (311 [EL1, RCT]).

Energy expenditure is an important component of maintaining a healthy weight and lowering CV risk. The 2008 Physical Activity Guidelines for Americans recommends at least 150 minutes of moderate physical activity or 75 minutes of vigorous physical activity per week, as well as muscle-strengthening activities at least twice per week for health benefits (312 [EL4, NE]). While many factors besides nutrition affect obesity and CVD risk, the focus of this section is on the impact of optimal nutrient intake in the form of foods—in the context of an appropriate caloric intake—on chronic disease events, status, and risk factors.

4.Q3.2 Nutritional Strategies for Dyslipidemia

Carbohydrates and fat intake affect plasma lipid profiles and thus must be considered in the treatment of

Table 16
Classifications of Overweight and Obesity by BMI, Waist Circumference, and Associated Disease Risks

			Disease risk relative to normal weight and waist circumference	
	BMI, kg/m^2	Obesity class	Men ≤102 cm, Women ≤88 cm	Men >102 cm, Women >88 cm
Underweight	<18.5	---	---	---
Normal	18.5-24.9	---	---	---
Overweight	25.0-29.9	---	Increased	High
Obesity	30.0-34.9	I	High	Very high
	35.0-39.9	II	Very high	Very high
Extreme obesity	≥40	III	Extremely high	Extremely high

Abbreviation: BMI = body mass index.
Adapted from: National Heart, Lung, and Blood Institute. Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults: The Evidence Report. 1998, National Institutes of Health. No. 98-4083. Bethesda, MD.

dyslipidemia (Tables 18 and 19) (313 [EL4, NE]; 314 [EL1, RCT]).

Saturated fat intake increases LDL-C and HDL-C; *trans* fat intake increases LDL-C and decreases HDL-C compared with saturated fat; MUFA intake does not significantly raise or lower lipid levels; and PUFA intake has beneficial effects on lipid values (i.e., omega-6 PUFAs lower LDL-C and omega-3 PUFAs decrease TGs and may increase HDL-C) (85 [EL1, MRCT]; 313 [EL4, NE]). Lowering both total and saturated fat intake in a step-wise fashion (calories from total fat 37%, 30%, 26%; from saturated fatty acids 16%, 9%, 5%) while holding MUFAs and PUFAs constant elicits dose-dependent decreases in LDL-C and HDL-C (315 [EL1, RCT]). Lowering saturated and *trans* fatty acids and replacing these with MUFAs and PUFAs decreases CVD risk (63 [EL2, PCS]).

Carbohydrates typically replace fats in low-fat meal plans. However, low-carbohydrate meal plans (<60 g of carbohydrate per day) have a more favorable effect on TGs and HDL-C and a less favorable effect on TC and LDL-C when compared to traditional low-fat meal plans (316 [EL1, MRCT]). In a meta-analysis of RCTs comparing these two types of meal plans, a low-carbohydrate

Table 17
Clinical Identification of Dysmetabolic Syndrome as Defined by the National Cholesterol Education Program, Adult Treatment Panel III

Dysmetabolic syndrome characteristic	Classification levels
Abdominal obesity (as determined by waist circumference)	Men >102 cm (>40 in)
	Women >88 cm (>35 in)
Triglycerides	≥150 mg/dL
HDL-C	Men<40 mg/dL
	Women<50 mg/dL
Blood Pressure	≥130/85 mm Hg
Fasting glucose	≥110 mg/dL

Abbreviation: HDL-C = high-density-lipoprotein cholesterol.
Adapted from: National Heart Lung and Blood Institute. National Cholesterol Education Program. Third Report of the Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). 2002, National Institutes of Health No. 02-5215. Bethesda, MD.

Table 18
CVD Risk Stratification Based on Lipid Profile Recommended by the National Cholesterol Education Program, Adult Treatment Panel III

Classifications for lipid levels	LDL-C level (mg/dL)	Total cholesterol (mg/dL)	HDL-C level (mg/dL)	Triglycerides (mg/dL)	Lifestyle modifications	Drug therapy
Optimal	<100	<200	≥60	≤150	Encouraged	No[a]
Intermediate	100-130 (Borderline high) 130-159 (High)	200-239			Yes, with 2+ risk factors or CHD equivalents	Yes ≥130 mg/dL with 2+ risk factors ≥160 mg/dL with 0-1 risk factors
Increased CVD risk	≥160	≥240	<40	≥150	Yes, with at least 0-1 risk factors	Yes

Abbreviations: CHD = coronary heart disease; CVD = cardiovascular disease; HDL-C = high-density-lipoprotein cholesterol; LDL-C = low-density-lipoprotein cholesterol.
[a] Statins have shown to decrease risk of CVD mortality even in those with intermediate LDL-C levels (<130 mg/dL) but with elevated inflammatory status (C-reactive protein >2.0 mg/L)
Adapted from: National Heart, Lung, and Blood Institute. National Cholesterol Education Program. Third Report of the Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). 2002, National Institutes of Health No. 02-5215. Bethesda, MD.

meal plan resulted in greater weight loss at 6 months (3.3 kg) (but not at 12 months) and improved TG and HDL-C values (–22.1 mg/dL and +4.6 mg/dL, respectively). However, the low-fat meal plan was more effective in lowering LDL-C (–5.4 mg/dL). There were no differences in BP between the two meal plan types. Additionally, the low-carbohydrate meal plans did not require energy restriction, unlike the low-fat meal plans (316 [EL1, MRCT]). A meal plan that is >20% simple carbohydrates (see "Healthy Sources of Carbohydrates" section) can increase VLDL-C and decrease lipoprotein lipase activity, which contributes to increased TGs (314 [EL1, RCT]; 317 [EL1, RCT]). Increased TG levels are often accompanied by decreased HDL-C, which negatively affects atherosclerosis, as HDL-C removes cholesterol from peripheral cells (316 [EL1, MRCT]). Meals high in complex carbohydrates (see "Healthy Sources of Carbohydrates" section) compared with simple carbohydrates, such as DASH and vegetarian meals, raise TGs and lower HDL-C less, while still decreasing LDL-C due to high levels of viscous fiber (48 [EL4, NE]; 318 [EL4, NE]).

The primary nutritional strategy recommended for lowering LDL-C (and CVD risk) is the TLC meal plan, developed by the NCEP ATP III (48 [EL4, NE]). The meal plan is as follows (% values are of total daily calories): 25 to 35% total fat, ~15% total protein, 50 to 60% total carbohydrate, <7% saturated fat, <200 mg/day of cholesterol intake, low *trans* fat intake, up to 10% PUFAs, up to 20% MUFAs, and 20 to 30 g/day of fiber. Foods and nutrients that decrease serum cholesterol, such as viscous fiber (5 to 10 g/day) and plant sterols and stanols (2 g/day), are also recommended to enhance LDL-C lowering (Table 19) (48 [EL4, NE]; 98 [EL1, RCT]). This meal plan pattern is consistent with the AHA nutrition guidelines, and the recommended number of servings per day by food group is displayed in Table 6.

The Mediterranean dietary pattern is recommended for individuals with dysmetabolic syndrome (48 [EL4, NE]). In a review of treatments for dysmetabolic syndrome, the Mediterranean meal plan resulted in resolution of the disease (having <3 characteristics) in 25% of participants as compared to drugs (19%, metformin, rimonabant, rosiglitazone) or surgery (93%, laparoscopic and gastric bypass) (319 [EL4, NE]).

4.Q3.3 Nutritional Strategies for Hypertension

Hypertension is a major risk factor for CVD (Table 20). In 1996, obesity was estimated to cause 30 to 65% of diagnosed hypertension cases in Western countries (320 [EL4, NE]). For every 10-kg increase in body weight, SBP increases 2 to 3 mm Hg and DBP rises 1 to 3 mm Hg. Likewise, losing ~5 kg of body weight can decrease SBP by 4.4 mm Hg and DBP by 3.6 mm Hg (310 [EL1, MRCT]; 320 [EL4, NE]). Excess body weight clearly affects hypertension status. However, the composition of meals apart from calorie intake can play a significant role in causing and treating hypertension as well (49 [El4, NE]).

In the absence of weight loss, the DASH dietary pattern lowers BP significantly in both hypertensive and normotensive individuals (61 [EL1, RCT]). A dose-dependent

Table 19
Approximate and Cumulative LDL-C Reduction Achievable by Nutritional Modification

Modification	Recommendation	Approximate LDL-C reduction (range)
Major		
Decrease saturated fat intake (processed meats and commercial baked goods)	<7% of total calories	8-10%
Decrease dietary cholesterol intake (processed meats, egg yolk)	<200 mg per day	3-5%
Weight reduction	Loss of 4.5 kg	5-8%
Other LDL-C lowering options		
Increase viscous fiber intake (whole grains, fruits, vegetables, nuts)	5-10 g/day	3-5%
Increase plant sterol and stanol esters intake (modified margarines, whole grains, fruits, vegetables, nuts)	2 g/day	6-15%
Cumulative Estimate		**20-30%**

Abbreviation: LDL-C = low-density lipoprotein cholesterol.
Adapted from: National Heart, Lung, and Blood Institute. National Cholesterol Education Program. Third Report of the Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). 2002, National Institutes of Health No. 02-5215. Bethesda, MD.

relationship between salt intake and BP has been established by epidemiologic studies (321 [EL3, SS]) and RCTs (322 [El1, RCT]). The DASH-Sodium Collaborative Research Group assessed the effects of salt reduction on BP within the context of the DASH meal plan (322 [El1, RCT]). Similar to the DASH study, participants (n = 412) were generally healthy and prehypertensive or stage 1 hypertensive (120 to 159 mm Hg SBP, 80 to 95 mm Hg DBP). Each participant was assigned to either the DASH dietary pattern or a control meal plan for the entire study. Salt (NaCl) intake differed (high, 3,300 mg/day; medium, 2,300 mg/day; and low, 1,500 mg/day). The DASH dietary pattern decreased BP compared to the control meal plan (high salt intake, –2.9 mm Hg difference in DBP). Salt reduction, regardless of meal plan, also reduced BP in a dose-dependent manner (control and DASH changes in DBP: high to intermediate salt, –1.1 and –0.6 mm Hg; intermediate to low salt: 2.4 and –1.0 mm Hg). Therefore, decreasing sodium intake to 1,500 mg/day can provide additional benefits to a BP-lowering meal plan (high in fruits and vegetables and low-fat dairy products).

The current recommendations for treating hypertension according to the Seventh Report of the Joint National Committee (JNC7) on Prevention, Detection, Evaluation,

Table 20
Classification and Lifestyle Modification Management of BP for Adults

BP classifications	SBP mm Hg	DBP mm Hg	Lifestyle modification	Drug therapy
Normal	<120	And <80	Encourage	No (unless compelling indication)
Prehypertension	120-139	Or 80-89	Yes	No (unless compelling indication)
Stage 1 hypertension	140-159	Or 90-99	Yes	Yes
Stage 2 hypertension	≥160	Or ≥100	Yes	Yes

Abbreviations: BP = blood pressure; DBP = diastolic blood pressure; SBP = systolic blood pressure.
Adapted from: National Heart Lung and Blood Institute. Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC7). 2004, National Institutes of Health, No. 04-5230. Bethesda, MD.

and Treatments of High Blood Pressure are: weight reduction, adopt a DASH meal plan, sodium intake reduction, increase physical activity, and moderate alcohol consumption (Table 21) (323 [EL4, NE]). In addition, focusing on increasing potassium intake via fruits and vegetables may contribute to further blood pressure lowering (Table 21) (49 [El4, NE]).

4.Q4. What Nutrient Sources Should Be Limited for Cardiovascular Health?

Current intakes of macronutrients are within recommended ranges, but the overall meal plans of many Americans fall short of being viewed as "healthy" (324 [EL4, NE]). Adults consume 49.9% of calories from carbohydrates (recommended, 45 to 65%), 15.4% from protein (recommended, 10 to 35%), and 33.6% from fat (recommended, 20 to 35%). Furthermore, intake of MUFAs and PUFAs is 12.3% (recommended, 10 to 20%) and 7.0% (recommended, 5 to 10%) of calories, respectively (325 [EL3, SS]). All other recommendations for healthy eating are not achieved by the current American meal plan. Saturated fat intake is 11.4% of total calories (recommended <7%) and usual sodium intake is 1,554 mg/1,000 calories (recommended, 1,500 mg/day), equating to at least double the sodium intake recommendation (325 [EL3, SS]; 326 [EL3, SS]). Liquid calories (i.e., SSBs and alcohol) contribute 5.5 and 2.4% of calories (325 [EL3, SS]; 327 [EL3, SS]). According to intake data from 1994-2002, only 28 and 32% of adults met USDA fruit (≥2 servings/day)

Table 21
Approximate SBP Reduction Achievable by Lifestyle and Intake Modifications

Modification	Recommendation	Approximate SBP reduction (range)
Weight reduction	Maintain normal body weight (BMI: 18.5-24.5 kg/m^2)	5-20 mm Hg/10 kg (or 22 lb.) weight loss
Adopt DASH meal plan	Consume meals rich in fruits, vegetables (8-10 serv/d), and low-fat dairy products (3-4 serv/day) with reduced content of total and saturated fat	8-14 mm Hg
Sodium intake reduction	Reduce sodium intake as much as possible, ideally to ~65 mmol (1,500 mg sodium or 3.8 g sodium chloride) per day[a]	2-5 mm Hg[a]
Potassium intake increase	Increase potassium intake to 120 mmol (4,700 mg) per day, which is provided in DASH-type diets	2-5 mm Hg[b]
Physical activity	Engage in 150 minutes of moderate intensity (brisk walking) or 75 minutes of vigorous intensity (running) physical activity per week	4-9 mm Hg[c]
Moderate alcohol consumption	For those who consume alcohol, consume ≤2 drinks for men and ≤1 drink for women per day	2-4 mm Hg

Abbreviations: BMI = body mass index; DASH = dietary approaches to stop hypertension; SBP = systolic blood pressure.
[a] Updated sodium recommendation from AHA, 2006; corresponding BP decrease approximate.
[b] Potassium intake recommendation added by AHA, 2006; corresponding BP decrease approximate.
[c] Updated physical activity recommendations from 2008 Physical Activity Guidelines for Americans; corresponding BP decrease approximate.
Appel LJ, et al. Dietary approaches to prevent and treat hypertension: a scientific statement from the American Heart Association. *Hypertension*. 2006;47:296-308.
United States Department of Health and Human Services. Physical Activity Guidelines for Americans. 2008, Government Printing Office, Washington, DC.
Adapted from: National Heart, Lung, and Blood Institute. Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC7). 2004, National Institutes of Health, No. 04-5230. Bethesda, MD.

and vegetable (>3 servings/day) recommendations, respectively, and less than 8% met whole-grain intake recommendations (3 servings/day) (328 [EL3, SS]; 329 [EL3, SS]). Not surprisingly, intakes for potassium and fiber were not adequate, at ~2,435 to 3,223 mg/day (recommended, 4,700 mg/day) and ~14 to 18 g/day (recommended, 14 g/1,000 kcal), respectively (64 [EL4, NE]).

Nearly 2,400 American adults die each day from CVD, and 1 in 5 deaths can be attributed to CHD (330 [EL4, NE]). While some risk factors for CVD have improved over the last 50 years, the prevalence of obesity and DM has increased to at least 34.3 and 15.3% of Americans and continues to rise (330 [EL4, NE]). Healthy eating has the potential to reduce the prevalence and burden of chronic disease in American society.

Added Sugars

Soft drinks and SSBs are the greatest contributors of added sugars to meals (318 [EL4, NE]). At most, 450 calories (36 ounces) per week of SSBs can be consumed for those eating a 2,000-calorie per day meal plan (45 [EL4, NE]; 318 [EL4, NE]). Many healthful foods, such as fruits and dairy products, have intrinsic sugars and are not restricted.

The consumption of added sugars has increased with the growing popularity and affordability of SSBs; however, the magnitude of the effect that SSBs has on the obesity epidemic is not clear due to limitations of epidemiologic evidence and the fact that RCTs are not a viable option (331 [EL2, MNRCT]). In epidemiologic studies, any full-sugar soft drink consumption is linked to greater energy intake, higher body weight, lower intake of other nutrients, and poor indices of health status (332 [EL2, MNRCT]).

Increased intake of simple sugars adversely affects TGs and HDL-C (see section 4.Q3.2) and may increase BP; however, the evidence is inconclusive. Analysis of a cohort from the Framingham Heart Study demonstrated that consumption of ≥1 soft drink per day increased the risk of developing high BP. However, the relationship between obesity and BP confound conclusions about the association between sugar intake and BP (333 [EL3, SS]).

Excess Salt

Salt is added to processed foods to improve taste and also to preserve foods for a longer shelf life. A majority of salt in foods is "hidden," making it difficult to reduce intake to meet current recommendations for salt (49 [El4, NE]). BP is affected by the amount of salt intake, although some individuals are more sensitive to salt than others (i.e., African Americans, older persons, and individuals with pre-existing hypertension, DM, and CKD) (49 [El4, NE]).

A significant, positive, independent association between sodium intake and SBP was determined from the INTERSALT study, an international epidemiologic study of over 10,000 participants assessing the relationship between 24-hour urinary salt excretion and BP (321 [EL3, SS]). A dose-dependent response to salt intake on BP has been established in the DASH-Sodium trial (see section 4.Q3.3) (322 [El1, RCT]). In 2001, the IOM set an adequate intake at 1,500 mg/day to ensure nutrient adequacy, which is a level that also decreases BP in hypertensive individuals (322 [El1, RCT]). Therefore, 1,500 mg/day of salt is considered safe and is shown to be cardioprotective. Limiting salt intake to <1,500 mg/day is a primary goal for CVD prevention and treatment (45 [EL4, NE]).

The 2010 Dietary Guidelines for Americans recommend a sodium intake of <2,300 mg/day and a potassium intake of >4,700 mg/day with implementation of a DASH-type meal plan. Sodium intake should be reduced to <1,500 mg/day for people age 51 years and older and all people who are African American, regardless of age, those who have hypertension, DM, or CKD (64 [EL4, NE]).

Saturated Fats, Trans Fats, Processed Meats, and Commercially Baked Goods

Decreasing saturated fat intake to reduce LDL-C levels has long been the main focus of CVD prevention. The Dietary Guidelines Advisory Committee states that "there is strong evidence to support that increased saturated fat intake is positively associated with the etiology of CVD via LDL-C and insulin resistance." Furthermore, replacing 5% of energy from saturated fat with MUFAs or PUFAs will reduce the risk of CVD and T2DM in healthy adults (64 [EL4, NE]).

Reducing intake of both red and processed meats is often recommended for CVD prevention due to the high levels of saturated fat in some meats and as a result of previous epidemiologic findings relating intake with increased risk of CVD (334 [EL2, PCS]). However, in separating the effects of processed and red meat in a systematic review and meta-analysis of five large, epidemiologic studies, red meat intake (i.e., steak or pork at 100 g/day) was not associated with incident CHD (RR, 1.00; 95% CI, 0.81-1.23), while processed meat intake (i.e., processed beef, hotdogs, or deli meat at 50 g/day) was directly associated with incident CHD (RR, 1.42; 95% CI, 1.07-1.89) (335 [EL2, MNRCT]). Thus, processed meat intake should be limited to none or ≤2 servings per week (45 [EL4, NE]). Lean or very lean cuts of red meat should be chosen instead in order to achieve saturated fat recommendations.

What replaces saturated fat in the meal plan has proven to be very important. A meta-analysis of 21 prospective cohort studies reported that saturated fat intake was not significantly correlated with CHD (RR, 1.07; 95% CI, 0.96-1.19), stroke (RR, 0.81; 95% CI, 0.62-1.05), or CVD outcomes (RR, 1.00; 95% CI, 0.89-1.11) (336 [EL2, MNRCT]). Replacement of saturated with unsaturated fats decreases risk for CVD outcomes. On the other hand, substituting saturated fat with refined carbohydrates has the same CVD risk outcome (337 [EL4, NE]). Without

considering the foods that replace saturated fat in the meal plan, CVD risk may not be improved by saturated fat reductions.

Epidemiologic and prospective cohort studies rely on dietary assessment data, which is prone to regression dilution bias and measurement error. This is the likely explanation for null results of observational studies that do not relate saturated fat intake with CVD outcomes (338 [EL1, MRCT; EL2, MNRCT]). Conversely, RCTs, such as Oslo Diet Heart, Veteran Affairs, and Finnish Mental Hospital, have demonstrated consistently the decreased risk of mortality from decreasing saturated fat intake and increasing PUFA intake (338 [EL1, MRCT; EL2, MNRCT]). Intervention studies have shown that replacing saturated fat with PUFAs significantly decreases LDL-C and reduces risk for CVD mortality (48 [EL4, NE]; 336 [EL2, MNRCT]). Based on both a strong evidence base and the emerging data with regards to fats, intake should be shifted towards greater intake of unsaturated fats.

Refined Grains

Refined grains are produced by removing the germ and bran from the seed in processing. The resulting product is high in energy and B-vitamins and low in fiber and phytochemicals. The fortification of grains in the United States with iron, niacin, thiamin, riboflavin, folate, and calcium, however, has made micronutrients highly bioavailable in refined grains. Dietary patterns that include a high intake of refined grains increase risk for CVD, cancer, or all-cause mortality (339 [EL2, PCS]). Increased refined grain intake is independently associated with increased plasma plasminogen activator inhibitor type 1, a marker of chronic inflammation (340 [EL3, CSS]). Because of a lack of fiber and an abundance of readily absorbable sugars, refined grains are problematic for individuals with insulin resistance or DM.

The Nurses' Health Study reported that individuals who consumed 3 servings per day of refined grains had 53% increased risk of incident coronary artery disease (hazard ratio [HR], 1.53; 95% CI, 1.13-2.06), and 5 servings per day was associated with 34% increased risk of overall mortality (HR, 1.34; 95% CI, 1.04-1.72) in unadjusted models. Refined grain intake also was significantly associated with overall poorer meal planning and unhealthy behaviors, which could explain the association (341 [EL2, PCS]). In the fully adjusted models, whole-grain intake of 1 serving per day resulted in 20% decreased risk for overall mortality (HR, 0.80; 95% CI, 0.65-0.99), and 1.5 servings per day was associated with 27% decreased risk for incident CHD (HR, 0.73; 95% CI, 0.55-0.98). Few RCTs have evaluated the effects of refined grains on CVD risk factors. Assessing the contribution of refined grains to chronic disease is challenging because whole grains often replace refined grains, which beneficially affect CVD risk factors. More research is warranted to determine which effect is more important for health outcomes—decreasing refined grain intake or increasing whole grain intake.

4.Q5. What Nutritional Recommendations are Appropriate for Diabetes Mellitus?

How are healthy eating recommendations affected by the presence of DM? If the definition of nutrition is based on the interaction between ingested food and metabolism, then in order to address this question, specific healthy eating strategies should be based upon the key metabolic features of DM (Table 22). Healthy eating, which relates to basic nutritional principles and education, differs from MNT, which is an essential component of comprehensive DM management programs. MNT is more sophisticated than healthy eating, is typically provided by a health care professional experienced with DM management, and is directly coordinated with physician-directed medical therapy (342 [EL4, NE]; 343 [EL4, NE]). Evidence-based recommendations for MNT have been previously published and serve as the basis for many of the recommendations offered in the Executive Summary of this CPG (9 [EL4, NE]; 342 [EL4, NE]; 344 [EL4, NE]; 345 [EL4, NE];

Table 22
Correlation of Pathophysiological Changes in DM with Specific Nutritional Strategies

Disease component	Dietary strategy
Beta-cell dysfunction	Avoid excessive carbohydrate Delay intestinal carbohydrate absorption
Insulin receptor signaling defect	Attain and maintain a normal BMI
Dyslipidemia	Limit saturated fat
Risk for nephropathy	Avoid excessive protein, phosphate, salt, and potassium depending on the CKD risk level and stage
Accelerated atherosclerosis	Incorporation of healthy eating with overall lifestyle changes, including physical activity

Abbreviations: BMI = body mass index; CKD = chronic kidney disease.

346 [EL4, NE]). This section complements these previous reports on MNT by providing basic recommendations about healthy eating that physicians can provide to their patients with DM.

4.Q5.1 Patient Education in the Management of Diabetes Mellitus

In a case-controlled study of Latin women, as adjusted for socioeconomic confounders, those with T2DM who had consulted with a RD or CDE exhibited greater nutritional knowledge and adhered to healthier meal plans. This included greater understanding of food labels, increased intake of fruits, vegetables, lean meats, and artificial sweeteners and less intake of soft drinks and salty snacks (347 [EL2, RCCS]). A review of similar trials on education, including 6 RCTs, documented the benefits of MNT (348 [EL1, MRCT]).

4.Q5.2 Caloric and Protein Intake

Contrary to suggestions that patients with T2DM have impaired muscle protein synthesis, in patients with long-standing T2DM treated with oral medications, muscle protein synthesis is essentially normal following carbohydrate or carbohydrate plus protein ingestion (349 [EL1, RCT]). The controversy surrounding the benefits of high-protein/low-carbohydrate (HP/LC) meals has been recently reviewed (350 [EL4, NE]; 351 [EL4, NE]). Several observational studies involving patients with T2DM demonstrated short-term improvements with HP/LC meals on weight (with decreased appetite), other CVD risk factors, glucose tolerance, and A1c levels (352 [EL2, NRCT]; 353 [EL1, RCT]; 354 [EL2, NRCT]; 355 [EL2, NRCT]; 356 [EL1, RCT]). In addition, the source of ingested protein and the nature of the accompanying fat appear to affect markers of inflammation and metabolic risks. For instance, consumption of red meat increases (357 [EL3, CSS]) and consumption of cod protein decreases (358 [EL2, NRCT]) markers of inflammation and metabolic risk factors.

One of the HP/LC interventions is referred to as a "low biologically available glucose" (LoBAG) diet and is composed of 30% protein, 40 to 50% fat, and 20 to 30% carbohydrate (compared to a control meal plan of 15% protein, 30% fat, and 55% carbohydrate). In effect, a LoBAG dietary intervention contains very little starch (composed entirely of glucose molecules) or sucrose (composed of 50% glucose). LoBAG significantly improves glycemic control in the short term (weeks of intervention). The long-term effects and general applicability of increasing protein and fat content at the expense of carbohydrate remain to be determined, especially with regard to renal function and bone health (359 [EL1, RCT]; 360 [EL1, RCT]). A joint committee of the American Diabetes Association (ADA), North American Society for the Study of Obesity (now TOS), and American Society for Clinical Nutrition recommended individualized dietary guidance primarily targeting weight loss and maintenance and not favoring one meal plan over another based on macronutrient content (361 [EL4, NE]).

4.Q5.3 Carbohydrate Intake

Consuming less than 45% energy as carbohydrate is generally associated with insufficient ingestion of fiber and excessive ingestion of fat, leading to increased risk for CVD. On the other hand, consuming greater than 65% energy as carbohydrate is generally associated with insufficient intake of fat and protein. A meal plan rich in fruits and vegetables, including legumes, was associated with reduced all-cause and CV (but not cancer) mortality in a European diabetic population (362 [EL2, PCS]). From the standpoint of carbohydrate counting, foods containing >5 g of fiber or sugar alcohol should have half of their grams (corresponding to the approximate insoluble fiber content) subtracted from the total carbohydrate grams in the meal for computing insulin boluses (363 [EL4, NE]).

Patients with DM treated with insulin should synchronize insulin dosing with carbohydrate intake (364 [EL1, RCT]; 365 [EL1, RCT]; 366 [EL1, RCT]; 367 [EL1, MRCT]; 368 [EL1, MRCT]; 369 [EL1, RCT]; 370 [EL1, RCT]). Patients with T2DM treated with short-acting oral hypoglycemic agents (nateglinide, repaglinide) should also synchronize carbohydrate intake with administration of these medications (371 [EL1, RCT]; 372 [EL1, RCT]; 373 [EL1, RCT]).

Hypoglycemia and hypoglycemia unawareness are significant problems for the patient with T2DM on hemodialysis (374 [EL3. CCS]; 375 [EL4, NE]). These patients should be routinely queried regarding their eating habits, home glucose monitoring, and frequency and severity of hypoglycemia and then offered specific management options centered on matching treatment with the carbohydrate content of meals.

Sugar intake in patients with early T2DM is associated with a polymorphism in the glucose transporter type 2 (GLUT2) gene (376 [EL2, NRCT]). In addition, meals with a high sugar content lead to short-term regulatory events involving intestinal receptors, incretin production, and other metabolic sensing pathways that traffic GLUT2 to the enterocyte apical membrane (377 [EL4, NE]). These recent discoveries and novel systems biology models raise new possibilities for novel nutritional, pharmacologic, or biologic therapies in DM care.

4.Q5.4 Fat Intake

Total Fat

There are significant numbers of patients with DM failing to meet the recommendations for intake of saturated fat and fiber (378 [EL3, CSS]). Interventions and education programs directed toward these two nutrition components should be aggressively developed. For example, added

fruit, specifically strawberries, can improve the palatability of a cholesterol-lowering meal plan and reduce oxidative damage to LDL particles (379 [EL1, RCT]).

Trans fat

Trans fats have been emphatically admonished as a nutritional component. There is a positive relationship between increasing *trans* unsaturated fatty acid ingestion and an adverse lipid profile in the general population. This translates into an increased risk of CHD, but data are from heterogeneous and limited case-controlled and cohort studies. The possible relationship between consumption of *trans* fatty acids and increased risk of insulin resistance, or the development of T2DM, is also based on limited observational trials. However, recent data suggest that there is a high incidence of T2DM in peroxisome proliferator-activated receptor gamma-2 Pro12Ala carriers exposed to a high chronic intake of *trans* fatty acids. Therefore, there may be some genetically susceptible populations for whom restriction of *trans* fatty acids may be indicated. In this CPG, the evidence against the use of *trans* fat in the general population is applied to the subset of patients with DM (380 [EL3, SCR]; 381 [EL4, NE]; 382 [EL4, NE]).

4.Q5.5 Other Recommendations

Glycemic Index

The premise for recommending a low-GI or low-glycemic-load (GL) meal plan in the management of DM is based on (a) the theoretical advantage of foods that do not raise serum glucose excessively after ingestion, and (b) the focus on the amount of carbohydrate ingestion, since protein ingestion is relatively fixed and total fat is often low. Indeed, synchronization of mealtime carbohydrate ingestion can improve postprandial glucose (PPG) excursions. In T2DM, PPG >140 mg/dL has a major impact on A1c when A1c is <7.3%. Therefore, PPG becomes a treatment target at lower A1c values (383 [EL4, NE]).

A low-GI meal plan reduces A1c 0.5% compared with high cereal fiber intake, which leads to an A1c reduction of only 0.18% ($P<.001$) (384 [EL1, RCT]). In a study of patients with T2DM receiving high-carbohydrate/high-GI, high-carbohydrate/low-GI, or low-carbohydrate/high-MUFA meals for 1 year, a low-GI meal plan improved beta-cell function compared with a low-carbohydrate/high-MUFA meal plan (385 [EL1, RCT]). There were no differences in A1c among the 3 groups, raising the issue of whether these dietary changes were actually relevant to glycemic control (40 [EL 2]). Inclusion of low-GI foods and whole grains in the evening meal improves glucose tolerance results with breakfast. This may be mediated by salutary effects on the gut microbiome (386 [EL2, NRCT]).

Decreasing the level of hyperglycemia improves underlying inflammation. Ingestion of carbohydrate with a high GI is associated with greater nuclear factor-$\varkappa\beta$ activation compared with low-GI carbohydrate ingestion (387 [EL1, RCT]). For the most part, a low-GI/GL meal plan has many commonalities with a healthy eating meal plan dominated by fruits, vegetables, and other high-fiber foods. Even traditionally high-GI foods such as bread and biscuits can become low-GI foods with the addition of a fiber mix (inulin, guar gum, glucomannan, and wheat fiber) (388 [EL2, NRCT]).

Notwithstanding the above studies and theoretical framework for a low-GI, plant-based dietary pattern, a review of the literature yields insufficient strong clinical evidence to support the recommendation of a "low-GI" meal plan for the treatment of DM (389 [EL4, NE]).

Fad Diets

Vegan diets have been shown to reduce the risk for T2DM and improve management of T2DM. Compared with the ADA recommendations, vegan diets lower CV risk and improve the Alternate Healthy Eating Index score (390 [EL2, PCS]; 391 [EL1, RCT]; 392 [EL2, NRCT]; 393 [EL1, RCT]).

The disease-oriented evidence (DOE) for various "Vegetarian," "Mediterranean," "Raw," "Slow Food," and "Designer" diets was reviewed within the contexts of surrogate markers (lipid levels, A1c levels, medication use, weight, and others), clinical outcomes, food quality and safety, taste, pesticide and antibiotic use, organic and local farming, genetically modified foods, and overall planetary health. DOE does not support the use of one type of diet over another. This is true in general and also with respect to T2DM. The best approach for a healthy lifestyle is simply the "amelioration of unhealthy choices" (394 [EL4, NE]). It is argued that optimal human meal planning will need to be performed using patient-oriented evidence that matters (POEM) derived from studies involving large, unselected, free-living populations (394 [EL4, NE]). Even though the principles common to many of the above diets are congruent with healthy eating principles outlined in the Executive Summary, there is insufficient evidence to recommend any one of these diets as a sole intervention for the management of DM.

4.Q5.6 Diabetes Mellitus Prevention

There are lifestyle factors that are known to prevent or delay components of the dysmetabolic syndrome, including hyperglycemia (395 [EL4, NE]; 396 [EL4, NE]):

- regular physical activity
- increased intake of nonstarch polysaccharides (fiber)
- voluntary weight loss
- fish and fish oil ingestion
- ingestion of vegetables and fruits
- high potassium intake, and
- low to moderate alcohol consumption.

Other factors with a weaker evidence base for prevention or delay of the dysmetabolic syndrome include (396 [EL4, NE]; 397 [EL2, MNRCT]):

- ALA (e.g., 3 ounces of flaxseed provides 19,400 mg of ALA; 3 ounces of walnuts provides 7,700 mg of ALA)
- oleic acid (found in olive, canola, and grapeseed oils and in beef, chicken, and pork)
- whole-grain cereals
- unsalted nuts
- plant stanols and sterols (e.g., from fruits, vegetables, seeds, legumes, nuts, cereals, and vegetable oils—higher concentrations are present in peanuts, soybeans, wheat germ, and corn oil)
- folate (e.g., from yeast extract; dried herbs; sunflower seeds; dry roasted soybeans; dark leafy greens, including spinach, turnip greens, and collards; bean sprouts; pinto, garbanzo, or mung beans; asparagus; peanuts)
- low-GI foods (e.g., from fruits, vegetables, whole and minimally processed grains, and legumes)
- n-3 fatty acids (e.g., 2 tablespoons of flax seeds provides 3.19 g; one-fourth of a cup of walnuts provides 2.27 g; 4 ounces of salmon provides 1.47 g)
- flavonoids (e.g., from black, red, blue, and purple berries; black grapes; citrus fruits; black and kidney beans; peppers; tomatoes; eggplants; soy)
- milk and dairy products, and
- soy products.

Insufficient evidence exists for the prevention or delay of the dysmetabolic syndrome by the following (396 [EL4, NE]; 398 [EL4, NE]):

- vitamins C and E
- chromium
- magnesium
- calcium
- resveratrol (or red wine).

High consumption of low-calorie (diet) soft drinks, onions, SSBs, burgers and sausages, crisps and other snacks, and white bread is associated with an increased risk of development of T2DM (399 [EL3, SS]). The use of SSBs (containing HFCS) has not been identified as a risk factor for T2DM per se, though consumption is high in patients already at high risk for T2DM (400 [EL3, SS]). SSBs may also be associated with CKD and albuminuria (401 [EL3, CSS]).

In a RCT, nondiabetic patients were randomly assigned to receive a control diet (35% fat), a low-fat diet (20 to 30% fat), or a diet with >20% of fat as MUFAs (35 to 45% total fat) to assess the effect on weight-loss maintenance and DM risk factors. Weight regain was similar among the three groups, highlighting that lifestyle changes beyond dietary macronutrient composition are important for weight-loss maintenance. However, both the low-fat and MUFA groups experienced less body fat regain than did the control group. The dropout rate was lowest in the low-fat group. Fasting insulin and insulin resistance decreased and the ratio of LDL to HDL improved in the MUFA group (402 [EL1, RCT]). Larger RCTs corroborated these results and found that reduced-calorie meal plans in nondiabetic patients achieve meaningful weight loss regardless of macronutrients emphasized, and the weight loss is associated with improvements in metabolic profiles (403 [EL1, RCT]; 404 [EL1, RCT]). Strong evidence supports the implementation of nutrition and physical activity interventions to reduce the risk of DM (13 [EL1, RCT]; 405 [EL4, NE]).

4.Q6. What Nutritional Recommendations are Appropriate for Patients with Chronic Kidney Disease?

4.Q6.1 General Approach

CKD is an advancing syndrome of renal deterioration in which the kidneys lose their ability to filter blood, concentrate the urine, excrete wastes, stimulate red blood cell production, and maintain electrolyte and acid-base balance. CKD is common among adults in the U.S. and is estimated to affect approximately 20 million adults, or 10% of people age 20 years or older (406 [EL3, SS]). Risk factors for developing CKD include DM, hypertension, CVD, obesity, dyslipidemia, and a family history of CKD (406 [EL3, SS]). Depending on the type of the disease, renal function may be lost in a matter of days or weeks or may deteriorate gradually over many years. One epidemiologic study estimated that the rate of transition from a GFR between 15 and 60 mL/min/1.73 m^2 to ESKD is approximately 1.5% per year (407 [EL3, SS]). While CKD is more common among women, men with CKD are 50% more likely than women to progress to ESKD (406 [EL3, SS]). Inadequately treated DM and hypertension increase the risk of progression of CKD to ESKD, as do repeated episodes of acute renal injury from other causes, such as drugs, toxins, or frequent infections. Age, male gender, and Hispanic heritage are other known factors that increase the risk of progression from CKD to ESKD (406 [EL3, SS]). Individuals with CKD are more likely to die from any cause (all-cause mortality) compared to those without CKD. CVD is the major cause of death in patients with CKD (408 [EL3, SS]). CKD is an independent risk factor for CVD and vice versa. CVD is also a risk factor for developing worsening kidney function (409 [EL4, NE]).

Strong associations between malnutrition, inflammation, and atherosclerosis in the predialysis patient population are termed the malnutrition, inflammation, and atherosclerosis (MIA) syndrome, which is associated with an exceptionally high mortality rate (410 [EL4, NE]). Malnutrition is common in patients with CKD and is a predictor of poor clinical outcome when the disease progresses

to ESKD (411 [EL4, NE]; 412 [EL3, CCS]; 413 [EL3, SS]; 414 [EL3, SS]). Data from the U.S. NHANES III has shown that in patients over 60 years of age, advanced kidney disease (GFR <30 mL/ min) is independently associated with malnutrition (415 [EL3, CSS]). Nutrition parameters such as serum transferrin, albumin, cholesterol, anthropometric measurements, and protein intake are known to decline with worsening kidney disease (412 [EL3, CCS]; 416 [EL3, CSS]). Factors responsible for the decline in nutrition parameters include: inadequate intake of protein due to depression or gastrointestinal symptoms, psychiatric symptoms brought on by accumulating uremic toxins, and acidosis or inflammation from advanced renal insufficiency (412 [EL3, CCS]; 417 [EL1, MRCT]; 418 [EL4, NE]; 419 [EL2, CSS]).

Staging

Guidelines for classifying CKD based on GFR have been developed by the National Kidney Foundation (NKF) Kidney Disease Outcomes Quality Initiative (KDOQI) and have been used globally in the medical community (420 [EL1, MRCT]; 421 [EL1, MRCT]). Classification and general characteristics for each stage are described in Table 23.

Current literature suggests that a meal plan low in protein, sodium, potassium, and phosphorus may slow the rate of decline in renal function and in the progression of kidney disease (Table 24) (422 [EL4, NE]; 423 [EL4, NE]; 424 [EL1, MRCT]; 425 [EL1, MRCT]; 426 [EL1, MRCT]; 427 [EL1, RCT]). Greatest benefit is achieved when nutritional interventions are initiated early, before irreversible damage has occurred. However, nutritional interventions should be individualized and evaluated with care because the dietary changes required to offset decreases in renal function vary greatly. When severe intake restrictions are imposed, particularly with protein, total dietary intake and energy (kcal/day) may be adversely affected and the individual may reach a catabolic state, mobilizing their own protein stores.

4.Q6.2 Protein Requirements

Although data from more than 50 clinical studies are contradictory and not entirely conclusive, a low-protein meal plan is beneficial to patients with CKD and may prevent the natural progression of chronic renal insufficiency toward ESKD (422 [EL4, NE]; 423 [EL4, NE]; 424 [EL1, MRCT]; 425 [EL1, MRCT]; 426 [EL1, MRCT]; 427 [EL1, RCT]; 428 [EL1, MRCT]). A low protein intake reduces the amount of nitrogenous wastes generated, thus decreasing uremic symptoms (429 [EL1, RCT]). A low protein intake also helps regulate inorganic ions such as phosphorus. Post hoc analysis of the Modification of Diet in Renal Disease Study showed that low protein intake retards the progression of renal failure (430 [EL1, RCT]). A 40% reduction in renal death is possible for patients on a low-protein intake diet compared to those with larger or unrestricted protein intake (428 [EL1, MRCT]). The degree of protein restriction is dictated by the current stage of the patient's CKD. In CKD stages 1, 2, and 3, protein intake should be limited to 12 to 15% of daily calorie intake, or 0.8 g of high-quality protein/kg body weight/day. In stage 4 CKD, protein intake should be reduced to 10% of daily calorie intake. For non-dialyzed patients with GFR <25 mL/min, 0.6 g of protein/kg body weight/day should be prescribed, with at least 50% of the protein intake from HBV sources to ensure a sufficient amount of EAAs. For individuals who are unable to maintain this degree of protein restriction, an intake of up to 0.75 g of protein/kg body weight/day may be prescribed. For patients with stage 5 CKD or those patients already on dialysis, a protein intake of 1.1 to 1.2 g/kg body weight/day is recommended (431 [EL4, NE]). It is important to

Table 23
Classification of CKD and Expected Actions

Stage	Description	Glomerular filtration rate (mL/min/1.72 m^2)	Expected action
1	Kidney damage with normal or increased GFR	≥90	Treat comorbidities Slow progression of CKD
2	Kidney damage with mild decrease in GFR	60-89	Treat comorbidities Estimate progression
3	Moderate decrease in GFR	30-59	Treat comorbidities Treat complications
4	Severe decrease in GFR	15-29	Prepare for renal replacement therapy
5	Kidney failure	<15	Renal replacement therapy

Abbreviations: CKD = chronic kidney disease; GFR = glomerular filtration rate.
Adapted from NKF K/DOQI clinical practice guidelines for chronic kidney disease: evaluation, classification, and stratification. *Am J Kidney Dis*. 2002;39:S37-S75, S112-S115, S170-212.

Table 24
Nutrition Recommendations for Patients with CKD

Nutrient	Recommendation
Protein	0.6-0.8 g/kg body weight per day, 50 to 75% provided by those of HBV
Sodium	<2 g/day
Potassium	2,000-3,000 mg/day (40-70 mEq/day)
Phosphate	600-800 mg/day
Calcium	1,400-1,600 mg/day (not to exceed 2,000 mg/day)
Free water (in excess of urine output)	1-1.5 L/day

Abbreviations: CKD = chronic kidney disease; HBV = high biological value.

note that the average protein intake in the United States is ~12 to 15% of the total kcal/day, but the total amount of protein varies greatly with the level of total caloric intake needed. A recommendation of 0.6 g/kg body weight/day may not provide the needed protein, so a low-protein meal plan should rarely go below 40 g/day. A 40 g/day protein meal plan provides ~13% of kcal/day at the 1,200 kcal/day level but only ~8% of kcal at the 2,400 kcal/day level. Additionally, in order to provide EAAs, consumption of HBV proteins, including those from animal sources (milk, eggs, meat, fish poultry) should be emphasized.

There is no consensus as to whether urinary losses of protein in nephrotic syndrome should be replaced, but a low-normal protein DRI of 0.8 to 1.0 g/kg body weight/day is reasonable (417 [EL1, MRCT]; 420 [EL1, MRCT]; 431 [EL4, NE]; 432 [EL2, NRCT]; 433 [EL2, NRCT]).

To prevent stored protein from being catabolized for energy needs, adequate energy intake is important for patients with CKD, especially since energy expenditure may be similar to, or increased, in patients with progressive CKD compared to healthy individuals (432 [EL2, NRCT]; 434 [EL3, RCCS]). Numerous studies have documented that patients with CKD rarely consume enough calories to meet their nutritional needs, including those in clinical studies where strict follow-up was required (435 [EL2, NRCT]; 436 [EL3, CCS]). For patients with stage 1, 2, or 3 CKD, a meal plan providing 35 kcal/kg body weight/day is sufficient to maintain neutral nitrogen balance. For patients with GFR <25 mL/min, the energy intake should be 35 kcal/kg body weight/day for those below age 60 years and 30 to 35 kcal/kg body weight/day for individuals who are over 60 years of age (since they are more sedentary and burn less energy on average) (420 [EL1, MRCT]).

4.Q6.3 Electrolytes

Sodium

Patients with CKD are often salt-sensitive and may respond to high intakes of NaCl with increases in GFR and proteinuria (423 [EL4, NE]). Limiting salt intake to ≤2 g/day may be necessary, especially for patients with edema, heart failure, or hypertension. High BP is known to worsen renal function in patients with CKD, and sodium restriction is an important part of BP control in CKD (437 [EL4, NE]). Patients with CKD who adhere to low daily sodium intake have 50% less decline in GFR than those who have high sodium intake (438 [EL3, CCS]).

Potassium

Patients with CKD are at increased risk for hyperkalemia due to reduced capacity for potassium excretion by the failing kidneys. Potassium levels may be normal until late in ESKD. When serum potassium levels are elevated, potassium intake (including salt substitutes) should be limited to 2,000 to 3,000 mg/day (40 to 70 mEq/day). When diarrhea or vomiting is present, potassium intake should be liberalized and meals should include a variety of fruits, vegetables, and grains. Potassium should still be limited if blood tests show phosphate or potassium levels above normal (420 [EL1, MRCT]).

Phosphorus and Calcium

As CKD progresses, excretion of phosphorus by the kidneys can decrease, leading to an increase in the serum phosphorus level. Phosphorus precipitates calcium in the vasculature and other tissues, and this leads to a decrease in the serum calcium concentration. The activity of the renal hydroxylase that activates vitamin D also decreases with progressive renal failure. The ensuing loss of activity of vitamin D also contributes to a decrease in serum calcium concentration. Together, these events lead to an increase in PTH release, which returns phosphorus and calcium to normal levels. As GFR continues to decline, this cycle maintains serum calcium and phosphorus concentrations within the normal ranges, at the expense of rising PTH levels. When GFR drops below 30 mL/min/1.73 m^2, hyperphosphatemia can become sustained (439 [EL4, NE]). The treatment goal becomes to maintain phosphorus levels within target range (2.7 to 4.6 mg/dL for CKD stages 3 and 4; 3.5 to 5.5 mg/dL for CKD stage 5 or ESKD). This allows the calcium-phosphorus product to be held at ≤55 mg^2/dL^2. Treatment should begin with restricting phosphorus intake to approximately 800 mg/day. In addition to intake restriction, patients with a GFR <30 mL/min/1.73 m^2 may need oral phosphate binders given with meals to decrease gut

absorption of phosphorus. No more than 1,500 mg/day of elemental calcium should be given as binders (2,000 mg/day of total calcium intake; binders plus meal calcium) (440 [EL1, MRCT]). Recommendations for calcium intake for CKD patients have yet to be established.

Vitamin D

Supplemental vitamin D should be given to treat secondary hyperparathyroidism. 25(OH)D levels should be measured and replacement with vitamin D (D_2 or D_3) should occur if levels are <30 ng/mL (441 [EL4, NE]). If the intact PTH level is elevated (above the upper limit of normal) and the serum 25(OH)D level is >30 ng/mL, treatment with an activated form of vitamin D (calcitriol, alfacalcidol, paracalcitol, or doxercalciferol) is indicated. During vitamin D therapy, serum calcium and phosphorus levels need to be monitored closely to prevent hypercalcemia and hyperphosphatemia, aiming for calcium and phosphorus levels of <10.2 mg/dL and <4.6 mg/dL, respectively (440 [EL1, MRCT]).

Anemia

Anemia commonly occurs in patients with stage 3, 4, or 5 CKD and should be screened for when the estimated GFR is <60 mL/min/1.73 m^2. The target hemoglobin level for both predialysis CKD and ESKD patients is 11 to 12 g/dL. Iron should be administered to maintain the transferrin saturation >20% and serum ferritin level >100 ng/mL. This is typically achieved by oral iron supplementation, with a daily dosage of approximately 200 mg of elemental iron (ferrous sulfate, 325 mg three times daily). Oral iron absorption is best when given without food, typically in between meals; but, this form of therapy is not always well tolerated because of gastrointestinal side effects. Intravenous iron is typically reserved for patients already on dialysis, although it may be used in predialysis CKD patients not achieving targeted iron levels (421 [EL1, MRCT]). Judicious use of iron supplementation is needed to prevent iron overload, which carries an increased CV risk (442 [EL4, NE]).

4.Q6.4 Renal Replacement Therapy

When renal function declines to stage 5, it is considered kidney failure based upon KDOQI Guidelines (417 [EL1, MRCT]). RRT is initiated with hemodialysis, peritoneal dialysis, or renal transplantation. Dialysis should be started when kidney function drops to 15% or less (417 [EL1, MRCT]). Symptoms that can occur include anorexia, nausea or vomiting, headaches, fatigue, anuria, swelling around the eyes and ankles, muscle cramps, tingling in hands or feet, and changing skin color and pigmentation. When RRT is initiated, nutritional changes must be implemented (Tables 25 and 26).

Hemodialysis

The recommended daily caloric intake for individuals less than 60 years of age on hemodialysis is 35 kcal/kg body weight/day but is decreased to 30 kcal/kg body weight/day for individuals over 60 years of age (417 [EL1, MRCT]). Energy-intake requirements have been studied in hemodialysis patients considered to be under metabolic balance conditions. Six hemodialysis patients' dietary energy requirements were examined after they ingested meals on three different meal plans, varying in the amount of calories, ranging from 25 to 45 kcal/kg body weight/day and a protein intake of 1.13 g/kg body weight/day for 21 days. The study showed that the necessary energy intake of 35 kcal/kg body weight/day was enough to maintain neutral nitrogen balance and body composition (443 [EL4, NE]). Hemodialysis and peritoneal dialysis patients have the same energy expenditure as compared to normal, healthy individuals (434 [EL3, RCCS]; 444 [EL3, CSS]; 445 [EL2, NRCT]; 446 [EL2, NRCT]).

Several prospective studies have looked at the effects of varying levels of protein intake on nutritional status

Table 25
Nutrition Recommendations for Hemodialysis Patients

Nutrient	Recommendation
Protein	1.2-1.5 g/kg of body weight per day with 50% HBV protein
Energy	35 kcal/kg of body weight
Sodium	2-3 g/day
Potassium	2-3 g/day or 40 mg/kg of IBW
Phosphorus	0.8-1.2 g/day or <17 mg/day of IBW
Vitamin C	60 mg (not to exceed 200 mg daily)
Fluid	750-1,000 mL/day plus urine output

Abbreviations: HBV = high biological value; IBW = ideal body weight.

Table 26
Nutrition Recommendations for Peritoneal Dialysis Patients

Nutrient	Recommendation
Protein	1.2-1.5 g/kg of body weight per day with 50% HBV protein
Energy	35 kcal/kg of body weight
Sodium	2-3 g/day
Potassium	2-3 g/day or 40 mg/kg of IBW
Phosphorus	0.8-1.2 g/day or <17 mg/day of IBW

Abbreviations: HBV = high biological value; IBW = ideal body weight.

(443 [EL4, NE]; 447 [EL2, NRCT]; 448 [EL3, CCS]; 449 [EL2, PCS]). For stable hemodialysis patients, the recommended protein intake is 1.2 g/kg of body weight/day, with at least 50% coming from HBV protein. HBV protein has an amino acid composition that is similar to human protein, is likely to be an animal protein, and tends to be utilized more efficiently by humans to conserve body proteins. The increased efficiency of utilization of HBV protein is particularly likely to be of benefit in individuals with low protein intake.

Studies on individuals who are on maintenance hemodialysis showed a higher incidence of protein-energy malnutrition, which can often underscore the importance of maintaining an adequate caloric as well as overall nutrient intake (450 [EL2, NRCT]; 451 [EL3, CSS]). While there are many reasons for the development of malnutrition, decreased caloric intake is usually the most important. Causes of poor nutrient intake include anorexia from uremia itself, the dialysis procedure, intercurrent illness, and acidemia. Other contributors to decreased intake include comorbid physical illnesses affecting gastrointestinal function, depression, organic brain disease, and socioeconomic factors (447 [EL2, NRCT]; 452 [EL2, NRCT]; 453 [EL1, RCT]; 454 [EL2, NRCT]).

Muscle carnitine is significantly reduced by dialysis, causing myopathy, muscle cramping, and high TGs (455 [EL2, NRCT]). Therefore, the standard of care is to replace carnitine at dialysis (456 [EL4, NE]).

A renal MVI is recommended as this patient population tends to have decreased intake of nutritious foods. The following are recommended doses, often found in renal vitamins: vitamin C, 60 mg (not to exceed 200 mg daily); folic acid, 1 mg; thiamine, 1.5 mg; riboflavin, 1.7 mg; niacin, 20 mg; vitamin B_6, 10 mg; vitamin B_{12}, 6 μg; pantothenic acid, 10 mg; biotin, 0.3 mg (457 [EL4, NE]).

Peritoneal Dialysis

Patients on peritoneal dialysis should have a total daily caloric intake of 35 kcal/kg body weight/day, similar to those on hemodialysis (417 [EL1, MRCT]). However, care should be taken to include the energy resulting from the glucose absorbed from the peritoneal dialysate in addition to the ingested amount. Fluid, unlike hemodialysis, is usually not restricted, with the recommendation of a minimum of 2,000 mL/day plus urine output. Recommendations for a MVI are the same as for HD (457 [EL4, NE]).

Many patients with ESKD who are treated with peritoneal dialysis often develop protein-energy malnutrition. Due to this, maintaining adequate amounts of protein intake is essential (446 [EL2, NRCT]; 458 [EL3, CSS]; 459 [EL3, CSS]; 460 [EL3, CSS]). Although causes of malnutrition in peritoneal dialysis are similar to those in hemodialysis patients, there is an increased loss of protein into the peritoneal dialysate. In fact, protein losses average about 5 to 15 g/24 hours. During episodes of peritonitis, dialysate protein may be considerably higher (461 [EL3, CCS]). Patients on peritoneal dialysis experience decreased appetite, largely due to the absorption of calories from glucose from the dialysate, leading to decreased dietary intake and malnutrition.

Numerous studies have looked at nitrogen balances in peritoneal dialysis patients who ingested different levels of protein and have indicated that protein intake of ≥1.2 g/kg body weight/day usually results in neutral or positive nitrogen balance (462 [EL1, RCT]; 463 [EL2, NRCT]; 464 [EL2, PCS and EL3, CSS]).

Diabetes and Kidney Disease

Data from three RCTs of overweight CKD patients (mean BMI of approximately 27 kg/m^2) with T1DM or T2DM suggest that a total daily energy intake of 1,780 to 1,823 kcal (when consuming protein-restricted meals ranging from 0.68 to 0.86 g/kg/day) can decrease body weight without causing malnutrition or having a negative effect on renal function (465 [EL1, RCT]; 466 [EL1, RCT]; 467 [EL1, RCT]).

For adults with DM and CKD, including post kidney transplant, hyperglycemia should be treated to achieve a target A1c of approximately 7%. Intensive treatment of hyperglycemia, while avoiding hypoglycemia, prevents diabetic kidney disease and may slow progression of established kidney disease. As kidney function declines, the half-life of insulin increases and more frequent episodes of hypoglycemia may occur.

Evaluation of A1c should include assessment of home blood sugar records showing pre- and postprandial blood sugar excursions, as well as frequency and severity of hypoglycemic episodes. In patients with advanced CVD, an A1c below 6.5% may be associated with increased mortality risk (468 [EL4, NE]; 469 [EL4, NE]).

4.Q7. What Nutritional Recommendations are Appropriate for Bone Health?

4.Q7.1 Calcium

Adequate lifetime calcium intake is necessary for development of peak bone mass as well as prevention of bone loss once peak bone mass has been reached (470 [EL4, NE]). Calcium intake averages about 935 mg/day in teens, which is below the recommended intake of 1,300 mg/day. In adults over age 51, mean calcium intake is about 674 mg/day, which is inadequate based on IOM recommendations for daily calcium intake of between 1,200 and 2,500 mg (122 [EL1, MRCT]).

Calcium absorption decreases with age, with about 50% less absorption after menopause, as compared with adolescence. This decreased calcium absorption is due at least in part to vitamin D insufficiency. Vitamin D insufficiency is common in older patients with decreased amounts of 25(OH)D as well as decreased conversion of

25(OH)D to 1,25$(OH)_2$D by the kidneys. Calcium balance studies indicate that the amount of calcium intake needed to maintain a positive calcium balance is over 1,000 mg/day for premenopausal women and about 1,500 mg/day for postmenopausal women (471 [EL2, NRCT]; 472 [EL4, NE]; 473 [EL4, NE]).

Adequate amounts of calcium can be obtained from food sources. The USDA maintains a nutrient website that includes calcium content of foods (474 [EL4, NE]). Calcium-fortified orange juice, soy milk, and soft drinks are becoming more popular as sources of calcium. Preparations may vary in bioavailability. Calcium citrate has significantly better absorption than tricalcium phosphate or lactate, for example (475 [EL1, RCT]). One difficulty with calcium-fortified beverages is that the calcium may settle out of solution, thus decreasing the actual intake (476 [EL4, NE]). Mineral water has calcium absorption similar to that of milk and is a good alternative to calcium-unfortified soft drinks (477 [EL1, RCT]).

Calcium absorption is dependent on many factors (Table 27). There is both passive and active absorption in the small bowel. Absorption is decreased in the setting of low vitamin D, advanced age, low or absent stomach acid, and high fiber intake. In perimenopausal women, calcium absorption is about 35% but varies between 17 and 58% (478 [EL2, NRCT]). Calcium absorption decreases with higher calcium intake, higher fiber intake, and increased alcohol use. On the other hand, calcium absorption tends to be higher in patients with high BMI values and increased fat intake.

Calcium ingestion slows age-related bone loss and reduces osteoporosis fracture risk. The timing of intervention with calcium supplementation is important. A RCT of women 40 to 70 years of age (with 67 early postmenopausal women and 1,690 late-menopausal women) studied the difference between calcium intake below 400 mg daily and calcium intake of 400 to 650 mg daily. Groups were randomized to placebo, 500 mg calcium carbonate daily, or 500 mg of calcium citrate daily. In the early postmenopausal women, bone loss was not prevented at the spine by 500 mg of supplemental calcium. In late-postmenopausal women, calcium prevented bone loss in the women with low dietary intake but did not stop bone loss at the spine in women with higher dietary intakes (479 [EL1, RCT]).

A meta-analysis of 15 clinical trials randomized to calcium supplements or usual calcium ingestion over 2 years showed increased bone density and a trend towards reduced vertebral fractures with calcium supplementation (480 [EL1, MRCT]). In women with low calcium intake and pre-existing fractures, supplemental calcium of 600

Table 27
Medication and Food Interactions for Calcium

Medication or food	Interaction
Thyroid hormone	Calcium reduces absorption. Calcium supplements and calcium rich foods should be taken 4 hours or more after dosing of thyroid hormone.
PPI, H2 blockers	Decrease calcium carbonate absorption. Calcium citrate may be preferable and should be taken with food.
Bisphosphonates	Calcium and many other substances will prevent absorption of bisphosphonates. Bisphosphonates should be taken with plain water at least 30-60 minutes (depending on the particular drug) before taking anything else except water.
Quinolone antibiotics	Calcium decreases absorption and should be taken several hours before or after the medication.
Anticonvulsants	Many anticonvulsants, especially phenytoin and phenobarbital, can cause significant decreases in 25(OH)D levels and therefore impair calcium absorption.
Glucocorticoids	Even low doses can be associated with bone loss and decreased calcium absorption.
Digoxin	Hypercalcemia can cause cardiac toxicity and calcium dosing and levels should be carefully monitored.
Thiazide diuretics	Decrease renal loss of calcium and may predispose to hypercalcemia in mild primary hyperparathyroidism. Calcium, and often PTH, should be monitored periodically. Thiazides may have therapeutic value in idiopathic hypercalciuria, especially when associated with renal stones.
Fiber	May decrease calcium absorption if in the form of phytic acid.
Caffeine	May increase urine calcium loss at high levels.
Sodium	May increase urine calcium loss at high levels. Can be measured in a 24-hour urine sample along with creatinine and calcium.

Abbreviations: 25(OH)D = 25-hydroxyvitamin D; H2 = histamine 2 receptor; PPI = proton-pump inhibitors ; PTH = parathyroid hormone.

mg twice daily reduced spine fracture risk and decreased bone loss (481 [EL1, RCT]). Elderly women taking 600 mg of calcium plus 800 IU of D_3 had a reduced risk of hip and nonvertebral fractures compared to placebo (117 [EL1, RCT]).

In the Women's Health Initiative, 36,282 women were randomly assigned to take 1,000 mg of calcium plus 400 IU of vitamin D daily or placebo. Women were allowed to supplement up to 1,000 mg of additional calcium on their own. They were also allowed to take osteoporosis medications, including about one-half who were taking hormone therapy. In the subset of women with bone density measurements, after about 7 years the hip BMD was about 1% higher in the calcium/vitamin D-supplemented group as compared to the placebo group. The risk of hip fracture was not statistically different in the treated versus placebo groups using an intention-to-treat analysis. However, the subset analysis of only those patients who adhered to treatment (those taking more than 80% of their supplements) showed a significant 29% reduction in hip fracture risk (130 [EL1, RCT]). A meta-analysis recommended that healthy adults over 50 years of age should have a daily intake of at least 1,200 mg of elemental calcium and 800 IU of vitamin D (482 [EL1, MRCT]).

Adults with established osteoporosis, glucocorticoid therapy, pregnancy, current breastfeeding, or age over 65 years should take a minimum of 1,500 mg of calcium daily (122 [EL1, MRCT]).

Calcium Supplements

If calcium intake from meals is insufficient and cannot be corrected, then calcium supplementation should be considered. Lactose intolerant patients, vegans, chronic glucocorticoid users, and those with a history of stomach surgery or malabsorptive bariatric procedures, celiac disease, or inflammatory bowel disease may need supplementation. Adequacy of calcium intake can be assessed by a 24-hour urine calcium collection (483 [EL2, NRCT]). Adequate vitamin D levels are also necessary to optimize absorption.

Supplemental calcium should not be given in the setting of hypercalcemia associated with primary hyperparathyroidism, sarcoidosis, vitamin D toxicity, or hypercalcemia of malignancy among other disorders. Calcium supplements are available as tablets, capsules, liquids, chews, and powders. Calcium carbonate and calcium citrate are the most common forms available, but other forms may also be found, including lactate and gluconate.

Coral calcium preparations are essentially calcium carbonate and offer no advantage over conventional calcium carbonate. They are much more expensive and offer no added health benefit. Calcium carbonate is about 40% calcium. Calcium citrate is 21% calcium, so more milligrams of calcium citrate are needed to provide the same amount of calcium. Calcium lactate is only 13% elemental calcium, and calcium gluconate is 9% calcium. Since so many more tablets need to be consumed to get the appropriate amount of calcium, these preparations are not generally recommended.

In some studies, calcium carbonate and calcium citrate have similar bioavailability in vitamin D-sufficient postmenopausal women (484 [EL1, RCT]; 485 [EL2, NRCT]). In other studies, calcium citrate may have better bioavailability than calcium carbonate with meals (486 [EL1, RCT]). The amount of stomach acid is important for calcium absorption. Calcium carbonate requires stomach acid for absorption, so it is best dosed in the presence of food (487 [EL2, NRCT]). Proton pump inhibitors and H2-blockers may interfere with calcium carbonate absorption. The dose of calcium carbonate should not exceed 500 mg at a time since absorption decreases as the dose increases above this level.

Calcium citrate does not require stomach acidity for absorption, and absorption is probably similar if taken with meals. In institutionalized patients or those with adherence problems, calcium citrate dosed with meals may be more helpful.

Calcium excretion occurs through the urine and feces. Calcium loss through the urine may be increased by caffeine and excessive sodium intake (488 [EL3, CSS]). Excess protein may promote urinary calcium excretion but does not appear to have an adverse effect on bone and may actually be associated with an increased bone density (489 [EL1, RCT]). This suggests that the elderly may benefit from increased protein intake in addition to sufficient calcium, vitamin D, and physical activity.

Potential Side-effects of Calcium Supplementation

Gastrointestinal Symptoms

Gastrointestinal symptoms (bloating, gas, constipation) can be a problem in some patients. Calcium carbonate may be more associated with gastrointestinal symptoms, and changing to calcium citrate may help in some patients. Evaluation for lactose intolerance, celiac disease, or lack of sufficient fluid or fiber should be considered in patients with persistent symptoms.

Kidney Stones

In the WHI, there was an increased risk of kidney stones (17% increase) in those supplemented with calcium and vitamin D (130 [EL1, RCT]). Since these women were permitted to use additional supplements on their own and they already had higher intakes than predicted by NHANES, it is likely the increased risk of stones was related to calcium intake in the range of 2,000 mg/day. A low calcium intake increases the risk of calcium oxalate kidney stones, probably due to binding of ingested calcium with oxalate in food, resulting in decreased oxalate absorption (490 [EL1, RCT]). Stone recurrence was decreased by about 50% in patients receiving a normal calcium intake as compared with calcium restriction. In the Health

Professionals Follow-up Study, there was no significant increased risk of kidney stones with calcium supplementation (491 [EL2, PCS]).

Prostate Cancer

Prostate cancer risk was increased in 3,612 men followed prospectively who had an increased amount of dairy product intake (492 [EL2, PCS]). The Health Professionals Follow-up Study, a prospective cohort study of 47,750 male health professionals with no history of cancer other than nonmelanoma skin cancer at baseline, found no correlation between total number of prostate cancer cases and calcium intake (493 [EL2, PCS]). However, there was a higher risk of advanced and more aggressive prostate cancer in men with calcium intake above 1,500 mg daily (493 [EL2, PCS]). Although these are observational studies, until more is known it may be prudent to limit calcium intake to below 1,500 mg daily, especially in men.

4.Q7.2 Vitamin D

Adequate vitamin D intake reduces the risk of fractures. $1,25(OH)_2D$ is necessary to absorb calcium from the intestines. Low levels of vitamin D result in decreased intestinal calcium absorption and cause secondary hyperparathyroidism and bone loss. Vitamin D deficiency may decrease calcium absorption by 40% or more (119 [EL1, RCT]). In patients with osteoporosis or with increased fracture risk, serum 25(OH)D should be measured to ensure the level is in the optimum range of 30 to 60 ng/mL. A 25(OH)D level below 20 ng/mL is deficiency and between 20 and 30 ng/mL is insufficiency (494 [EL4, NE]). Vitamin D insufficiency and deficiency are very common (495 [EL4, NE]). About 48% of Caucasian girls between 9 and 11 years old in Maine have a serum 25(OH)D level below 20 ng/mL during winter months (496 [EL2, PCS]). The NHANES III revealed that about 42% of African American women between 15 and 49 years of age have 25(OH)D levels less than 15 ng/mL (497 [EL2, PCS]).

Dosing of vitamin D should be at least 800 IU or more to reduce the risk of fractures (498 [EL3, SS]). The North American Menopause Society recommends a daily intake of 1,200 mg of calcium and 800 IU of vitamin D every day to keep the plasma level of 25(OH)D at 30 ng/mL or higher (472 [EL4, NE]; 473 [EL4, NE]).

In addition to bone loss, vitamin D deficiency has other significant systemic effects (123 [EL4, NE]; 470 [EL4, NE]; 499 [EL1, MRCT]). Vitamin D improves muscle tone and balance and reduces fall risk. A meta-analysis of RCTs documented that vitamin D supplementation reduced the risk of falls among ambulatory or institutionalized older individuals with stable health by more than 20% (110 [EL1, MRCT]). This beneficial effect of vitamin D is due at least in part to better lower extremity function (500 [EL3, SS]).

4.Q8. What Nutritional Recommendations are Appropriate for Pregnancy and Lactation?

Healthy eating in pregnancy and lactation has a significant effect on both the mother and the child and can have a tremendous impact on their health, morbidity, and even mortality. Suboptimal maternal nutritional status can compromise pregnancy outcome and increase the prevalence of low birth weight (501 [EL4, NE]; 502 [EL4, NE]). Decreased prevalences of pre-eclampsia, prematurity, and neonatal morbidity and mortality have been reported when nutritional services and dietary supplements are given to pregnant women at nutritional risk (503 [EL2, RCCS]). Furthermore, with the concurrent epidemics of obesity and T2DM, especially in women, pregnancy and the postpartum period should be seen as a critical opportunity to diagnose, treat, and educate patients (504 [EL4, NE]; 505 [EL2, RCCS]). Developing healthy eating behaviors requires active participation by the pregnant woman, as well as a multidisciplinary approach from her health care team, including her care provider, a registered dietician, and health professionals trained in prenatal and postpartum nutrition counseling and education. Meal plans including optimal caloric intake and weight gain should be tailored to each woman's individual needs, and preferences and should be culturally and ethnically sensitive. Discussion of the benefits of breast-feeding should be frequent and begin early in the prenatal period.

4.Q.8.1 Pregnancy Planning

Ideally, pregnancy nutritional needs should be assessed prior to conception to improve pregnancy outcome. Folic acid supplementation to reduce the risk of neural tube defects is most beneficial if initiated prior to conception. The neural tube closes between 18 and 26 days after conception, before most women know they are pregnant. All women of childbearing age should consume at least 400 μg dietary equivalents of folate per day (506 [EL4, NE]). All women should also ingest a minimum of 250 μg iodine daily because iodine deficiency in pregnancy is associated with children with lower intellectual quotients or neurocognitive delays (507 [EL4, NE]; 508 [EL4, NE]; 509 [EL2, NRCT]).

Physicians should perform a thorough history and physical examination prior to conception. Specific exam findings can be very useful in the diagnosis of pre-existing disease. For example, the physical finding of acanthosis nigricans is pathognomonic for insulin resistance. A pre-pregnancy BMI should be obtained as part of the physical examination. Prior to pregnancy, women should be encouraged to achieve a normal BMI (504 [EL4, NE]; 505 [EL2, RCCS]; 510 [EL2, MNRCT]; 511 [EL4, NE]). Patients who exercise in excess and undereat are at risk for intrauterine growth restriction (512 [EL4, NE]). Overweight

and obese patients are at higher risk for GDM, neural tube defects, and pre-eclampsia (504 [EL4, NE]; 505 [EL2, RCCS]; 510 [EL2, MNRCT]; 511 [EL4, NE]). Screening laboratory tests including complete blood count and fasting glucose should be ordered, as abnormal results require immediate treatment prior to conception. Elevated fasting blood glucose should prompt the care provider to screen for DM and begin a healthy meal plan and lifestyle modification. Any chronic diseases, including DM, thyroid disorders, and rheumatologic disorders should be optimally controlled prior to conception, and the pregnancy should be carefully planned. Physicians should pay particular attention to stopping any medications that could be potentially harmful to the fetus. Common examples of harmful medications include ACEIs and statins, both of which are recommended in T2DM management guidelines.

4.Q.8.2 Pregnancy

Obtaining a thorough history and physical examination during the first patient visit to identify possible risk factors or undiagnosed disorders is vital to optimizing nutrition in pregnancy. A detailed history should include screening for previous GDM, eating disorders, and chronic diseases, including phenylketonuria (PKU), as they will often have specific nutritional needs. For example, physicians must remind women with PKU who are pregnant or planning a pregnancy that they must maintain a strict phenylalanine-free meal plan, avoiding especially artificial sweeteners containing aspartame (Equal©, in the blue packet). Furthermore, with the increasing prevalence and much earlier incidence of T2DM, patients at high risk for either T2DM or GDM should be screened on initial exam (342 [EL4, NE]). There are a growing number of young women with undiagnosed T2DM who do not receive treatment until routine 2nd trimester screening and are misdiagnosed as having GDM (513 [EL2, PCS]). Risk factors for T2DM include family history of DM; overweight or obese state; sedentary lifestyle; Latin American, Mexican American, nonLatin black, Asian American, Native American ,or Pacific Islander ethnicity; hypertension; history of GDM; history of delivery of an infant with a birth weight greater than 9 pounds; PCOS; or psychiatric illness (342 [EL4, NE]).

A prenatal nutrition questionnaire helps the practitioner to identify pregnancy-related problems affecting appetite and nutritional status (e.g., nausea, vomiting, heartburn, constipation). Patients should also be queried on personal nutritional habits, including vegetarian, vegan, lactose-free and gluten-free diets, as well as cravings and aversions. All patients would benefit from referral to a dietician who specializes in nutrition in pregnancy and can evaluate the patient's individual habits, create an individualized meal plan, and address any special needs.

Medications and allergies should be carefully reviewed, as well as active substance use (e.g., tobacco, alcohol, or illicit drugs) that may impair the patient's ability to make sound nutritional choices.

Physical examination must include a calculation of current BMI and best estimate of the patient's prepregnancy BMI, if not known (504 [EL4, NE]). It should also include a thorough thyroid exam and careful observation for any manifestations of chronic diseases, such as acanthosis nigricans.

All pregnant women should be screened for GDM at 24-weeks gestation (342 [EL4, NE]). The prior recommendations to screen for GDM at 24- to 28-weeks gestation often delay diagnosis until 30- to 34-weeks gestation, well after the effects of hyperglycemia have begun to cause macrosomia (514 [EL2, PCS]). Screening for GDM in patients with risk factors should be performed as soon as possible. Risk factors for GDM are similar to those for T2DM and include overweight or obesity; family history of DM; history of abnormal glucose metabolism; history of poor obstetric outcome; history of delivery of infant with a birth weight greater than 9 pounds; history of patient's own birth weight greater than 9 pounds; history of PCOS; and Latin American, Mexican American, nonLatin black, Asian American, Native American, or Pacific Islander ethnicity (342 [EL4, NE]). In the United States, obstetricians currently follow ADA guidelines. A new set of criteria derived from the Hyperglycemia and Adverse Pregnancy Outcome (HAPO) trial is likely to be adopted as universal screening guidelines in a global attempt to standardize screening for GDM (514 [EL2, PCS]; 515 [EL4, NE]). These new guidelines are shown in Table 28.

Hyperglycemia in pregnancy, even in the preGDM range, has been associated with neonatal macrosomia and elevated C-peptide levels (514 [EL2, PCS]). Exposure to a hyperglycemic environment "in-utero" increases the risk of developing obesity and dysmetabolic syndrome in childhood (516 [EL4, NE]; 517 [EL2, PCS]; 518 [EL2, PCS]). Women with GDM have a 60% risk of developing T2DM later in their lifetime (519 [EL4, NE]). For all these compelling reasons, early and accurate identification of GDM will expedite optimal nutrition in this population and prevent short- and long-term complications.

Patient Education During Pregnancy

Pregnant women are more susceptible to food-borne illnesses and should practice safe food handling. Women should be encouraged to use frequent hand washing; avoid unpasteurized dairy products; thoroughly wash fresh produce before consuming it; and ensure that meats, poultry, and fish are fully cooked (501 [EL4, NE]).

Caffeine during pregnancy can increase the incidence of miscarriage and stillbirth when consumed in large quantities. Generally, consuming less than 300 mg of caffeine (3 cups of coffee) per day is not associated with increased incidences of these outcomes (520 [EL2, RCCS]). Sugar substitutes are considered a safe alternative in moderation.

Table 28
Diagnostic Criteria for GDM Using a 75-g Oral Glucose Tolerance Test[a,b]

State at plasma glucose measurement	Plasma glucose concentration (mg/dL)
Fasting	>90
1-hour postglucose	>162
2-hour postglucose	>126

Abbreviation: GDM = gestational diabetes mellitus
[a] Two or more plasma glucose concentrations must be met or exceeded for a positive diagnosis.
[b] The above table is a prediction of the new values that are currently being evaluated, which are intended to be universal multispecialty consensus screening guidelines for GDM.
Adapted from Metzger et al. Hyperglycemia and Adverse Pregnancy Outcomes. *N Engl J Med*. 358:1991-2002.

The one exception is saccharine (pink packet), which is possibly associated with midline cancers in rodents, (521 [EL4, NE]) and for which there are no specific recommendations on safe intake levels (501 [EL4, NE]).

Appropriate weight gain in pregnancy should be adjusted to each pregnant woman's prepregnancy BMI. More evidence is being published that support minimal weight gain for pregnant women who are obese. Women should be encouraged to meet their specific weight goal while eating balanced meals and participating in regular physical activity. Guidelines for weight gain during pregnancy are shown in Table 29. The topic of weight gain in pregnant women who are obese is controversial, and some experts believe that it may be safe to gain little or no weight in this special population.

Physical activity is also an important aspect of a healthy pregnancy. Pregnant women should be encouraged to participate in regular activity (506 [EL4, NE]; 511 [EL4, NE]).

Specific Nutrient Needs During Pregnancy

The nutrient needs during pregnancy were revised by the IOM in 2006, and for calcium and vitamin D in 2011 (Table 30) (122 [EL1, MRCT]; 272 [EL4, NE]; 506 [EL4, NE]; 522 [EL4, NE]; 523 [EL4, NE]).

Macronutrient Needs During Pregnancy

Caloric intake is the greatest predictor of weight gain in pregnancy. Though pregnancy creates a state of increased metabolic demands, it is not until the 2nd and 3rd trimesters that women should increase their caloric intake. It is important to assess average caloric intake during the initial assessment. Many women incorrectly estimate their daily caloric intake and may be consuming excessive calories. Nonpregnant American women of average height and stable weight ingest approximately 2,400 kcal/day (272 [EL4, NE]). Pregnant women in their 2nd and 3rd trimesters may increase their caloric intake by approximately 340 kcal/day and 450 kcal/day respectively (506 [EL4, NE]). However, in pregnant women who are obese, additional calories may not be necessary (524 [EL2, NRCT]). Healthcare professionals should determine the appropriate caloric intake for each individual woman based on her prepregnancy BMI and current pregnant BMI. Calculating specific caloric needs based on BMI helps to achieve optimal weight gain during pregnancy (Table 31).

The recommended percentages for macronutrient ingestion during pregnancy are: 40% carbohydrate, 20% protein, and 30 to 40% fat. This distribution may need to be adjusted with the help of a dietician to meet each individual woman's needs (501 [EL4, NE]). Women who have

Table 29
Recommendations for Total Weight Gain During Pregnancy by Prepregnancy BMI[a]

Prepregnancy BMI	Singleton Pregnancy	Twin Pregnancy
Underweight (<18.5)	12.5-18 kg	Insufficient Information
Normal Weight (18.5-24.9)	11.5-16 kg	17-25 kg
Overweight (25.-29.0)	7-11.5 kg	14-23 kg
Obese (≥30.0)	5-9 kg	11-19 kg

Abbreviation: BMI = body mass index.
[a] Adopted from: Rasmussen KM, Yaktine AL, eds; Committee to Reexamine IOM Pregnancy Weight Guidelines; IOM; National Research Council. Weight Gain During Pregnancy: Reexamining the Guidelines. Washington, DC: National Academies Press; 2009.

DM and/or are insulin resistant may need to decrease their percentage of carbohydrate ingestion to obtain glycemic control (524 [EL2, NRCT]; 525 [EL2, RCCS]; 526 [EL4, NE]).

The recommended daily intake of carbohydrates increases during pregnancy. The recommended intake of carbohydrates should be calculated regularly during a woman's pregnancy using Table 31 as a guide (523 [EL4, NE]). A pregnant woman's choice of carbohydrates is vast. Women who are pregnant should consider meeting their daily carbohydrate intake with vegetables, legumes, whole grains, and complex carbohydrates. These foods are often more nutrient dense and are more likely to supply essential micronutrients (501 [EL4, NE]). Simple carbohydrates and

Table 30
Dietary Reference Intakes for Women[a,b]

Nutrient	Adult woman	Pregnancy	Lactation (0-6 mo)
Energy (kcal)	2,403	2,743[c], 2,855[d]	2,698
Protein (g/kg/day)	0.8	1.1	1.1
Carbohydrate (g/day)	130	175	210
Total fiber (g/day)	25	28	29
Linoleic acid (g/day)	12	13	13
α-Linoleic acid (g/day)	12	13	13
Vitamin A (μg RAE)	700	770	1,300
Vitamin D (μg)	15	15	15
Vitamin E (mg α-tocopherol)	15	15	19
Vitamin K (μg)	90	90	90
Vitamin C (mg)	75	85	120
Thiamin (mg)	1.1	1.4	1.4
Riboflavin (mg)	1.1	1.4	1.6
Vitamin B6 (mg)	1.3	1.9	2.0
Niacin (mg NE)	14	18	17
Folate (μg dietary folate equivalents)	400	600	500
Vitamin B12 (μg)	2.4	2.6	2.8
Pantothenic acid (mg)	5	6	7
Biotin (μg)	30	30	35
Choline (mg)	425	450	550
Calcium (mg)	1,000	1,000	1,000
Phosphorus (mg)	700	700	700
Magnesium (mg)	320	350	310
Iron (mg)	8	27	9
Zinc (mg)	8	11	12
Iodine (μg)	150	220	290
Selenium (μg)	55	60	70
Fluoride (mg)	3	3	3
Manganese (mg)	1.8	2.0	2.6
Molybdenum (μg)	45	50	50
Chromium (μg)	25	30	45
Copper (μg)	900	1,000	1,300
Sodium (mg)	2,300	2,300	2,300
Potassium (mg)	4,700	4,700	5,100

Abbreviations: NE = niacin equivalents; RAE = retinal activity equivalents.
[a] Data from IOM, Dietary Reference intakes: The Essential Guide to Nutrient Requirements, Washington, DC, National Academies Press, 2006. Calcium and vitamin updated 2011.
[b] Values are Recommended Dietary Allowances except energy (Estimated Energy Requirement) and total fiber, linoleic acid, α-linoleic acid, vitamin D, vitamin K, pantothenic acid, biotin, choline, calcium, manganese, chromium, sodium, and potassium (Adequate intakes).
[c] Second trimester for women age 19 to 50 years.
[d] Third trimester for women 19 to 50 years.

Table 31
Recommended Daily Caloric Intake for Pregnant Women

Prepregnancy BMI Category	kcal/Current Weight (kg)/day	kcal/Current Weight (lb)/day
Underweight (< 18.5)	36-40	16.3-18.2
Normal Weight (18.5-24.9)	30	13.6
Overweight (25.0-29.9)	24	10.9
Obese (≥30.0)	12	5.4

Abbreviation: BMI = body mass index.

processed foods should be discouraged as they often are high in sugar and can quickly exceed daily requirements for caloric, sodium and *trans* fat intake (501 [EL4, NE]).

Protein requirements also increase during pregnancy. Women who are pregnant should consume 1.1 g/kg of protein per day in the 2nd and 3rd trimesters (523 [EL4, NE]; 527 [EL4, NE]). This is an increase from 0.8 g/kg/day in nonpregnant woman. Protein is essential for the expansion of plasma volume; the generation of amniotic fluid; and to support the growth of placental, fetal, and maternal tissue. Protein sources may be of animal, fish, or plant origin.

Vegetarian and vegan diets may lack sufficient macro- and micronutrients. Pregnant women who are vegetarian or vegan must be referred to a dietician specialized in pregnancy to assist in specialized meal planning and recommend necessary supplements.

There are no RDAs for fat intake during pregnancy. Fat is an important part of nutrition. Women should pay close attention to the type of fat being consumed. Less than 10% of calories should be derived from saturated fats and less than 10% should be derived from PUFA, with the remainder from MUFA. The adequate intake for EFA in pregnancy is 13 g/day of omega-6 and 1.4 g/day of omega-3 (272 [EL4, NE]; 506 [EL4, NE]; 523 [EL4, NE]; 528 [EL4, NE]).

DHA has recently garnered notoriety as an important supplement during pregnancy and lactation. DHA is a PUFA necessary for fetal brain development especially in the last trimester of pregnancy, and subsequently, in the first 2 years of life. Fish oil is rich in DHA and other EFAs. However, many mothers avoid fish due to concern about mercury content. Many studies have shown that pregnant women are falling significantly short of recommended levels of EFAs, especially DHA. Women should be educated that fish with low mercury content such as salmon, shrimp, Pollack, and canned light tuna is safe. Women should be encouraged to eat 12 ounces of fish per week. Fish that may contain high levels of mercury are usually large predatory fish and include shark, swordfish, king mackerel, and tuna steaks. A vegetarian source of DHA is microalgae, which is added to infant formula or sold as a supplement. Many studies indicate that low levels of DHA are associated with poor retinal development, low visual acuity, and poor cognitive development in infants (529 [EL2, NRCT]; 530 [EL1, RCT]; 531 [EL1, RCT]; 532 [EL1, RCT]). A working group from the International Society for the Study of Fatty Acids and Lipids recommended 300 mg/day of DHA for pregnant and lactating women, whereas the average consumption was between 45 mg and 115 mg per day for the women in the study (528 [EL4, NE]).

Trans fatty acids may cross the placenta and may have adverse effects on fetal development. *Trans* fatty acids should be avoided during pregnancy (533 [EL4, NE]; 534 [EL2, PCS]).

Micronutrient Needs During Pregnancy

Pregnant women require specific micronutrients to meet their gestational needs. Most women in developed countries who have access to a variety of foods are meeting most of their nutrient needs with meals alone. This said, the simplest way to assure that a woman is getting adequate micronutrients is to prescribe a daily PNV. Most PNVs are formulated to provide the recommended daily intake of all required micronutrients. PNVs have been shown to decrease the risk of low birth weight as compared to iron or folic acid alone (535 [EL2, MNRCT]).

Folate functions as a coenzyme and is essential in early gestation. Folate deficiency during early gestation is associated with impaired cellular growth and replication resulting in fetal malformations, spontaneous abortions, preterm delivery, and low birth weight (272 [EL4, NE]; 536 [EL2, PCS]). Folic acid supplementation has been shown to decrease the incidence of neural tube defects (536 [EL2, PCS]; 537 [EL3, SS]; 538 [EL2, RCCS]). The U.S. Public Health Service recommends that all women in their childbearing years consume 400 μg/day of folic acid. This should be increased to 600 μg/day during pregnancy (537 [EL3, SS]).

Women should maintain a daily iodine intake of 250 μg to ensure adequate maternal and fetal thyroid function during gestation (507 [EL4, NE]; 539 [EL4, NE]). The iodine content of some PNVs are inadequate to meet this goal (540 [EL2, NRCT]).

Iron deficiency in pregnancy increases the risk of low birth weight and may increase the risk of preterm delivery and perinatal mortality (501 [EL4, NE]). The RDA for iron

is 27 mg/day throughout pregnancy (272 [EL4, NE]). Iron is needed for fetal erythropoiesis and an increase in maternal red blood cell mass. The daily iron requirement is often found in PNVs. Women with anemia may need 60 mg/day of iron supplementation, in addition to the iron in PNVs, until anemia resolves.

Calcium and vitamin D are both necessary for fetal skeletal development. Calcium absorption increases in pregnancy and women should continue with the same recommended intake of 1,000 mg/day (122 [EL1, MRCT]). Many PNVs have approximately 20 to 40% of the RDA of calcium. Women should provide the rest with calcium-containing foods. Vitamin D requirements also do not change with pregnancy, and the recommended daily allowance is 15 μg (or 600 IU) (122 [EL1, MRCT]). The best sources of vitamin D are fortified milk and exposure of the skin to sunlight.

Vitamin A is imperative for fetal eye development and has been known to be deficient in developing countries. In the United States, with the combination of balanced nutrition and PNVs, pregnant women are ingesting more than adequate amounts. Vitamin A toxicity, which affects organogenesis, should be avoided. Women should be advised that the threshold for toxicity is 10,000 IU daily (541 [EL4, NE]; 542 [EL2, PCS]).

Zinc is important for the metabolism of nucleic acids. The RDA for zinc in pregnancy is 11 to 13 g/day (541 [EL4, NE]). Zinc deficiency in pregnancy is associated with pregnancy-induced hypertension, congenital malformations, intrauterine growth retardation, and premature birth. Alcohol, tobacco, and iron supplementation can interfere with zinc absorption. Anemic women on iron supplementation should take supplemental zinc.

4.Q.8.3 Lactation

The American Academy of Pediatrics and the WHO recommend exclusive breastfeeding for at least the first 6 months of life (543 [EL4, NE]; 544 [EL1, MRCT]). Exclusive breastfeeding is extremely beneficial for the well-being of both mother and child. Maternal nutrition during lactation is fundamental for healthy and successful breastfeeding.

Women should be counseled on the benefits of breastfeeding early in pregnancy and should be educated on the myriad of educators and support groups such as lactation consultants, nurse educators and the La Leche League, all of which can help promote successful lactation. The benefits of lactation for the woman include the immediate stimulation of uterine contractions that aid in postpartum hemostasis and uterine recovery to its prepregnancy state (544 [EL1, MRCT]). Further benefits include decreased risk of breast cancer, enhanced immune system, and improved glycemic control in mothers who have DM (544 [EL1, MRCT]). Their infants will benefit from a nutritional source with the appropriate nutrients and antibodies that change as the child develops. Maternal milk is also at the appropriate temperature, and breastfeeding creates a bonding relationship that is important for development (545 [EL4, NE]). Breastfeeding may also decrease the risk of childhood obesity (546 [EL4, NE]). This decreased risk is likely because it conditions both parent and child to stop eating when the child is full (547 [EL4, NE]). Many bottle-fed infants experience "finish your plate" syndrome, where parents will push infants to finish their bottle so as not to waste any formula (547 [EL4, NE]).

Breastfeeding leads to an increase in energy requirements. A woman's calorie, fluid, protein, vitamin and mineral requirements all increase during lactation. The IOM DRIs for women also show nutrient recommendations for lactation from 0 – 6 months (523 [EL4, NE]; 548 [EL4, NE]) (Table 30).

Caloric intake exceeds prepregnancy demands by approximately 650 kcal/day in average sized women who exclusively breastfeed (548 [EL4, NE]). However, these needs may be partially met by extra fat stored during pregnancy, which can provide on average 150 to 170 kcal/day (549 [EL4, NE]). Therefore, an average breastfeeding woman may only need 450 to 500 additional kcal per day (549 [EL4, NE]). Studies examining the effect of calorie deprivation on lactation demonstrate that quality and quantity of breast milk is maintained until a threshold of approximately 1,500 kcal/day. It has been shown that moderate calorie restriction and physical activity are safe during lactation (550 [EL2, NRCT]). To avoid hypoglycemia, women who are both breastfeeding and on a form of basal insulin must either decrease their basal rate during lactation or eat a carbohydrate-containing snack prior to breastfeeding (551 [EL2, NRCT]).

There is no conclusive evidence that breastfeeding is superior to formula feeding to assist in maternal weight loss. Weight loss is possible with both methods. This non-superiority of breastfeeding to foster weight loss is likely because breastfeeding stimulates appetite. The recommended rate of weight loss of 0.5 to 1 lbs./week is safe. Rapid weight loss (>4.4 lbs./month) is not advised for breastfeeding women (552 [EL3, SS]; 553 [EL4, NE]).

The need for supplementation with micronutrients during lactation depends on each woman's nutritional status (545 [EL4, NE]; 548 [EL4, NE]). Nutrients that should be repleted during lactation include calcium, magnesium, zinc, thiamin, vitamin B6, iodine, and folate. A simple solution is to recommend that lactating women continue their PNV and additional supplements while breastfeeding. Women should also continue to consume adequate amounts of EFAs, including DHA, for infant central nervous system development. Adequate EFA intake is achieved either by 12 oz. fish oil per week, or by EFA/DHA supplements (528 [EL4, NE]). Women who are anemic after delivery should take 60 to 120 mg/day of ferrous sulfate. Iron supplementation should be continued until anemia is resolved.

Women with personal or family history of T1DM who may be HLA-DR3 and DR4 carriers should be counseled on the medical evidence suggesting that infant formula derived from cow's milk may be associated with T1DM by stimulating antibody formation to the beta-cells (554 [EL2, PCS]; 555 [EL2, MNRCT]). Some experts recommend that bovine-based infant formula be completely avoided during the first year of life. If formula is required, parents should use soy-based products.

4.Q.9 What Nutritional Recommendations are Appropriate for the Elderly?

Introduction: Why the Need for Healthy Eating for the Elderly?

The WHO defines elderly as those 60 years old or older (556 [EL4, NE]; 557 [EL4, NE]). However, chronological age (biological age) does not always reflect an individual's physiological age (functional age) or true aging status. We consider "healthy eating for the elderly" applicable even to those in their "middle age," insofar as modifying eating behaviors is more effective when it is started early. Additionally, there is usually a long lag time before chronic diseases manifest with age, and earlier nutritional modification is considered to be of more benefit (556 [EL4, NE]). Therefore, each "elderly" person must consider his/her own aging status, health conditions, and specific medical needs and follow appropriate guidelines for healthy eating (557 [EL4, NE]; 558 [EL4, NE]).

Healthy eating for the elderly should be based on scientific knowledge and evidence, not only to ensure nutritional adequacy, but also to prevent diseases, and/or affect favorably the disease status if already present (106 [EL4, NE]; 541 [EL4, NE]; 556 [EL4, NE]; 559 [EL4, NE]; 560 [EL4, NE]; 561 [EL4, NE]; 562 [EL4, NE]; 563 [EL4, NE]). The age-related changes that have significant implications for healthy eating in older adults include the following:

- reduced energy requirement (564 [EL2, PCS]; 565 [EL2, PCS]; 566 [EL2, PCS]; 567 [EL2, CSS]; 568 [EL2, NRCT]; 569 [EL3, CSS]; 570 [EL2, PCS])
- body composition changes featuring:
  - loss of muscle and lean body mass (571 [EL2, PCS]; 572 [EL2, PCS]; 573 [EL2, PCS]) and
  - relative increases in fat mass (574 [EL2, PCS]; 575 [EL2, PCS]; 576 [EL2, PCS])
- decreases in the sensitivities of the sensory functions for smell, taste, or thirst (577 [EL2, NRCT]; 578 [EL3, CSS]; 579 [EL2, PCS]; 580 [EL3, CSS]; 581 [EL2, NRCT]; 582 [EL2, NRCT]; 583 [EL2, NRCT]; 584 [EL2, NRCT]; 585 [EL2, NRCT]; 586 [EL2, NRCT]), and
- decline of the immune system (587 [EL4, NE]; 588 [EL4, NE]; 589 [EL4, NE]), which may be associated with the vulnerability of an aging body to infections and/or developing degenerative and chronic diseases (557 [EL4, NE]; 590 [EL3, CCS]; 591 [EL3, CCS]).

4.Q.9.1 Healthy Eating for Energy Balance and Toward an Ideal Body Weight

To achieve and maintain an ideal body weight is advisable for all age groups because both over- and underweight statuses lead to increased morbidity and mortality (282 [EL2, RCCS]; 592 [EL2, PCS]; 593 [EL2, PCS]; 594 [EL2, PCS]; 595 [EL2, PCS]; 596 [EL2, PCS]; 597 [EL2, PCS]; 598 [EL2, PCS]). However, both overweight and underweight are present more frequently in older adults. Aging is associated with unfavorable changes in body composition (599 [EL4, NE]). The coexistence of muscle mass loss and increased fat mass with aging is sometimes termed "sarcopenic obesity" (599 [EL4, NE]; 600 [EL4, NE]; 601 [EL4, NE]). Older people are also prone to underweight and cachexia because malnourishment associated with aging and undernutrition associated with chronic diseases are more prevalent in the elderly. Both overweight and underweight are predictors of functional impairment, chronic diseases, and disability (602 [EL2, PCS]; 603 [EL3, SS]; 604 [EL3, CSS]). Weight gain or unintentional weight loss also predict subsequent loss or limitation of activity of daily living (605 [EL3, CSS]; 606 [EL3, SS; EL2, NRCT]; 607 [EL2, PCS]).

To achieve and maintain an ideal body weight may be especially challenging for the elderly because of the inherited physiological changes of aging. On the one hand, age-related decline in total energy expenditure makes it harder to avoid weight gain if caloric intake is not reduced accordingly. On the other hand, age-related anorexia (608 [EL4, NE]; 609 [EL4, NE]), and functional declines of the gastrointestinal tract (610 [EL4, NE]; 611 [EL2, NRCT]; 612 [EL2, NRCT]; 613 [EL4, NE]; 614 [EL3, CSS]; 615 [EL4, NE]; 616 [EL3, CCS]; 617 [EL3, CSS]) predispose to underweight status in the frail individuals who may have a chronic medical condition or who may suffer social, economic, personal, or family hardships in their later years (618 [EL3, SS]; 619 [EL3, CSS]).

Aging is associated with progressive declines in RMR and physical activity (564 [EL2, PCS]; 565 [EL2, PCS]; 566 [EL2, PCS]; 567 [EL2, CSS]; 568 [EL2, NRCT]; 569 [EL3, CSS]; 570 [EL2, PCS]). Body composition changes with aging in favor of fat accumulation, particularly abdominal fat, and loss of muscle mass and body cell mass (620 [EL2, NRCT]; 621 [EL2, PCS]). Although variable, a person may start to lose skeletal muscle mass and bone mass as early as age 40 (622 [EL4, NE]). Age-related muscle loss is referred to as geriatric "sarcopenia" (623 [EL4, NE]; 624 [EL4, NE]; 625 [EL4, NE]). Sarcopenia is a major cause of the decline in metabolic rates that come with aging because skeletal muscle contributes more to energy metabolism than any other tissue. With reduced

muscle mass, the overall body metabolism and energy expenditure also decrease accordingly. Many people start to gain weight, particularly fat mass, when they get older. In part, this is because their caloric intake is not adjusted to match their reduced metabolism and energy expenditure. In addition to healthy eating, maintaining a regular physical activity program (including resistance training) should be part of healthy aging (557 [EL4, NE]; 558 [EL4, NE]; 626 [EL4, NE]; 627 [EL4, NE]). Physical activity increases energy expenditure and helps maintain appropriate energy balance. Physical activity also helps maintain muscle mass and, hence, retards aging processes in this regard.

The opposite problem of weight gain is unintentional weight loss in the elderly. Aging is associated with gradual declines in appetite, taste and smell sensitivity, and decreased gastrointestinal tract function (577 [EL2, NRCT]; 578 [EL3, CSS]; 579 [EL2, PCS]; 580 [EL3, CSS]; 581 [EL2, NRCT]; 582 [EL2, NRCT]; 583 [EL2, NRCT]; 584 [EL2, NRCT]; 585 [EL2, NRCT]; 586 [EL2, NRCT]; 608 [EL4, NE]; 610 [EL4, NE]; 611 [EL2, NRCT]; 612 [EL2, NRCT]; 613 [EL4, NE]; 614 [EL3, CSS]; 615 [EL4, NE]; 616 [EL3, CCS]; 617 [EL3, CSS]; 628 [EL3, CSS]; 629 [EL1, RCT]; 630 [EL4, NE]). Aging is also associated with an increased risk of poor food safety, including the inability to avoid food spoilage (631 [EL4, NE]). In some people, significant anorexia develops, which may be accompanied by dental (bad teeth or ill-fitting dentures) or medical (chronic diseases and polypharmacy) problems that adversely affect food intake. In these elderly people, underweight or cachexia is a major problem. The major obstacle to achieving and maintaining ideal body weight in these individuals is inadequate food intake. Importantly, the priority in achieving healthy eating objectives in this subgroup of the elderly should be very different from people who are overweight and/or obese. Selection of palatable and calorie-dense foods for this group of frail elderly, together with supplementation of essential micronutrients, should be the focus of the healthy eating strategy and take precedent over the usual recommendation of "balanced food selection" for healthier older adults.

The need and the pace of eating towards achieving ideal body weight should be determined on an individual basis and is best advised by a person's physician and/or nutritionist. In general, however, body weight is the ultimate measure for energy balance in the absence of edematous states or dehydration. Gaining weight means a positive energy balance, which results either from too little physical activity, too much food intake, or both. On the other hand, weight loss means negative energy balance resulting from more energy expenditure than caloric intake. The change in body weight (toward or away from the ideal body weight) is a very practical and useful way to determine whether caloric intake is too high or too low for the particular person.

4.Q.9.2 Healthy Eating to Prevent Micro-Nutrient Deficiency in Older Adults

Prevention of micronutrient deficiency may be challenging for the elderly for 2 reasons. There is evidence that micronutrient requirement for older adults may be increased because of impaired absorption and/or metabolism due to age-related functional declines, medical conditions, or polypharmacy (632 [EL2, NRCT]; 633 [EL4, NE]; 634 [EL4, NE]; 635 [EL2, NRCT]; 636 [EL4, NE]; 637 [EL4, NE]; 638 [EL4, NE]; 639 [EL2, NRCT]; 640 [EL3, CCS]). Additionally, there is the need for caloric reduction in the elderly in order to maintain energy balance. To constrain caloric overconsumption while ensuring micronutrient adequacy, foods low in calories and rich in micronutrients should be ingested routinely. Quality foods containing adequate amounts of essential amino acids and EFAs that are also rich in micronutrients and fibers are recommended. The 2005 USDA Food Guide Pyramid and the Tufts University Modified MyPyramid for Older Adults, provide general guidelines for food selection in relative proportions among the major food groups. Both are designed to meet caloric and other nutritional requirements, leading to improved nutrient intakes within recommended caloric constraints (563 [EL4, NE]; 641 [EL4, NE]; 642 [EL2, PCS]).

Quality foods high in proteins, minerals, and vitamins but low in saturated fat, cholesterol, and *trans* fat, such as lean meat, fish, poultry, eggs, and dry beans and nuts, are recommended. These food choices provide adequate protein intake without carrying a high risk for cardiovascular disease (643 [EL2, NRCT]; 644 [EL1, RCT]; 645 [EL2, PCS]). For carbohydrates, older adults are encouraged to consume more nutrient-dense whole grain foods (high nutrient-to-calorie ratio), such as brown rice, whole wheat breads, whole grains, and fortified cereals (646 [EL2, PCS]; 647 [EL2, PCS]). Consumption of refined starch-based foods poor in other micronutrients, such as processed potato, white bread, pasta, and other commercial products made of refined wheat flour, should be decreased. These carbohydrate-based foods are particularly discouraged for older adults with DM, obesity, or risk factors for T2DM (648 [EL3, SS]; 649 [EL2, PCS]; 650 [EL2, PCS]). Saturated and *trans* fats should be limited, and animal fat and processed food intake should be minimal in order to meet the guidelines for cardiovascular health. Water is an essential component of nutrition that must receive attention. Adequate and habitual fluid intake is encouraged for the elderly, as the thirst mechanism may become impaired with aging. Dehydration proves to be a prevalent condition in this age group (583 [EL2, NRCT]). About 2 quarts (~1.9 L) of fluid daily is recommended to prevent dehydration in the elderly (563 [EL4, NE]).

To ensure adequacy of a wide variety of micronutrients, choosing a mix of nutrient-dense foods on a daily

basis is preferred over narrow selection of certain foods (651 [EL3, SS]; 652 [EL3, SS]; 653 [EL4, NE]). This recommendation may be of particular importance for older adults because a decreased variety is more prevalent in the elderly (652 [EL3, SS]). Of note, the tendency toward monotonous single food consumption may be associated with chemosensory changes of aging (654 [EL4, NE]). In general, whole grains are better than refined flours, and wholesome vegetables and fruits (including the skins) contain more balanced nutrients than vegetable or fruit juices only. A variety of colored vegetables and fruits (both bright- and deep-colored) are excellent sources of minerals, vitamins, phytochemicals, and antioxidants. Special or restrictive meal plans should be limited to individuals with specific diseases, where there is a need for limiting certain food components.

Pills should not be used as a substitute for meals but can be used as a supplement as appropriate. With a good meal plan, both energy and macro-/micronutrient requirements can be met. However, a high risk for deficiency of several micronutrients (calcium and vitamins D and B12) has been recognized in older adults (563 [EL4, NE]). Inadequate intake of calcium and vitamin D leads to increased PTH-mediated bone resorption. Increased bone mineral density loss is in turn a strong predictor of fracture risk (655 [EL3, CSS]). Low-fat dairy products and other calcium-rich foods can provide much needed calcium and vitamin D that are often deficient in the elderly (619 [EL3, CSS]; 656 [EL4, NE]; 657 [EL3, SS]; 658 [EL3, SS]; 659 [EL3, CSS]). In order to obtain 1,200 to 1,400 mg/day of calcium from food, 3 to 4 servings of calcium-rich dairy products such as milk, cheese, yogurt, or calcium-fortified fruit juice (such as orange juice) need be consumed daily. Achieving adequate vitamin D intake through food may be more challenging, as even milk products may not be fortified with vitamin D. Vitamin D deficiency is a consequence of inadequate sun exposure in many older adults, especially those who are institutionalized. Calcium and vitamin D supplements should be added to the meal plan if daily intake from food does not meet the daily requirements for these nutrients. This recommendation is based on the evidence that calcium and vitamin D supplementation in high-risk individuals increases bone density and significantly lowers the rates of fracture (117 [EL1, RCT]; 660 [EL1, RCT]; 661 [EL2, MNRCT]; 662 [EL1, RCT]; 663 [EL2, NRCT]). Vitamin B12 deficiency in older adults has a high prevalence because of age-related atrophic gastritis and drug-induced hypochlorhydria (614 [EL3, CSS]; 628 [EL3, CSS]; 664 [EL3, CSS]; 665 [EL2, NRCT]). Vitamin B12 absorption may be further decreased by intestinal bacterial overgrowth (616 [EL3, CCS]; 617 [EL3, CSS]; 629 [EL1, RCT]). The requirement for vitamin B12 supplementation in the elderly is high, and aggressive case finding is reasonable. Surveys show poor micronutrient adequacy in a high percentage of older adults through their usual food intake (619 [EL3, CSS]; 656 [EL4, NE]; 657 [EL3, SS]; 658 [EL3, SS]; 659 [EL3, CSS]; 666 [EL3, CSS]). Therefore, it is appropriate to recommend a daily MVI to complement food intake for older adults. On the other hand, ingestion of minerals and vitamins in excess of their daily allowance should be discouraged because of risk for toxicity. Ingestion of nutrition supplements between meals (such as commercially available protein-based shakes or "energy bars") may be beneficial for selected individuals (667 [EL1, RCT]).

3.Q.9.3 Healthy Eating for the Frail Elderly

Frail elderly who are nutritionally vulnerable require special attention. These are individuals who are underweight or at great risk for unintentional weight loss. They usually are at an advanced age, have impaired activity of daily living, or have debilitating chronic disease(s). The nutritional priority for these individuals is to increase caloric intake and achieve energy balance. The principles of healthy eating for other older adults should still apply to the greatest extent possible.

Whether they are community dwelling or institutionalized, there are several proven methods that are effective for treating the frail elderly. Selection of energy- and nutrient-dense foods or manipulating energy and nutrient density of the foods increases caloric and micronutrient intakes in these vulnerable older adults (668 [EL1, RCT]; 669 [EL1, RCT]; 670 [EL1, RCT]). Methods directed to improving the palatability of foods with various flavor enhancement techniques increase food intake, promote weight gain, and improve clinical outcomes (671 [EL1, RCT]; 672 [EL2, NRCT]). Successful strategies to increase caloric and micronutrient intake include the ingestion of between-meal snacks (673 [EL1, RCT]; 674 [EL1, RCT]; 675 [EL3, SS]; 676 [EL3, CSS]) or oral nutrition supplements (667 [EL1, RCT]; 673 [EL1, RCT]; 677 [EL1, MRCT]; 678 [EL1, RCT]; 679 [EL1, MRCT]; 680 [EL1, RCT]; 681 [EL1, MRCT]; 682 [EL4, NE]; 683 [EL1, MRCT]; 684 [EL2, NRCT]; 685 [EL1, RCT]; 686 [EL1, RCT]; 687 [EL1, RCT]; 688 [EL1, RCT]; 689 [EL2, MNRCT]) and community nutrition assistance programs that provide individuals with home-delivered meals (690 [EL1, RCT]; 691 [EL3, CSS]; 692 [EL2, PCS]). Other related issues that may be major contributors to malnutrition in the elderly must be addressed. These issues include, but are not limited to:

Social Isolation and Eating Alone

Eating is a social activity. Eating alone and in silence may be a major contributor to eating poorly. Efforts should be made by caregivers to assist the frail elderly individuals with meals and to improve the feeding environment. This holds true whether at home or in a long-term care facility. It has been shown that a cafeteria-like service that brings people together at a dining table is better than the traditional meal delivery service on trays (693 [EL2, NRCT]). Every

effort should be made to have trained person accompany frail individuals at mealtimes. Direct feeding assistance should be provided to the extent warranted by individual needs (694 [EL2, NRCT]). Depression is common among older adults in social isolation and should be screened for and treated when present.

Problems with Eating

Difficulties with eating, chewing, or swallowing are associated with inadequate food intake (609 [EL4, NE]; 695 [EL3, CSS]; 696 [EL3, CSS]; 697 [EL3, SS]; 698 [EL4, NE]; 699 [EL3, SS]). The problems may be due to poor dental care, poorly fitted dentures, gingivitis, dry mouth, or poor oral hygiene. Many of these problems are potentially reversible and should be screened for and corrected if present. Also, attention should be paid to selecting foods with appropriate consistency to best accommodate the oral and dental conditions of individual patients (700 [EL3, SS]; 701 [EL3, CSS]).

Anorexia with Chronic Medical Diseases and Polypharmacy

Anorexia has many causes (608 [EL4, NE]; 609 [EL4, NE]). Age-related reduction in appetite may be common but is usually mild. It is accompanied by age-related decline in metabolism and physical activity and may be associated with reduced taste and smell senses. Social isolation, physical disability, inability to shop or prepare tasty meals, and depression can all lead to poor appetite and undernutrition in the elderly. Importantly, many medical conditions are directly, and indirectly through polypharmacy, associated with anorexia. Caregivers and physicians should be vigilant for potentially reversible causes of anorexia. Diseases that are associated with fatigue, loss of coordination of body functions, restriction of mobility, pain, nausea, or acute malaise, may all cause anorexia.

Polypharmacy in the elderly often leads to unintended adverse effects associated with malnutrition (702 [EL4, NE]). Numerous drugs can cause dry mouth and alter taste function, resulting in poor perception of otherwise palatable foods. Some side effects of medications, such as diarrhea, nausea, and abdominal discomfort, are directly linked to poor food intake and/or absorption. Chronic laxative use in the elderly may also impair nutrient absorption or cause increased water and electrolyte loss. Additionally, drug-nutrient interactions may affect the absorption and metabolism of both the drugs and nutrients (703 [EL4, NE]; 704 [EL4, NE]). Physicians treating geriatric patients should make every effort to reduce the number of medications for their patients. This practice is important for achieving better adherence to the treatment regimens and for better nutritional care of the patients under the treatment (705 [EL4, NE]).

Healthy Eating to Reduce the Risk for Chronic Diseases in Older Adults

Dietary factors contribute to the development of chronic or degenerative diseases, and the risks for these diseases can be modified by healthy eating (98 [EL1, RCT]; 322 [El1, RCT]; 390 [EL2, PCS]; 706 [EL2, PCS]; 707 [EL4, NE]; 708 [EL4, NE]; 709 [EL4, NE]; 710 [EL4, NE]; 711 [EL4, NE]; 712 [EL2, MNRCT]; 713 [EL4, NE]; 714 [EL1, RCT]; 715 [EL4, NE]; 716 [EL3, SS]; 717 [EL4, NE]; 718 [EL3, CCS]; 719 [EL4, NE]; 720 [EL3, SS]; 721 [EL2, PCS]). The other sections of this CPG deal with these diseases, including obesity, DM, osteoporosis, hypertension, dyslipidemia, CVD, and renal disease. It is important to highlight that these chronic endocrine and metabolic diseases are more prevalent in the elderly, and more often than not co-exist in the same individual.

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DISCLOSURE

Co-Chairs

Dr. J. Michael Gonzalez-Campoy reports that he does not have any relevant financial relationships with any commercial interests.

Dr. Sachiko T. St. Jeor reports that she has received consultant honoraria from Consumer Reports.

Task Force Members

Dr. Kristin Castorino reports that she does not have any relevant financial relationships with any commercial interests.

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