PART E. FUTURE DIRECTIONS

A valuable outcome of the extensive review of scientific evidence undertaken by the Committee is a keen awareness of additional work that must be done. The Committee drafted Future Directions to highlight research recommendations that could advance knowledge in nutrition science and support future activities related to the Dietary Guidelines, both within and outside the Federal government. A number of topics require additional research or data, and these gaps in evidence should be communicated to those who fund and conduct primary research and surveillance data projects. The Committee also has insight into some of the methodological limitations and inconsistencies that pervaded the available evidence and provided suggestions to improve research design and methods and to help the research community better understand how these issues affect the confidence with which systematic review conclusions may be drawn. The Committee encourages mechanisms, including journal articles, workshops, or other approaches, to communicate the research recommendations to the audiences they target. The Committee's Future Directions described herein include support for Federal data, needs for updated Dietary Reference Intakes, and other related activities, as well as research recommendations and topics for consideration by future Committees.

SUPPORT FOR FEDERAL DATA, DIETARY REFERENCE INTAKES, AND RELATED ACTIVITIES

Support for Federal Data

The data generated in the National Health and Nutrition Examination Survey (NHANES), including What We Eat in America (WWEIA), are essential for the development of the Committee's report. The inclusion of the age group birth to 24 months, women who are pregnant or lactating, plus the lifespan approach for the Dietary Guidelines require the availability of relevant data to adequately assess food and nutrient intake and health status for these population groups. The Committee identified several specific types of data needs:

- Ensure national surveillance systems expand diversity and sample size of underreported populations. This should include those individuals in *underrepresented life stages*, such as women who are pregnant or lactating and infants and children younger than age 24 months, as well as those in *underrepresented populations*, such as Native Americans, Pacific Islanders, and Native Hawaiians. USDA databases also should be expanded by analyzing and incorporating additional foods and beverages from diverse populations. Further, national surveillance systems should incorporate survey questions that query participants on

food and beverage intake in the context of socioeconomic status, food security status, cultural food traditions, and religious or ethnic food "rules."

Rationale: All aspects of the population should be represented in the data considered and used to inform national guidance.

- Include biomarker data that are national in scope to adequately describe the nutritional status of Americans, particularly those who are currently underrepresented in national data (i.e., infants and toddlers, reproductive-aged females, women who are pregnant or lactating, and certain race and ethnic groups). For example, include biomarkers of iodine and zinc status in nutrition surveys, especially for women who are pregnant or lactating, and infants and children younger than age 24 months.

  Rationale: Very limited biomarker data are available in recent survey years. This Committee, in some instances, had to rely on biomarker data from NHANES 2003-2006 or older to inform decisions on contemporary nutritional status.

  In several chapters, concerns were raised about potential underconsumption of iodine by women who are pregnant or lactating and infants and children younger than age 24 months. Very little to no data are available on urinary iodine for children younger than age 24 months, so the extent of the problem is unknown. Iodine deficiency has been documented in other high-income countries (e.g., Norway). Only 53 percent of table salt sold at retail level in the United States in 2009 was iodized,[1] and the iodine content of cow milk in the United States is highly variable.[2] Underconsumption of iodine during infancy has important potential consequences for brain development, especially if maternal intake was also low during pregnancy.[3]

  For zinc, lack of biomarker data in nutrition surveys limits the judgments that can be made about risk of inadequacy. Zinc status of older infants fed human milk is of particular interest (see ***Part D. Chapter 5: Foods and Beverages Consumed During Infancy and Toddlerhood***). Therefore, surveys should be designed to include stratification by milk source. For children from birth to age 24 months, very little information on nutritional status is available in national surveys due to inadequate sample size and the NHANES policy of not taking blood samples for infants younger than age 1 year. Efforts are underway to conduct a pilot study on the feasibility of conducting blood draws from infants through NHANES.[4] The Committee supports these efforts.

- Improve dietary assessment methods that can more accurately estimate energy intakes feasible for use in Federal surveillance and monitoring.

  Rationale: All existing dietary assessment methods are subject to under-reporting of energy intakes in most population subgroups. Because excess energy intakes without concomitant increases in energy expenditures can lead to weight gain, more accurate assessment tools are needed. Energy intake estimates among infants are of particular concern because they appear to exceed needs for growth and development, and may result from care provider over-reporting dietary intakes.

- Harmonize the Federal sampling framework with the Dietary Reference Intakes (DRI) age groups, and develop clear definitions of life stages.

Rationale: The Committee took a life-stage approach to address the role of nutrition and health; however, a lack of consistency in terms used to define life stage exists. Furthermore, the sampling frameworks and age groupings do not align with the DRI age groupings, complicating data analysis and interpretation.

- Implement surveillance systems to gather more information about the contextual aspects of food and beverage intake, such as the frequency and/or timing of food and beverage consumption.

  Rationale: This information is important to fully understand how individuals consume specific foods and beverages to better align with nutrient requirements and changes in meal and snacking occasions across life stages.

- Continue the ongoing Federal initiative to expand research on human milk composition and how it relates to maternal and infant health.[5] Update USDA databases to establish a reference or standard human milk composition profile that incorporates data from diverse populations and across lactation, with consideration of how milk composition may be influenced by maternal diet and other factors. The ultimate goal is an accurate and current database of representative values for the energy and nutrient composition of human milk across the full course of lactation, including beyond 1 year of life. The milk samples should be collected from diverse groups of individuals and linked to dietary intake and other metadata (e.g., age, parity).

  Rationale: Human milk composition was last analyzed and updated in USDA databases in 1976. Analytical methods for human milk composition have significantly advanced over the past 4 decades and some components, such as human milk oligosaccharides, are not in the current database. In addition, the human milk samples were not collected from diverse populations of women and were not linked to metadata regarding maternal diet, supplement use, genetics (e.g., secretor status), or other factors that could influence milk composition. In addition, little information is available on milk composition during extended lactation, which limited the Committee's food pattern modeling activities for infants older than age 12 months who consume human milk. The Committee made many assumptions about the energy and nutrient composition of human milk. Much more research is needed to develop an accurate database of representative values that reflects the dynamic changes in milk composition based on the age of the infant and maternal characteristics.

- Enhance surveillance systems to enable linkage of parent-child or other family member intakes within surveys.

  Rationale: Parents play an important role in shaping children's eating habits and food preferences by serving as gatekeepers for food entry into the home and by modeling eating behaviors. The ability to link parental and care provider dietary intake data to that of their children would strengthen the ability to determine how parental and care provider dietary practices affect child health and development.

- Link surveillance systems that collect data about infant feeding and health outcomes.

  Rationale: Despite the importance of the questions that examined relationships between human milk and/or infant formula consumption and long-term health outcomes in

offspring, the available evidence for many questions was insufficient to form conclusion statements. Generally, much more evidence exists about shorter-term outcomes (e.g., in infancy and early childhood) than for long-term outcomes (into adulthood), because studies of the latter require such a long timeframe. Large datasets, especially those that follow participants longitudinally, and in particular link children with siblings and parents, would be very useful for more robustly assessing associations and providing more confidence in conclusions regarding causality.

Dietary Reference Intakes

The DRIs are essential resources for evaluating the nutritional quality of current dietary patterns for the American public, and the Committee has identified where updates are needed for the DRIs to be relevant in the Dietary Guidelines process.

- Updates to existing DRIs are urgently needed for many nutrients for all age-sex groups and life stages to better characterize potential risk of dietary inadequacy and excess.

  Rationale: Intake of choline is below the Adequate Intake (AI) for several segments of the population, and it is important to understand if this level of intake presents a public health concern for certain age-sex groups. Further progress on understanding the essentiality of choline and recommended intakes is needed. Older adults may benefit from protein intakes above existing DRI recommendations given the high prevalence of sarcopenia, and may have differential energy and nutrient needs based on presence of chronic disease, polypharmacy, changes in oral health and tooth loss, among a myriad of other potential factors that influence needs. Therefore, reassessing protein and macronutrient requirements across the lifespan is warranted. In situations in which it is difficult to meet the Recommended Dietary Allowances (RDA) in food patterns, but the specific public health concern associated with current intakes is not clear (e.g., vitamins A and E), more research and a better understanding is needed about the basis of the DRIs and the implications for underconsumption of the nutrient.

- Update and strengthen the DRI values for infants and children younger than age 24 months, as well as women during pregnancy and lactation, ideally all at once, with careful attention to new data on human milk composition.

  Rationale: Especially among infants, a limited set of Estimated Average Requirement reference values exist. As described in ***Part D. Chapter 7: USDA Food Patterns for Children Younger Than Age 24 Months***, most of the DRI values for ages 7 to 12 months are AI values, with RDA available only for iron, zinc, and protein for older infants. Several of the AI values may be overestimates, which makes food pattern modeling difficult. Moreover, the AI values at ages 7 to 12 months are generally based on expected intakes of nutrients from human milk, plus the estimated contribution from complementary foods and beverages. However, the nutrient values for human milk used for those estimates have serious weaknesses, as described elsewhere.[6] A NASEM Committee has evaluated these limitations,[7] and their findings will help set the stage for next steps. At ages 1 to 3 years, RDA values have been established for most nutrients,

but for some nutrients only an AI is available (e.g., potassium, choline) and some of these may be overestimates. Some DRI values have discrepancies with other published nutrient reference values for ages 6 to 24 months,[8] which warrants attention. This should include evaluation of Tolerable Upper Intake Levels (UL), as some of them have been challenged as being too low during this age range.[9] It should be noted that the World Health Organization has embarked on a review of nutrient reference values for this age range, starting with calcium, zinc, and vitamin D.[10] The Committee recommends coordination of efforts toward updating and harmonizing DRIs for infants and children younger than age 24 months, in conjunction with similar efforts for updating the DRIs for women who are pregnant or lactating.

- Update the *Dietary Reference Intakes for Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids*.[11]

  Rationale: The growing interest in low carbohydrate diets as well as the need to understand metabolic responses to different fatty acids indicates the importance of updating the DRIs for macronutrients. In addition, the availability of the Chronic Disease Risk Reduction Intake (CDRR) framework for the DRIs will be useful in examining appropriate recommendations for all of the macronutrients and subcategories within each classification.

Support for Activities Related to the Dietary Guidelines

The Committee was asked to address questions on diet and heath to inform food-based dietary guidance for the general public. The Committee offers support for related activities to complement the Committee's review:

- Identify collaborative efforts across the Federal government, such as convening a multidisciplinary ad-hoc Advisory Committee, to integrate systems science approaches, including consideration of dietary patterns, in treating and managing diet-related conditions and disorders, such as type 2 diabetes, obesity, and cardiovascular disease (CVD).

  Rationale: The public comments reviewed by the Committee demonstrate a strong interest in the development of dietary patterns for individuals with diet-related chronic diseases, including strategies for weight loss, to aid in the management and treatment of these conditions. In addition, such a concern also may exist for individuals with disabilities.

  Given that overweight and obesity can occur early in life and persist and increase risk of diet-related chronic conditions across the lifespan, future collaborative efforts across the Federal government must address primary preventative *and* secondary treatment strategies related to these conditions. The Committee was not charged with treatment strategies. Furthermore, although conditions such as obesity, type 2 diabetes, and CVD are related to diet, diet alone is not solely responsible for the complex, multifactorial nature of these conditions, as other genetic, biological, behavioral, socioeconomic, and environmental factors have been identified. Thus, the Committee recommends

approaches be identified, such as establishing a multidisciplinary ad-hoc Advisory Committee to integrate systems science approaches with existing socioecological frameworks to focus on this issue.

- Develop tools and technologies to help individuals manage weight and analyze and plan their diets. Develop simulation models for public use for different nutrient and food group patterns (e.g., how much added sugars can be consumed within a particular macronutrient distribution, alcohol intake level, weight maintenance).

  Rationale: Without continued funding for national monitoring and surveillance (i.e., NHANES and all data sources used within ***Part D. Chapter 1: Current Intakes of Foods, Beverages, and Nutrients***), and without consumer resources for tracking diet and physical activity (i.e., SuperTracker), it is unlikely that Americans will be able to reduce obesity and chronic disease. Without such resources, it is difficult for individuals to follow the Dietary Guidelines.

- Include a review of public health-based strategies that have been successful in promoting higher quality dietary intakes, especially in key populations that are at high risk and/or disadvantaged, including strategies that affect the price, availability, and marketing of various foods and beverages.

  Rationale: Dietary intakes have never aligned with the Dietary Guidelines recommendations. Although the Committee can identify areas in which Americans need to make improvements, the Committee was not tasked with examining how to change behaviors to improve intakes. A need exists to tailor specific messaging on how to achieve energy balance to maintain a healthy weight and improve or maintain nutrient intakes in population-specific ways across the lifespan.

- Support efforts to consider the Dietary Guidelines in relation to sustainability of the food system.

  Rationale: The achievability and maintenance of healthy food and beverage intakes is dependent on a complex number of factors that influence food access, availability, and cost. Long-term maintenance of healthy intakes requires long-term support of associated food systems. The 2017 National Academies of Sciences, Engineering, and Medicine (NASEM) report, *Redesigning the Process for Establishing the Dietary Guidelines*[12] recommended the need for research to develop a systems approach that is relevant to the Dietary Guidelines.

- Promote and support systems-based approaches to increase breastfeeding initiation and lengthen duration, with a focus on disparities by geography, income, education, and race and ethnicity.

  Rationale: Breastfeeding initiation and duration rates vary by race and ethnicity, with notably lower rates among non-Hispanic Blacks, and by infant birthweight (i.e., low birth weight infants are less likely to be fed human milk). Given the numerous health benefits to both the child and mother, understanding the barriers to breastfeeding and developing context-specific strategies to facilitate breastfeeding are needed.

- Review existing guidance relevant to high-income countries about both *what* to feed and *how* to feed infants and toddlers, to complement the Committee's reviews about *what* to feed infants and toddlers.

  Rationale: The Committee's reviews did not include topics related to *how* to feed infants and toddlers, such as feeding human milk at the breast compared to by bottle, repeated exposure to foods, and care provider feeding practices such as responsive feeding. USDA and HHS should provide some guidance on these issues, which are of critical importance with regard to outcomes such as eating behaviors, food acceptance, and obesity. Regarding *what* to feed, the Committee's reviews did not cover all possible child and maternal outcomes, so a review of existing relevant guidance would complement the conclusions reached by the Committee.

- Reexamine issues related to the iron content of infant formulas. Further characterize if and when iron intakes may be too high by evaluating the iron content of infant formulas in the U.S. marketplace and estimated iron intakes (and status) of infants consuming infant formulas with varying levels of iron as sole source nutrition and in combinations with complementary foods and beverages. Conduct consumer research to better understand care provider decisions for selection of formula based on iron content, and clinical research to evaluate potential risks of high iron intake.[13]

  Rationale: For infants ages 6 to 12 months, consuming infant formula (with 1.8 milligrams [mg] iron/100 kilocalories [kcal]; 12.3 mg iron/liter [L]) and 0.5 ounce equivalents (oz eq) of fortified infant cereal (with 15.7 mg iron/oz eq) would result in the potential for excess intakes of iron of up to about 2 times the RDA. Though this level does not exceed the UL for iron (40 mg), if infant formula were consumed containing the allowable maximum level (i.e., 3.0 mg/100 kcal)[14] in combination with iron-fortified cereal, the UL could be exceeded. Internationally, regulations regarding the iron content of infant formula vary, with debate over both the amount and the rationale. The latter has primarily focused on preventing iron deficiency and iron deficiency anemia with less consideration of potential implications of risk of excess intakes.[15]

FUTURE DIRECTIONS FOR THE DIETARY GUIDELINES PROCESS

As the Departments look ahead to support future Dietary Guidelines Advisory Committees, the Committee offers the following support for future directions to the process and topic areas that are emerging for consideration by future Committees:

- Investigate a process to identify topics that can be carried forward into a future cycle of the Dietary Guidelines without additional review by the Advisory Committee.

  Rationale: Certain issues have been included sporadically in the Dietary Guidelines and, while not covered by each Committee, should be represented in public health messaging. In some cases these topics may reflect links to related areas that are relevant to diet and nutrition (e.g., food safety, oral health, physical activity), and in other cases they may reflect nutritional issues (e.g., *trans* fatty acids, reduction in sodium

intake) that remain of public health importance but do not need additional review from a Federal Advisory Committee because of existing, current guidance from other authoritative sources. Such a process would maintain the integrity of the Dietary Guidelines while enabling the Federal Advisory Committee to focus its attention on topics of highest priority for scientific review.

- Continue reviewing the scientific evidence on nutrition and health on an ongoing basis. Conduct systematic reviews and consider meta-analysis for appropriate questions on a continuous process, including between Committees.

  Rationale: Dietary Guidelines Advisory Committees are time limited. To increase the scope of what future Committees can address, Federal agencies should continue to identify and review scientific evidence on nutrition and health between Advisory Committee cycles. This would enable Advisory Committees to focus on the most current literature and cover a wider range of topics. For example, the relationship between dietary patterns and health outcomes should be examined using a continuous model to identify and evaluate evidence as it is published in an effort to more efficiently document and update the state of the science on dietary patterns and health. Presently, Dietary Guidelines Advisory Committees are convened and the Dietary Guidelines for Americans are updated on an every-5-year cycle. As suggested by the NASEM report, *Redesigning the Process for Establishing the Dietary Guidelines*,[12] this approach may not allow for the adaptability and flexibility needed to recognize the rapidly changing environment of diet and health. Conducting systematic reviews using a continuous model would allow NESR to better document the current state of science on high-priority topics, particularly those that serve as the foundation for the Dietary Guidelines. A more continuous model would be beneficial for a number of reasons, as outlined in the NASEM report. Not only would it enhance continuity between each cycle, it would allow for increased engagement from a range of subject-matter experts, as well as other stakeholders and the general public.

- Conduct research to implement systems approaches into the Dietary Guidelines process.

  Rationale: Improvements in developing the Committee's report were implemented in response to the NASEM report on the Dietary Guidelines process, to make the process more transparent, inclusive, and science-driven. The Committee encourages future research to apply a systems approach into the Dietary Guidelines process. Such an approach would examine multilevel social ecologic determinants such as the large array of determinants of food choice (e.g., food palatability, food cost, convenience, advertising, and exercise patterns) and the contribution of the food environment (e.g., household factors such as cultural practices, community factors like food store availability, and food policies) on food and beverage intake.

- Develop a systematic approach to examine dietary drivers of overweight and obesity across the lifespan.

  Rationale: Given that overweight and obesity are such critical public health problems and underlie multiple health outcomes of interest, for future Dietary Guidelines Advisory Committees, this outcome should be addressed in a focused, systematic way. For example, one Subcommittee could focus on dietary drivers of obesity across the

lifespan, or Subcommittees could develop a systematic approach to considering overweight and obesity, sorting between weight-related impacts and dietary influences independent of weight.

- Consider the role of the gut microbiome in future guidelines.

  Rationale: Diet is one of the key moderators of the composition and function of the microbiome. Dysbioses have been associated with many of the same chronic and immune-mediated diseases that are associated with less healthy dietary patterns. These findings suggest that the microbiota may mediate or moderate some diet-disease associations. Advances in understanding of the role of the microbiome in health outcomes could inform future dietary guidance.

- Examine the relationship between nutrition and immune function.

  Rationale: As the epidemic caused by COVID-19 has evolved, those at most risk of the most serious outcomes of COVID-19, including hospitalization and death, are people afflicted by non-communicable diseases (e.g. obesity, type 2 diabetes, and CVD). This association indicates the importance of understanding how the dietary patterns most associated with risk of these chronic diseases also may affect immune response and response to infectious diseases. Additionally, as many nutrients are involved in immune function, the 2025 Committee should examine associations between nutrient status and immune function. Because of the disparities across race and socioeconomic status in dietary intake and rates of non-communicable diseases, research should focus on underserved populations.

- Consider the role of genetics and epigenetics in future guidelines (e.g., single nucleotide polymorphisms (SNPs) for fatty acid metabolism; folate metabolism).

  Rationale: SNPs may alter how people absorb, transport, synthesize, or metabolize nutrients. Folate has two methylenetetrahydrofolate reductase (MTHFR) gene variants, called C677T and A1298C, which are common. In the United States, about 25 percent of people who are Hispanic, and 10 to 15 percent of people who are non-Hispanic White have two copies of C677T. Other SNPs have been associated with a higher risk of having an infant with a neural tube defect.

  Epigenetic factors may also influence the effect of dietary fats on CVD risk factors. Dietary and environmental factors can change the expression of genes. Early in life, the plasticity of the epigenome in response to the diet is thought to be important for health, but empirical data are needed. The underlying relationship of diet in early life and its influence on epigenetics requires further study. In early infancy, the preferred single food source is human milk with its very specific fatty acid profile that is eventually complemented at approximately 6 months with fats found in complementary foods and beverages.

RESEARCH RECOMMENDATIONS AND CONSIDERATIONS FOR FUTURE COMMITTEES RELATED TO THE TOPICS AND QUESTIONS

The Committee identified research needs as well as considerations for future Committees related to the topics and questions examined in its review. The Committee encourages *funders* to use this information when prioritizing research to support and *researchers* to consider these topics and recommendations when conducting research. The Committee encourages the next Committee and the Departments to carefully consider all the research recommendations listed below when developing any future questions or topics for the next Dietary Guidelines Advisory Committee. This section begins with overarching methodological considerations and follows with more specific research needs and considerations for future Committees that have been identified by chapter. In addition to the research recommendations provided in the report, the Committee identified specific research recommendations for systematic reviews conducted with support from USDA's Nutrition Evidence Systematic Review (NESR) team. These research recommendations can be found in each of the 2020 Committee's systematic reviews, which are available on NESR's website at nesr.usda.gov/2020-dietary-guidelines-advisory-committee-systematic-reviews.

Overarching Methodological Considerations

- Broadly consider diverse populations with varying age groups and different racial, ethnic, and socioeconomic backgrounds. Consider diversity in multiple areas of future diet and health research as well as consideration of socioeconomic factors, such as food security and access to healthy foods.

  Rationale: Lack of data inhibits the scientific community from being able to assess health and develop guidance for diverse populations. This information is needed to inform relevant guidance for all Americans and to support more effective public health strategies.

- Consider the degree to which a reported dietary exposure reflects true customary intake over the timeframe of a prospective cohort trial.

  Rationale: A strength of prospective cohort studies is their ability to assess the impact of a dietary exposure (e.g., a dietary pattern, nutrient intake) on health outcomes over a long time period in a large number of people. However, it is well known that dietary exposures change over the lifespan. Consequently, it is not clear whether an exposure at one time point adequately reflects the customary intake of the individual (or population) at another time point over an extended time period (e.g., years to decades). If the nature or strength of exposure changes over the follow-up period, the predictive value of the exposure assessment at baseline may be incorrect, leading to less than accurate estimates of the importance of the dietary exposure and any recommendations that may stem from it. Thus, it is strongly recommended that the dietary exposure be

assessed regularly over the follow-up period to establish the degree to which dietary intake remains stable within and between individuals. Not only should dietary exposures be reassessed regularly, but the degree to which they confirm the validity of the baseline assessment or indicate changes may have occurred should be included in published reports. An attempt to administer the prospective cohort trial's dietary collection method systematically over the lifespan of the cohort would assist with addressing this potential shortfall.

- Develop strategies to classify dietary habits and behaviors from existing assessment methods.

  Rationale: Many decisions were made in the work of the Committee to classify individuals' dietary behaviors based on one 24-hour dietary recall. For example, the Committee classified infants into human milk-fed and formula-fed and mixed-fed groupings based on 1 report, which may or may not accurately reflect habitual patterns. Similarly, the Committee examined the number of eating occasions and how that related to dietary intakes, based on 1 report, which may or may not reflect usual meal and snack patterns or the timing of consumption.

  The addition of recommendations for all stages of the lifespan is important for the Dietary Guidelines. For such guidelines to be effective and science-based, research knowledge on these dietary habits and behaviors is essential.

- Use validated and reliable age-appropriate outcome assessment methods for children that do not rely only on parental report, particularly for developmental domains, when conducting research on dietary intake and neurocognitive development among children. Include accurate reporting of adverse and detrimental effects.

  Rationale: Existing neurocognitive assessment tools and what they measure vary greatly, thereby limiting ability to compare results across studies. Determining standardized, validated, and commonly used assessment tools in this field need to be identified and linked with the relevant dietary data. Culturally specific and age-appropriate assessment tools are needed as well as better methods for parental report of outcomes. Use of validated assessment tools would allow comparison of results across studies and strengthen the evidence base.

- When examining CVD outcomes, conduct studies to determine how diet affects risk of stroke vs risk of coronary heart disease (CHD) and CHD mortality.

  Rationale: The dietary factors that affect risk of stroke appear to differ from those related to CHD and CHD mortality. Further research is needed to inform nutrition recommendations that reduce the risk of all forms of CVD.

Current Dietary Intakes Through the Life Course

Chapter 1: Current Intakes of Foods, Beverages, and Nutrients

- Collect nationally representative longitudinal data to inform future Dietary Guidelines.

Rationale: To understand how early life nutritional exposures relate to risk of chronic disease, including obesity, taste preferences, and shaping of dietary patterns, longitudinal data with multiple assessments of dietary intake over time in the same population are needed. With this type of research, a better understanding could be gained of how to tailor initial dietary patterns to foster taste and acceptance of fruits, vegetables, and whole grains, echoing the *Dietary Guidelines* recommendations. Longitudinal data will enhance understanding of life transitions and how these relate to diet and health. Transitions are not only age-specific (e.g., starting school, career, retirement) but can also be contextual (e.g., food security), or biological (e.g., perimenopause to menopause).

- Develop a dietary pattern scoring system, such as the Healthy Eating Index (HEI), for infants and children from birth to age 24 months, considering findings from this report and future dietary guidance.

  Rationale: Comparisons of diet quality are not possible from birth to less than 24 months of age, as HEI recommendations do not exist.

- Investigate approaches to better quantify and describe existing contemporary dietary patterns in national survey data.

  Rationale: Existing dietary patterns have been compared with the HEI. As dietary patterns are not aligned with the HEI, a better quantitative assessment of existing dietary patterns in the United States is needed (aside from the HEI). The nature of this assessment illustrates discrepancies between the recommendations inherent in the HEI and actual dietary patterns; however, it does not define the existing contemporary dietary patterns. Being able to define these existing patterns can be useful to encourage changes to improve dietary quality. Previous NHANES survey years included questions about self-reported patterns, such as vegetarian, that would aid future research in this area.

- Examine how overall income and food security status interact to predict dietary intakes and the resulting diet quality.

  Rationale: The *2015-2020 Dietary Guidelines* includes a socio-ecological model to illustrate the many complex factors that affect food choices, including food security. Although the 2020 Committee did not review evidence in this area, it recognized that food security and access to healthy food choices are significant factors that affect the ability of individuals and households to follow recommendations in the *Dietary Guidelines for Americans*. Research is necessary to understand the impact of these factors on diet quality so that recommendations reflect an understanding of these factors in encouraging better quality diets for all Americans. Taste and cost have been reported as primary drivers of food choice; future work should address these dimensions.

- Examine the interaction between the nutrition status of the mother and the health of the child. Risk of iron deficiency anemia among pregnant women and how that affects infant iron stores and cognitive development should be an area of priority.

Rationale: Most breastfed infants do not meet iron requirements from the diet alone and may depend on innate iron stores early in life that vary based on many factors identified in relation to the birth to 24 months age group, such as delayed cord clamping.

- Examine how the diets of women who are pregnant or lactating shape dietary preferences of offspring.

  Rationale: Maternal diet during pregnancy and lactation may provide the earliest opportunity to positively influence child food acceptance. A systematic review conducted as part of the Pregnancy and Birth to 24 Months project[16] concluded that limited but consistent evidence suggested that some flavors originating from the maternal diet during pregnancy can transfer to and flavor amniotic fluid, and that fetal flavor exposure increases acceptance of similarly flavored foods when re-exposed during infancy and potentially childhood.[17] Additional research is needed because existing findings may not generalize to all foods and beverages and the relationship between mothers' diet during either pregnancy or lactation and children's *overall dietary intake* has not been examined. Further investigation would benefit the birth to age 24 months population and beyond.

- Develop research methodologies to determine diet quality that can be used to compare diets with the HEI.

  Rationale: For some questions the Committee examined, the Committee was unable to measure diet quality with the HEI relative to specific dietary components because the component was a part of the HEI. Added sugars is one example.

- Examine optimal dietary factors to support healthy aging, including preventing age-related cognitive decline.

  Rationale: Various food components, such as vitamin B_{12}, have been related to cognitive function. Although the Committee did not specifically address cognitive health data and biomarker data from NHANES, 8 percent of older women have low dietary intakes of vitamin B_{12}. Future Committees may wish to examine optimal nutritional intake for prevention of cognitive decline, focusing on a wide range of food components and dietary patterns.

Diet and Health Relationships: Pregnancy and Lactation

Overarching Research Recommendations

- Strengthen research designs for studies conducted during pregnancy and lactation to support future recommendations.
  - Begin the study design process with dietary questions in mind so that appropriate dietary assessment tools and timing of assessment to exposure can be used.
  - Conduct additional well designed and sufficiently powered RCTs to expand the evidence base, which currently relies on cohort studies.

  - Conduct meta-analyses on questions related to key nutrients and food groups.
  - Develop and validate novel dietary assessment tools to accurately capture the complexity of dietary habits.

- Future research should use standardized outcomes (e.g., birthweight adjusted for gestational age and sex, standardized neurocognitive tests conducted at specific times, inclusion of length with growth data) to enable valid comparisons between studies.

  Rationale: The use of a standardized birth size measure would enable valid comparisons between and within countries.

- Foster collaborative efforts across different regions and populations so that dietary patterns can be consistently scored, compared, and reproduced across studies.

  Rationale: The inclusion of participants from diverse cultures and geographical locations will enhance knowledge about the generalizability of the data on dietary patterns during pregnancy and lactation and enable specific approaches to the dietary patterns observed in diverse populations

- Broaden the consideration and control of confounding variables when conducting studies with women who are pregnant or lactating, particularly for confounders such as prepregnancy body mass index (BMI), gestational weight gain (total and rate of gain), and postpregnancy BMI.

  Rationale: These confounding variables significantly influence the outcomes measured in studies on diet during pregnancy and lactation. The validity of such studies depends on appropriate inclusion and control of these variables.

Chapter 2: Food, Beverage, and Nutrient Consumption During Pregnancy

- Investigate how preconception nutrition and diet, including BMI and metabolic health, are related to maternal and child outcomes.

  Rationale: Include women before and during pregnancy and design studies to determine whether dietary patterns and other nutrition exposures, including supplements, are more critical during certain time periods than others, for maternal and child outcomes.

- Evaluate the relative contribution of nutrients from all sources of foods and beverages, including fortified foods and supplements among women who are pregnant, with a focus on omega-3 fatty acids, folate, iron, vitamin D, choline, and iodine. Identify strategies to help women attain sufficiency and avoid excess to balance intake from foods, including fortified foods, and supplements.

  Rationale: For iron and folate/folic acid, a potential exists for excess intake. Therefore any research on health outcomes should consider intake from all sources (food folates, folic acid fortification, and folic acid supplementation) before developing guidance for women who are pregnant. Research should focus on refining the understanding of the recommended levels of folate fortification of foods and folic acid consumed as a dietary

supplement, both individually and in combination, in pregnant women, including the potential for masking vitamin B_{12} deficiency.

- Build upon the existing research to identify how maternal dietary patterns, including beverages and foods, as well as specific components, including intakes of seafood, omega-3 fatty acids, choline, iodine, iron, and folate, are related to child development (i.e., child language and physical development, autism spectrum disorder, cognitive development, social emotional development, academic performance, attention deficit disorder/attention deficit hyperactivity disorder [ADD/ADHD], anxiety and depression).

  Rationale: Some evidence exists on the relationship of omega-3 supplementation to these outcomes, yet much less is available on choline, iodine, and folate. All of these nutrients and foods are important for brain development and need to be considered jointly when considering these outcomes.

- Identify dietary patterns (including frequency of eating and beverages in addition to foods) that support recommended gestational weight gain (GWG), prevent excess postpartum weight retention, and reduce maternal morbidity and mortality, especially among high-risk women (e.g., those with high BMI before pregnancy, history of adverse pregnancy outcomes).

  Rationale: Current evidence is insufficient to explain the relationship between multiple important aspects of dietary patterns and the significant diet-related health outcomes of GWG, postpartum weight retention, and morbidity and mortality in pregnant women.

- Evaluate the role of meal frequency and macronutrient composition during pregnancy on measures of maternal and child metabolic health (gestational diabetes mellitus, small for gestational age, and large for gestational age).

  Rationale: The 1990 *Nutrition During Pregnancy* [18] included guidance to eat 3 meals and 2 snacks daily, but this guidance lacked a clear evidence base. The 2009 *Weight Gain During Pregnancy: Reexamining the Guidelines* [19] did not extend this guidance. However, the Academy of Nutrition and Dietetics has similar guidance ("3 meals and 2 or more snacks helps to distribute carbohydrate intake and reduce postprandial blood glucose elevations") for women who have gestational diabetes. For macronutrient composition, the DRIs recommend a minimum of 175 grams (g) of carbohydrate, 71 g of protein (or 1.1 g/kg/d protein) and 28 g fiber per day for women who are pregnant, including those who have gestational diabetes. The Academy of Nutrition and Dietetics concurs with this guidance, and recommends individualized amounts and types of carbohydrate, with an emphasis on controlling carbohydrate intake at breakfast to improve postprandial blood glucose for women who have gestational diabetes. Additionally, no clear consensus on recommended macronutrient intakes has been established for women with gestational diabetes. For example, national guidance on the percent of energy coming from carbohydrate ranges from 33 to 60 percent (e.g., American College of Obstetricians and Gynecologists recommends 33 to 40 percent; American Diabetes Association none; Academy of Nutrition and Dietetics about 37 to 60 percent; Endocrine Society 35 to 45 percent; International Federation of Gynecology and Obstetrics 35 to 45 percent). This evaluation is important to inform development of dietary guidelines.

- **For the next Committee**: Examine a question on the dietary determinants of maternal iodine status (in both pregnancy and lactation) and the relationship between maternal iodine intake and maternal and child outcomes, including child development.

  Rationale: Low iodine intake is of public health concern among women who are pregnant, based on biomarker data that suggest low nutrient status (see ***Part D. Chapter 1***). Prenatal iodine deficiency may lead to irreversible neurocognitive defects and lower childhood IQ. In addition, food values for iodine need to be included in the USDA database, so that intakes across the lifespan can be estimated.

- **For the next Committee**: Examine questions on the relationship between maternal dietary supplement and/or fortified food intake of vitamins B_{12}, vitamin D, iron, and choline and maternal and child outcomes.

  Rationale: Given the importance of these nutrients to achieve optimal pregnancy outcomes, and the fact that they are all nutrients of concern among females of reproductive age, additional attention should be given to these nutrients by future Dietary Guidelines Advisory Committees.

- **For the next Committee**: Examine a question on the relationship between omega-3 fatty acid supplements consumed before and during pregnancy and pregnancy outcomes.

  Rationale: The Committee did not assess the effect of omega-3 fatty acid supplements consumed before or during pregnancy and pregnancy outcomes. However, seafood emerged as a component that was higher in dietary patterns associated with a reduced risk of excessive GWG, gestational diabetes, hypertensive disorders during pregnancy, and preterm birth. Although seafood contain nutrients other than omega-3 fatty acids, systematic reviews have associated omega-3 supplements with preventing early or any preterm delivery.[20,21] Less evidence is available for other pregnancy outcomes. However, relevant trials are underway, and future Committees should have available evidence to consider both seafood and omega-3 supplementation on pregnancy and longer-term infant outcomes.

Chapter 3: Food, Beverage, and Nutrient Consumption During Lactation

- Evaluate the relative contribution of nutrients from all sources of foods and beverages, including fortified foods and supplements among women who are lactating, with a focus on omega-3 fatty acids, folate, iron, vitamin B_{12}, vitamin D, choline, and iodine. Identify strategies to help women attain sufficiency and avoid excess to balance intake from foods, including fortified foods, and supplements.

  Rationale: For iron and folate/folic acid, a potential for excess intake exists. Therefore, any research on health outcomes should consider intake from all sources before developing guidance for women who are lactating. Research should focus on refining the understanding of the recommended levels of folate fortification of foods and folic acid consumed as a nutrient supplement both individually and in combination, in women who are lactating.

- Develop research in women who are lactating that focuses on an examination of maternal dietary intake patterns and child development (child language development, autism spectrum disorder, cognitive development, social emotional development, academic performance, ADD/ADHD, anxiety, and depression) emphasizing foods rich in key nutrients for which a relationship between maternal intake and human milk composition has been established (e.g., seafood and/or polyunsaturated fatty acids, choline, iodine, and B vitamins in relation to brain development).

  Rationale: Human milk is the preferred single source of nutrition for infants during a critical period of brain development. Insufficient evidence is available to determine the relationship between maternal dietary intake patterns, the presence of nutrients in human milk that play a key role in central nervous system development, and multiple diverse cognitive and behavioral developmental outcomes in breastfed infants and children.

- Conduct studies that consider the duration and intensity of human milk feeding (proportion of milk feedings coming from human milk) when assessing the relationship between maternal dietary patterns, including frequency of eating, and postpartum weight loss (PPWL), and assess PPWL/postpartum weight retention (PPWR) at multiple time points, rather than just a onetime measure.

  Rationale: Maternal obesity is both a risk factor for, and a consequence of, excessive GWG and/or excessive postpartum weight retention. The majority of women with overweight or obesity exceed GWG recommendation[22,23] and fewer than half of women revert to pregravid weights following pregnancy[24-28] and postpartum weight retention results in about 1 in 7 women moving from a normal weight classification prepregnancy to an overweight classification.[23] Energy requirements during lactation account for mobilization of adipose stores; therefore, the duration and intensity of human milk feeding has the potential to reduce postpartum weight retention and reduce obesity risk of the mother.

- Identify optimal intake of fatty acids during lactation to attain optimal levels of fatty acids in human milk with respect to infant outcomes.

  Rationale: It is known that maternal dietary intake affects fatty acids in human milk and fatty acid intake of the infant is related to development. However, the optimal intake of fatty acids by the mother is still unknown.

Diet and Health Relationships: Birth to 24 Months

Chapter 4: Duration, Frequency, and Volume of Exclusive Human Milk and/or Infant Formula Feeding

- **For the next Committee:** Review evidence about human milk feeding and *maternal* health outcomes (e.g., postpartum weight loss, diabetes) to complement reviews about human milk feeding and *offspring* health outcomes.

Rationale: HHS and USDA should include maternal health outcomes within the evidence base underlying its recommendations about human milk and/or infant formula consumption, such as the optimal duration of exclusive human milk feeding and of any human milk feeding. The cumulative duration of lactation over a woman's lifetime is a key exposure to examine with regard to certain long-term maternal health outcomes. Recommendations regarding feeding of infants and toddlers younger than age 2 years should ideally take into account the benefits and risks of all relevant outcomes, which includes outcomes in mothers who are lactating as well as their offspring.

- **For the next Committee:** Consider examining relationships between infant milk-feeding practices and infant mortality, infectious diseases, and child development.

  Rationale: An examination of infant mortality, infectious diseases, and child development will enable the next Committee to strengthen the advice provided to the HHS and USDA by this Committee related to human milk and/or infant formula consumption. For example, evidence about infant mortality (e.g., Sudden Infant Death Syndrome [SIDS]) could strengthen the foundational advice provided by this Committee to recommend human milk consumption. U.S. data about SIDS may be available to provide important and relevant evidence for the next Committee. This Committee was unable to examine child neurobehavioral outcomes. Child development and infectious diseases (e.g., gastrointestinal, respiratory, and ear infections) are important childhood outcomes, and examining them could allow the next Committee to provide stronger advice about human milk and/or infant formula consumption, and perhaps to advise the HHS and USDA about the consumption of human milk beyond age 12 months.

- Investigate how the patterns and proportions of human milk feeding across the day and night and within each feeding, in the context of mixed feeding, are related to health outcomes in offspring.

  Rationale: Despite the high prevalence of mixed feeding in the U.S. population, the Committee was unable to make recommendations about how much human milk an infant should consume relative to infant formula due to the paucity of evidence.

- Conduct studies to examine the relationship between consuming human milk by bottle vs from the breast and health outcomes in offspring.

  Rationale: Very little evidence was available for the Committee to review the consequences of feeding human milk by bottle vs from the breast. The composition of human milk varies during the day and within a feeding, which may affect the infant's physiology[29]; bottle-feeding human milk may modify these patterns. In addition, some evidence suggests that the feeding dynamics of breast- and formula-feeding mothers and their infants differ, which also deserves further investigation.

- Conduct studies that examine outcomes related to extended human milk consumption (e.g., durations longer than 12 months) in comparison to shorter durations, and study the duration of any human milk consumption among infants fed human milk (i.e., assess infants who were never fed human milk separately from infants who were fed human milk).

  Rationale: To provide the USDA and HHS with stronger recommendations about the optimal duration of human milk consumption, the next Committee will need more

evidence that includes infants fed human milk longer than 1 year. Studies that group infants who were never fed human milk with infants who were fed human milk for short durations, and compare them with infants who were fed human milk for longer durations, make it difficult to interpret whether a difference in a health outcome relates to the initiation or the duration of human milk consumption.

- Conduct research that clarifies any unique contributions of the duration of exclusive human milk feeding and the timing of the introduction of complementary foods and beverages on health outcomes.

  Rationale: Current literature that examines the duration of exclusive human milk feeding (which may terminate with complementary feeding) and the timing of the introduction of complementary foods and beverages (which may immediately follow a period of exclusive human milk feeding) may overlap substantially. However, the degree of overlap is difficult to ascertain. Infant feeding research does not often specify whether exclusive human milk feeding is followed by complementary feeding or formula feeding or both, and complementary feeding research does not often specify whether complementary foods and beverages are introduced to infants fed human milk exclusively or fed infant formula in some amount. Future researchers should be mindful about this potential ambiguity when designing and conducting research about the duration of exclusive human milk feeding or the timing of the introduction of complementary foods and beverages and strive to clarify any unique contributions of each of the 2 feeding practices on health outcomes.

- Conduct RCTs of breastfeeding promotion (like the Promotion of Breastfeeding Intervention Trial, or PROBIT), especially in populations that have the lowest rates of breastfeeding in the United States. Also conduct observational studies about human milk and/or infant formula consumption and health outcomes in offspring that are designed to reduce bias from confounding factors as much as possible, such as sibling-pair studies, and studies that use instrumental variables, such as Mendelian randomization approaches.

  Rationale: Infant-feeding research can be prone to bias from confounding because infant feeding is strongly socially patterned. Randomization mitigates confounding, but it is unethical to randomize infants to feeding conditions. RCTs of breastfeeding promotion (such as the PROBIT trial in Belarus) can be useful for studying relationships between infant feeding and health outcomes if they achieve substantial differences in duration or exclusivity of breastfeeding between intervention groups. Sibling-pair studies reduce bias from confounding because siblings share genetic and environmental factors. Few such studies exist, and they tend to have much smaller sample sizes than other types of observational studies. Large sibling-pair studies are needed, and such studies need to examine siblings that differ in terms of the duration of human milk consumption (e.g., <6 months, ≥6 months) and not just with respect to ever vs never consuming human milk. Observational studies need to pay careful attention to minimizing confounding, and using instrumental variables, such as Mendelian randomization, may be beneficial.

- Consider effect modification and biological mechanisms when designing studies that examine relationships between infant feeding and health outcomes.

Rationale: Different biological or environmental factors may modify the relationships between infant feeding and health outcomes, and may be important to consider when developing dietary guidance. For example, the relationship between human milk feeding and child overweight may differ between infants of mothers with high vs low BMI. Inclusion of maternal and child characteristics that relate to potential biological mechanisms for the associations between infant feeding and health outcomes can provide insight into subgroups that could be targeted for specific guidance. For example, assessment of human milk composition (e.g., nutrients, immune components and human milk oligosaccharides) as well as maternal and infant intestinal microbiota composition may reveal host-microbe-nutrition interactions in the pathogenesis of atopic diseases.

- Identify ways to study large, prospective, representative U.S. samples from the period of infant feeding into adulthood, such as accessing electronic medical record data and create funding opportunities to examine existing data sources from vanguard national child studies.

  Rationale: Scant evidence examined the relationships between human milk and/or infant formula consumption and outcomes in offspring beyond childhood, such as type 2 diabetes and CVD. Studies from representative U.S. samples is especially important because the United States has a higher prevalence of type 2 diabetes and CVD than some of the other countries that conduct long-term studies, and so the evidence from such non-U.S. studies may have limited generalizability in the United States.

- Evaluate the most useful biomarkers of nutrient status for infants and children younger than age 2 years, and cutoff values appropriate for identifying both deficiency and excess in this age group. Nutrients of interest include those addressed by the 2020 Committee (iron, zinc, iodine, vitamin B_{12}, vitamin D, and fatty acids), but may also include some that were not addressed (e.g., choline, iodine).

  Rationale: Heterogeneity in the methods used to assess nutrient status in the systematic reviews about infant feeding and nutrient status exist, in part, because of uncertainty about the most appropriate biomarkers to use in this age group. During infancy, in the average values of certain biomarkers change profoundly between birth and 12 months, such as hemoglobin and markers of iron status, due to normal physiological changes. This makes the identification of appropriate cutoff values challenging. Serum zinc is useful as a marker of zinc status at the population level, but has serious limitations for use at the individual level. For fatty acid status, interpretation of results may differ depending on whether serum/plasma values or red blood cell values are assessed, whether samples are collected in a fed or fasted state, and on how the results are expressed (e.g., as percentage of total fatty acids, or as concentrations).

Chapter 5: Foods and Beverages Consumed During Infancy and Toddlerhood

- **For the next Committee:** Review evidence about *how* to feed infants and toddlers to complement reviews about *what* to feed infants and toddlers. Important topics may include feeding human milk at the breast compared to by bottle, repeated exposure to foods, and care provider feeding practices, such as responsive feeding.

  Rationale: Little evidence is currently available on the *how* of feeding infants and toddlers. Such evidence could help USDA and HHS in providing guidance on how, as

well as what, to feed infants and toddlers. Both aspects of feeding are of critical importance with regard to outcomes such as eating behaviors, food acceptance, and obesity.

- Conduct research investigating the relationships between the consumption of sugar-sweetened beverages and juice during the complementary feeding period and obesity in childhood and other measures of growth, size, and body composition.

  Rationale: The systematic reviews that examined types and amounts of complementary foods and beverages and growth, size, and body composition identified limited evidence about intakes of sugar-sweetened beverages and juices and their relationship with growth, size, and body composition. This relationship is important to examine to strengthen existing dietary guidance regarding beverages for this age group.

- Conduct RCTs to examine the relationships between complementary feeding and key outcomes. For example, conduct RCTs to examine specific types of foods consumed during infancy and toddlerhood and risk of developing atopic disease, and the timing of the introduction of complementary foods and beverages and child development.

  Rationale: With 2 notable exceptions (i.e., peanut intake and food allergy to peanut, egg intake and food allergy to egg), the systematic review that examined types and amounts of complementary foods and beverages and food allergy and atopic allergic diseases identified insufficient evidence or limited evidence that examined the relationships between most food types and atopic disease outcomes. Similarly, insufficient evidence existed to draw conclusions about the timing of introduction of complementary foods and beverages and child development. Some of the available evidence had methodological limitations that are important to address in future studies.

Chapter 6: Nutrients from Dietary Supplements and Fortified Foods During Infancy and Toddlerhood

- Evaluate how best to identify and treat infants who become iron deficient before 6 months of age, including populations with racial and ethnic diversity, and investigate the biological mechanisms by which iron supplementation during infancy may affect growth, including potential effects on morbidity, the microbiome, zinc and copper status, and oxidative stress or lipid peroxidation.

  Rationale: Evidence suggesting slower growth among infants given iron supplements suggests that routine iron supplementation of all breastfed infants may not be advisable. An alternative could be to screen for iron deficiency among higher-risk infants younger than age 6 months, and provide iron supplements only to those with biomarkers indicating iron deficiency, but more research is needed to ensure the proper identification and treatment of such infants.

- Investigate how much (if any) vitamin D supplementation is needed for breastfed infants when the mother is taking high doses of vitamin D, and when the infant has short periods of sun exposure in certain latitudes. Future studies should be appropriately powered, include

racially and ethnically diverse samples, and report baseline vitamin D status, human milk vitamin D content, and sun exposure.

Rationale: The body of evidence the Committee reviewed does not provide a basis for recommending vitamin D supplementation above 400 IU per day during infancy (the current AAP recommendation).[30] Additional research can help guide future decisions about whether and how much vitamin D from supplements is necessary for breastfed infants under specific conditions.

Chapter 7: USDA Food Patterns in Infants and Children Younger than Age 24 Months

- **For the next Committee:** Use tools, such as linear programming, for food pattern modeling. This is particularly important for ages 6 to 24 months given the challenges of meeting nutritional goals during this age range.

  Rationale: Using tools such as linear programming and other types of optimization modeling allows for incorporation of multiple nutritional constraints and food sources of nutrients simultaneously, to identify combinations of foods and beverages that meet all nutritional goals. These analyses should be designed to take into account nutrient bioavailability (especially iron, zinc, and calcium) from various food sources, including human milk. The 2017 NASEM report, *Redesigning the Process for Establishing the Dietary Guidelines*,[12] recommended that food pattern modeling should be enhanced "to better reflect the complex interactions involved, variability in intakes, and range of possible healthful diets." In future work, the Committee also should consider models that allow for amounts of individual foods to vary within each food group, not just the current nutrient profiles approach using representative nutrient-dense foods selected based on current intake patterns in the United States.

- **For the next Committee:** Using tools such as linear programming, develop food patterns for infants and toddlers fed human milk.

  Rationale: The 2020 Committee was not able to develop food patterns for these subgroups because of uncertainties regarding DRI values and challenges presented by using the nutrient profiles approach for food pattern modeling. The Committee presented example combinations of foods and beverages that meet most nutritional goals for infants and toddlers fed human milk, but these are not formal USDA Patterns. With tools such as linear programming, as described above, and ideally with updated DRI values for the key limiting nutrients, the next Committee will be in a strong position to continue work on developing food patterns for these subgroups.

- Investigate whether advice to not add salt to complementary foods and beverages puts certain infants or toddlers at risk of iodine or sodium inadequacy.

  Rationale: Infant feeding guidance usually recommends that salt not be added to foods for infants. This has implications not only for adequacy of sodium intake, but also adequacy of iodine intake, as iodized salt is a key contributor to the latter. If infants are fed some prepared foods to which salt has been added, sodium intakes may not be low,

but if the recommendation to avoid added salt were fully implemented, underconsumption may be a concern. Insufficient information is currently available to judge whether iodine intakes are adequate among infants not consuming iodine-fortified infant formula, and among toddlers in general.

- Conduct analyses to determine whether the vegetarian pattern for toddlers supports adequate iron and zinc status.

  Rationale: Most of the iron in the Vegetarian-Style Pattern developed for toddlers comes from whole grains, soy products, nuts and seeds, and legumes, from which bioavailability of iron is likely to be low due to relatively high levels of phytate and absence of heme iron (IOM 2001).[31] Zinc absorption also is affected by high phytate levels. Further work is needed to evaluate whether the foods and beverages in this pattern can adequately support iron and zinc status during the second year of life.

- Conduct research to determine the proportion of toddlers ages 12 to 24 months who continue to receive human milk, and in what amounts.

  Rationale: Little information is available on the amounts of human milk consumed after age 12 months. This information is needed for food pattern modeling in this age range. Methods using stable isotopes (dose to the mother) can be used to obtain this information. In addition, little information is available on human milk composition after 12 months postpartum.

Diet and Health Relationships: Ages Two Years and Older

Chapter 8: Dietary Patterns

- Develop a standard definition of low-carbohydrate diets, with gradations at specified cut-offs for all macronutrients, to inform the systematic assessment of diets based on macronutrient distribution where proportions fall sufficiently outside of the Acceptable Macronutrient Distribution Range (AMDR).

  Rationale: No standardized cut-offs below the AMDR have been established to define what level of carbohydrate proportion is considered to be “low” or “very-low.” Although a growing body of evidence suggests benefits of a carbohydrate-restricted diet, the lack of a standard definition makes it difficult to systematically assess whether diets restricting carbohydrate levels may aid in the treatment of chronic diseases. Based on the Committee’s reviews, which comprehensively examined any evidence with regard to carbohydrate levels below the AMDR, regardless of how extreme, insufficient or limited evidence was available to support diets with carbohydrate levels below the AMDR in the context of disease prevention. However, additional research in this topic area is needed and should be guided by a universal understanding of the AMDR cut-offs considered to be “low” and very-low” carbohydrate.

- Conduct additional research examining a constant dietary pattern (i.e., describes the foods and beverages consumed and controls for diet quality) that varies by macronutrient distributions with carbohydrate below 25 percent of energy to determine whether a

relationship exists between “low-carbohydrate” dietary patterns and the prevention of diseases, such as obesity, CVD, and type 2 diabetes.

Rationale: Few studies that examine diets based on macronutrient distribution do so with a relatively constant dietary pattern between groups that would isolate the effects of the macronutrient distribution from the variation in the foods and/or beverages (i.e., diet quality) consumed. Specific dietary patterns with carbohydrate levels below 25 percent of energy may be detrimental to long-term health if they are poor in diet quality, whereas higher quality dietary patterns with carbohydrate levels below 25 percent of energy may be beneficial. However, this relationship is not currently known. Conducting this research could expand knowledge in this area and inform whether the public may benefit by consuming specific dietary patterns with varied macronutrient levels.

- Expand knowledge about the relationship between dietary patterns and bone health by examining additional outcomes and dietary factors beyond calcium and vitamin D that may affect bone health.

  Rationale: Currently available studies are lacking information on a broad spectrum of bone health outcomes across the lifespan, as well as data on the effect of complete dietary intake on bone health. This may be due to limited data on bone health outcomes in younger populations. The few studies that are available indicate that consumption of a healthy diet is significantly related to reduced fractures in the older population. Continued broad research would allow for this relationship to be further understood and provide guidance on beneficial dietary intake for positive bone health outcomes.

- Study dietary patterns within the context of confounding variables, such as weight status, physical activity, biomarkers, racial or ethnic background, and socioeconomic status to understand additional factors influencing health outcomes.

  Rationale: The influence of confounding variables on outcomes compared to the influence of dietary patterns on outcomes is not well understood and less commonly studied. A better understanding of which confounding variables may have stronger influences on outcomes than dietary patterns would provide further insight into risk of chronic diseases, and thus, preventive measures.

- Design studies with sufficient detail and differentiation of the types and amounts of foods and beverages consumed, including inadequate or excessive intake, to inform an overall assessment of diet quality in the study of dietary patterns and/or diets based on macronutrient proportion.

  Rationale: Studies often lack or provide limited information on the type and amount of foods and beverages consumed by participants, and this may be due to inconsistency in dietary instruments used to collect data on dietary intake. When information is limited or inconsistent, it is difficult to draw strong conclusions for what types and amounts of foods and beverages to consume or avoid, such as, “processed meat” vs “red and processed meat” vs “meat.” More information would allow more detailed guidance to be developed.

- Collect diet information at multiple time points in the course of study follow-up, beginning early in life, to strengthen the evidence on dietary patterns and health outcomes over the lifespan.

Rationale: The currently available literature features many observational studies with dietary data collected once at baseline, which fails to reflect changes in dietary intake throughout follow-up. Without accounting for change in dietary intake over time, the dietary intake reflected in studies may be far from accurate, and may miss changes in intake that result based on a change in health status or based on medical recommendations. Collecting data at multiple time points would encourage a new standard for observational studies that use dietary intake data and provide greater accuracy in the data used to determine relationships between dietary intake and health outcomes.

- Conduct additional dietary patterns research with well-designed, sufficiently powered RCTs that include standardized assessments of dietary intake to strengthen the evidence for health outcomes, including sarcopenia, neurocognitive health, cancer, bone health, overweight and obesity, CVD, and type 2 diabetes in populations of various racial and ethnic backgrounds across life stages particularly childhood and adolescence.

  Rationale: Few studies evaluate the relationships between dietary patterns and health outcomes with RCTs and adequate sample size in diverse populations. Though many chronic health outcomes are observed in middle-aged and older adults, it is unclear if dietary intake across the lifespan affects these outcomes both in childhood and adolescence and into adulthood. Many observational studies indicate a significant relationship between dietary patterns and health outcomes, but RCTs are needed to confirm this relationship with reproducible results.

Chapter 9: Dietary Fats and Seafood

Dietary Fats

- Conduct longitudinal research to understand how early life dietary exposures, specifically types and ratios of dietary fatty acids, affect cardiovascular health across the lifespan.

  Rationale: Limited longitudinal studies exist assessing the relationship between types and ratios of fatty acids consumed early in childhood and long-term CVD outcomes. Serial cross-sectional studies have suggested associations, but stronger study designs that better control for confounding are needed. This evidence could inform dietary recommendations and help communicate the importance of establishing healthy dietary patterns in childhood.

- Examine the effects of replacing saturated fats with other macronutrients, including different types/sources of carbohydrate (complex vs refined) on CVD-related outcomes in children and adults. Conduct research to provide quantitative data to show effects of replacing saturated fats with different types of carbohydrates on blood lipids. Conduct studies to determine whether replacement of saturated fats with different type of carbohydrates affects low density lipoprotein cholesterol (LDL-C) particle size and the impact of LDL-C particle size on risk of atherosclerosis.

Rationale: If energy intake remains constant, reducing 1 macronutrient is associated with a corresponding increase in other macronutrients. Thus, research needs to examine how replacement of saturated fats with other macronutrients affects blood lipids and CVD risk. Although multiple studies have examined replacement of saturated fats with carbohydrates, few have distinguished among types or sources of carbohydrates. Foods containing complex carbohydrates, which also tend to be high in dietary fiber, appear to be associated with more favorable changes in blood lipids, especially triglycerides, compared to foods containing refined carbohydrates.

The mechanism by which different types of carbohydrates influence blood lipids is not yet fully understood. Diets high in carbohydrate are often associated with elevated levels of triglycerides and very low-density lipoprotein cholesterol. Some research suggests that this may shift the distribution of LDL-C particles to smaller, cholesterol-depleted LDL-C particles. Researchers are studying whether atherogenicity differs by LDL-C particle size. However, measures of overall LDL-C that do not differentiate between particle size are currently considered sufficient to monitor atherogenic risk and response to therapeutic intervention. More research is needed on CVD biomarkers that may provide increased specificity for predicting risk compared to LDL-C.

- Examine the effects of different food sources of saturated fats, including animal (e.g., butter, lard) and plant (e.g., palm vs coconut oils) sources, different food matrices that encompass saturated fats (e.g., saturated fats in cheese vs yogurt), and different production techniques (e.g., refined deodorized bleached vs virgin coconut oil) on health outcomes.

  Rationale: Dietary fats are found in a wide variety of foods. Animal fat sources tend to have higher amounts of saturated fats and cholesterol, while plant sources tend to be higher in polyunsaturated fats and monounsaturated fats, and lower in saturated fats. These fatty acids differ in their atherogenicity. Although multiple studies have been conducted to examine types of fats in relation to CVD risk, very limited data exist on how different food sources of dietary fats, the food matrices they are found within, and the techniques used to produce them affect health outcomes. This information could help refine dietary guidance.

- Examine how puberty and sex hormones and male-female differences modify the effect of dietary fats on blood lipids and other CVD risk factors.

  Rationale: Males and females differ with respect to CVD risk, and the impact of diet on blood lipids differs by sex. Growth and sex steroid hormones appear to modulate risk of onset and severity of CVD, resulting in differential incidence of CVD, but how diet and sex hormones interact to affect CVD risk across the lifespan is largely unknown.

- Conduct feeding trials isolating the effect of dietary cholesterol on blood lipids and other CVD risk factors, controlling for baseline blood cholesterol levels and BMI.

  Rationale: Dietary cholesterol comes from animal source foods that also are high in saturated fats, with the exception of eggs and shellfish. Limited data elucidate the specific effect of dietary cholesterol independent of saturated fat on CVD risk. This is especially salient given that both dietary intake of dietary cholesterol and blood cholesterol levels have decreased over time, complicating interpretation of the seminal

research indicating a strong association between dietary cholesterol and blood cholesterol.

- Conduct studies to determine whether the substantial reduction of *trans* fat in the American diet has influenced responsiveness of CVD biomarkers to changes in saturated fat consumption.

  Rationale: Strong scientific evidence demonstrating the association of *trans* fat with blood lipids and CVD risk has resulted in the removal of partially hydrogenated oils from the food supply. Thus, a need exists to understand how dietary fats, particularly saturated fat, affect CVD risk in the current context of minimal *trans* fat consumption.

Seafood

- Conduct longitudinal research on seafood intake during pregnancy and lactation, and impact on infant and childhood neurocognitive development outcomes to establish the evidence base for impact across life stages.

  Rationale: The lack of sufficient, evidence-based research documenting causal influences of maternal diet on infant and childhood neurocognitive development outcomes curtails preventive efforts. The Committee established criteria for studies to draw scientifically meaningful conclusions on the questions developed by the USDA and HHS. No studies of maternal diet during lactation that reported on neurocognitive outcomes of the nursing infant during childhood met the criteria for inclusion. Additionally, no studies reported on clinical outcomes of subsequent development of ADD/ADHD or neurocognitive health (e.g., dementias, cognitive decline, anxiety and depression) in adulthood. Longitudinal studies with repeated measurements over time are needed to document associations of seafood intake, as well as other dietary factors, with neurocognitive outcomes during critical windows of development, including puberty. Studies designed to assess the long-term effect of diets on health are needed, specifically those on developmental milestones, including the underlying physiology associated with onset and progression of puberty.

- Establish and use standard methods to assess seafood intake or exposures. Use validated, standardized diet assessment methods to quantify seafood intake (e.g., amount, frequency, type, and preparation method). Control for baseline levels of seafood and non-seafood intakes, adjust for and report approach on how dietary compliance was achieved. Control for potential seafood-specific confounders and mediators in dietary seafood studies. Conduct research to assess levels of environmental toxins in seafood consumed and provision of results both adjusted and unadjusted. Encourage the use of standardized methods across studies.

  Rationale: No standard methods have been developed to assess fish intake or exposures. All existing dietary assessments, such as food frequency questionnaires, have limitations, specifically as it relates to episodically consumed foods, such as seafood. Validated questionnaires and/or biomarkers are needed. Standardized diet assessment methodology is key to investigating cross-comparisons within cohorts over the lifespan. No currently available studies adequately controlled for non-fish exposure for omega-3 polyunsaturated fats and few controlled for race and ethnicity, infant feeding mode, environmental contaminants, and concentration/ratio of the fatty acids, which vary

greatly among fish. Use of standardized methods and controlling for key confounders allows meaningful comparison of results across studies and strengthens the evidence base.

- Conduct mechanistic studies to understand relationships between seafood and neurocognitive development and neurocognitive health.

  Rationale: More definitive data from RCTs are needed, such as trials that address diet or nutrient related mechanisms underlying suspected associations on neurocognitive development and neurocognitive health through the lifespan. More research is needed to look at all nutrient components of seafood, not just fatty acids. Fish protein may be different than other animal protein. Unique properties of fish may affect neurocognitive development and health. Research to understand the mechanisms which modulate neurocognitive outcomes are needed.

- Determine at what stage in the lifespan maternal seafood intake is most critical (before pregnancy, prenatal, postpartum) and at what stage the child's seafood intake is most critical in determining health outcomes. Identify potential biomarkers signaling when the child's own dietary intake more strongly influences biological measures, including blood pressure, blood lipids, and other physiologic and neurodevelopmental health outcomes.

  Rationale: This type of research would allow for a better understanding of when the impact of a child's own dietary intake (e.g., intake of complementary foods) supersedes the impact of maternal intake during pregnancy and lactation for various outcomes, including neurocognitive outcomes. This would inform not only pregnancy and lactation dietary recommendations but also infant and early childhood feeding recommendations.

- Review effects of food sources of omega-3 fatty acids other than from seafood (e.g., algae, flax seeds, walnuts, soy oil) in relation to neurocognitive health, and examine the optimal ratio of docosahexaenoic acid and eicosapentaenoic acid.

  Rationale: More research continues to become available on these topics and should be monitored to inform refined guidance related to types of dietary fats and health.

Chapter 10-12: Beverages, Alcoholic Beverages, and Added Sugars

- Study beverage patterns alone and in conjunction with overall dietary patterns to better understand the impact of the pattern of beverage consumption on health during all stages of life.

  Rationale: Many studies have examined dietary patterns and their impact on health but few have assessed patterns of beverage consumption and health or have combined dietary and beverage patterns to create a comprehensive view of overall intake. Studies are needed to tease apart the relationship between beverages and health outcomes, the association between beverage patterns (including alcohol) and dietary patterns that in turn affect health outcomes, and how combined beverage and dietary patterns are associated with health outcomes. Prospective research studies with strong experimental designs are needed that delve deeply into beverage patterns, including: 1) the time of

day consumed, 2) number of times a day consumed, 3) times consumed alone versus with food, 4) time of consumption relative to eating events, 5) volume consumed at each of the time points, 6) consumption of energy and non-energy yielding beverages including water, 7) contribution of beverages to total energy intake, 8) differences across population sub-groups (e.g., sex, age, BMI categories), 9) caffeinated vs non-caffeinated, 10) macronutrient content (protein, carbohydrate, fat), 11) beverage size, 12) consumption in relation to planned exercise, and 13) beverage use as a supplement or meal replacement.

Studies should specifically examine beverages' effect on health versus the effect of components contained within those beverages (e.g., sugar, fat, electrolytes, phytochemicals). Studies examining the relationship between beverage consumption and health outcomes need longer experimental timeframes: Even existing studies with strong experimental designs are often too short in duration to fully measure the effect on outcomes of interest and generally; these studies lack control for many key confounders. Studies also are needed that compare one type of beverage to another (e.g., sugar-sweetened beverages to water) or one type of beverage to none.

Understanding the effect of certain beverage intake patterns on health vs simply the effect of individual types of beverages on health will be critical to understanding of the role of the beverage vs its pattern of use on health and the subsequent development of accurate messages about beverage consumption in future Dietary Guidelines.

- Design well-controlled RCTs that examine the relationship between consumption of beverages during pregnancy and birth weight independent of gestational weight gain.

  Rationale: More studies are needed on beverage consumption during pregnancy and its effect on birthweight. Currently, the evidence is insufficient to make any recommendations. Studies are needed that compare one type of beverage to another (e.g., sugar-sweetened beverages to water) or one type of beverage to none as well as variations in fat and sweetener content within beverage types. These studies further need to determine, through careful study designs, whether effects of certain beverage types are due to the beverage itself or one or more components contained within the beverage. Study also are needed on whether broader patterns of beverage consumption during pregnancy are associated with birthweight. Studies of individual beverage types do not adequately account for how increased or decreased consumption of one beverage type affects consumption of all other beverage types, and understanding replacement of one beverage type with another is needed to fully understand the role beverages play in birthweight. Existing research has a high risk of bias; does not consistently adjust for gestational age, sex, and total maternal energy intake; has high rates of attrition, poor generalizability, inconsistent exposure definitions and assessment timing; and inconsistent results. Understanding the effect of beverage consumption during pregnancy on birthweight will be very important for providing guidance to expectant mothers in the Dietary Guidelines themselves as well as in programs that assist pregnant mothers, such as the Special Supplemental Program for Women, Infants, and Children (WIC).

- Examine the effects of the physical form of food (e.g., whether it is consumed by eating or drinking) on various health outcomes.

Rationale: The physical form of food may affect eating behaviors and physiological responses, which may in turn influence various health outcomes and could help inform dietary guidance.

- Assess the effects of caffeine contained in beverages on health using methods that isolate the effect of caffeine from that of the beverage in question.

  Rationale: Studies examining the relationship between beverage consumption and health outcomes should distinguish between caffeinated and decaffeinated or caffeine-free versions of the same beverage (e.g., caffeinated vs decaf coffee) to isolate the effects of caffeine from the effects of the beverage in which it is consumed. Many U.S. government programs limit or do not allow beverages with caffeine to be available or sold to children, including school meal programs, competitive foods, and summer meal programs. More knowledge about the effects of caffeine vs the effects of beverages that contain caffeine will better inform the nutrition standards these programs use as well as provide dietary guidance for vulnerable populations, such as children and women who are pregnant.

- Accurately quantify water intake and use this information to better study the associations between water consumption and health during all stages of life.

  Rationale: Better information about water intake is needed, including: 1) quantity consumed, 2) tap vs bottled water consumption, 3) whether it is filtered, carbonated, or flavored, and 4) proportion of total water in the diet from drinking water vs consuming water-containing products. The information is rarely found in food frequency questionnaires, individuals often do not report water intake on 24-hour recalls, and interviewers may not consistently probe for this information. Studying the effects of water consumption on health would be more feasible with this greater specificity. Currently, the effects of plain water consumption on health vs water consumed in other beverages and foods is not well understood, making it difficult to develop specific evidence-informed recommendations to consume water.

- Measure alcoholic beverage intake and consumption patterns with greater accuracy and determine their effect on human health through all appropriate life stages using more consistent and improved definitions, controls, and research methods.

  Rationale: More studies are needed on alcohol intake and health outcomes using stronger research designs, including RCTs, Mendelian randomization studies, and non-randomized intervention studies. Mendelian randomization studies of alcohol are often more practical than RCTs and are an emerging area of the literature that will likely expand during the next 5 to 10 years. Research on alcohol consumption and health should use multiple measures of intake over time, distinguish between lifelong never drinkers and either very low level consumers or former drinkers who refer to themselves as never drinkers, better control for key confounders, use longer study duration, and enroll younger study participants (as 40 percent of alcohol-attributable deaths occur by age 50 years). Additional research is needed on patterns of consumption, including health outcomes in relation to the frequency and usual amount of alcohol consumed during drinking days. This research could help disentangle effects of average (i.e., total) consumption vs the usual number of drinks consumed on days or occasions when

alcohol is actually consumed, including the maximum number of drinks consumed during a particular recall period. Although increasing attention is being paid in the research literature to the effects of alcohol consumption patterns (i.e., how much is consumed and how often), more evidence is needed on this topic with respect to mortality outcomes, and all-cause mortality in particular. Finally, more research is needed about how alcohol consumption across different levels and patterns of consumption is associated with dietary patterns and overall diet quality.

- Examine associations between neurocognitive health and consumption of non-alcoholic beverages, added sugars, and alcohol in order to build the level of evidence necessary to make recommendations for future Dietary Guidelines.

  Rationale: Understanding these associations is critical for dietary guidance, especially during lactation and in older populations. Programs such as the Child and Adult Care Food Program and the Elderly Nutrition Program rely on the Dietary Guidelines to develop their standards. Before future Committee review, researchers should conduct RCTs and high quality longitudinal cohort studies, adjusting for key confounding variables, examining diet and neurocognitive health including questions related to beverage consumption (sugar-sweetened beverages, milk, juice, water, alcoholic beverages, beverage patterns) and consumption of added sugars. This should include research conducted on alcohol consumption during lactation and neurocognitive health of the infant. Use of existing cohorts for which appropriate design elements are available (e.g., appropriate measurements of exposure, outcomes and potential confounders) could be useful.

- Investigate how the consumption of specific non-alcoholic beverages and beverage consumption patterns affect growth, size, body composition, CVD, and type 2 diabetes across the lifespan.

  Rationale: The Committee was not able to assess the relationship between all beverage types and growth, size, body composition, and risk of overweight and obesity. Additionally, for the beverage types that were examined (milk, 100% juice, sugar-sweetened beverages and low- and no-calorie sweetened beverages), evidence was limited. Studies on beverages and body composition that use the most sensitive, accurate and precise methods available could provide valuable information on this relationship. Reliance on self-reported data is discouraged. Consistent measures would assist future Committees in developing conclusions. Studies also need more specificity and consistency in the definition of exposure, consistent and validated measures of beverage intake, more control for potential confounders, longer study durations, larger sample sizes, objective methods for assessing compliance in RCTs, methods that avoid high attrition, consistency in comparator beverages, and more generalizable populations.

  Studies should also assess whether certain beverages and beverage patterns have beneficial associations with risk of obesity, adiposity, CVD, and type 2 diabetes.

  For studies specifically related to dairy milk and growth, size and body composition, in addition to studies comparing milk to other beverages like water, evidence comparing different levels of fat within the milk category and comparisons of flavored to non-flavored milk is needed. The issue extends to comparisons of low- and no-calorie

sweetened beverages vs sugar-sweetened beverages for children, where evidence is insufficient to make a recommendation. For adults, only limited evidence of no association is available. Well-conducted studies of the effect of 100% fruit juice on adiposity also are needed. Obesity prevention programs need to understand how beverage consumption affects body composition measures. This additional research will aid in these efforts.

- Investigate how alcohol consumption affects growth, size, body composition, and risk of overweight and obesity.

  Rationale: Alcoholic beverages contain substantial energy but contribute little to nutrient intake. Understanding the impact of alcohol consumption on adiposity could help inform future evidence-based guidance on alcohol consumption.

- Conduct research assessing how frequency and quantity of exposure to added sugars across the lifespan influences the preferred level of sweetness in foods and beverages.

  Rationale: Promoting decreased added sugars consumption is challenging given personal and cultural taste preferences. Evidence suggests that preference for high-fat and high-salt foods is related to frequency of exposure to these food components.[32,33] Two large clinical trials are currently underway to assess whether and how frequency of exposure to added sugars influences preference for sweetness and these will add to this body of literature. Future Committees should review this evidence to examine the relationship between quantity, frequency, and timing across the lifespan of added sugars exposure and food habits and preferences. Conducting this review could inform future recommendations to limit frequency of added sugars exposure as well as practical recommendations to shift to foods and beverages lower in added sugars.

Chapter 13: Frequency of Eating

- Standardize terms used in frequency of eating research.

  Rationale: Multiple definitions of frequency of eating and health exist. Studies vary in their definition of an eating occasion. This Committee defined eating occasions as any ingestive event including eating and drinking energy yielding and non-energy yielding foods and beverages. Some studies define eating occasions based on the energy value of eating occasions (e.g., any ingested substance including water and non-energy-yielding beverages, > 50 kcals, >100 kcals), the minimal time between eating occasions to consider them distinct, as well as food form (e.g., include or exclude various categories of beverages). Some studies also differ on whether only meals or meals and snacks are counted as eating occasions. No widely accepted definition of these eating occasions exists in the scientific community. All of these factors can influence physiological mechanisms that can moderate a range of health outcomes of importance across the lifespan. Thus, a critical need exists to establish consensus-based definitions of eating occasions.[34]

- Collect and report all ingestive events occurring within a 24-hour period over multiple days and time periods.

Rationale: A large body of evidence exists that includes 24-hour intake data over multiple days and time periods. However, most of these RCTs were not primarily focused on eating frequency and thus did not report the number of ingestive events (of any kind) across the day. In addition, many other studies focusing on specific eating occasions and/or timing of eating occasions (e.g., breakfast, snacking, late night eating) also did not collect and/or report eating occasions over a full day to allow for accurate assessment of usual eating frequency patterns. This resulted in the exclusion of these trials for the Committee's review because it was not possible to assess the degree to which eating and drinking compensation at a later time point(s) may have occurred in these excluded trials. Lastly, the published studies that directly manipulate eating frequency across days and weeks (e.g., intermittent fasting, time-restricted feeding), did not collect and/or report eating frequency on non-fasting days or during feeding periods, again limiting the ability to assess the impact of eating frequency on the outcomes of interest. The Committee required the reporting of eating frequency on at least three, 24-hour periods and, for intervention studies, on 2 separate occasions. The 3, 24-hour period criterion was chosen as an attempt to capture customary eating frequency patterns that can vary significantly across days. The additional criteria for intervention studies of collecting ingestive event information on more than 1 period of time allows for the documentation of baseline (usual) eating frequency pattern to determine whether a change in pattern occurred as a result of the intervention, whereas the second occasion identifies eating frequency as a result of the intervention. Adequate collection and reporting of 24-hour ingestive event data is necessary for all future studies on frequency of eating and health. Additionally, the Committee recommends the reporting of key confounders to adequately assess the main effect.

- Conduct research on the relationships between timing and frequency of eating and diet quality.

  Rationale: Understanding the context of eating is an important strategy to target behavior change. The timing of eating occasions appears to affect diet quality. Very little data on chrono-nutrition exists. Previous research has associated temporal dietary patterns, or the distribution of energy and intake of food components over time, with diet quality and disease risk. In the Committee's review, late-night eating occasions appear to be associated with intakes of foods or beverages that should be limited (added sugars, saturated fats, sodium, and alcohol). Adolescents and teenagers have notable differences in the timing and frequency of eating occasions. This is a subgroup with a high proportion of low nutrient intakes and who could benefit from future research in frequency of eating and diet quality. In addition, it is not known how the frequency of eating during and after pregnancy affects gestational weight gain and/or postpartum weight loss.

- Report water intake as an eating occasion in research on frequency of eating.

  Rationale: Water intake is rarely recorded and reported in the scientific literature. A decision about whether to count water-only as an eating occasion or ingestive event is necessary to determine the frequency of eating over a given time period. Water intake may alter food choice, the timing and frequency of eating occasions, digestive process, metabolism, and if water-only ingestive events are counted, the direct estimate of eating frequency. The lack of reliable data on water intake precluded the Committee from

consistently including water intake in its examination of the effects of frequency of eating on the designated health outcomes. The Committee also recognizes a need for improved methods for quantifying the frequency, amount, and timing of water intake.

- Improve methods for measuring frequency of eating.

  Rationale: Nearly all of the published literature on the frequency of eating is based on participant self-report. The validity and reliability of these estimates are untested. Objective measures are needed to validate these self-reports in large epidemiological trials and to more directly quantify eating occasions in clinical trials. Methods capturing the full waking day's ingestive behavior are needed. One promising approach includes the use of minimally invasive biosensors that detect glucose fluctuations in response to eating occasions. Multiple non-invasive devices are being developed and tested, including wearable devices that monitor food and beverage delivery to the oral cavity, chewing, and swallowing as stand-alone or combined indices that may be coupled with image-based tools. Additional work on these approaches, including time and date stamps to verify when eating occasions occur, is central for evaluating the impact of both eating frequency and the timing of eating on health outcomes.

- Conduct well-designed RCTs that examine the relationship between frequency of eating and health.

  Rationale: Given the limited evidence available, the Committee was unable to identify the relationship between frequency of eating and health. Thus, long-term RCTs with multi-day, objective assessments of frequency of eating are vitally needed to directly assess whether the number of eating occasions throughout the day influences health.

- Conduct research on how food insecurity fits into hypotheses around frequency of eating and health.

  Rationale: The frequency of eating may be under volitional control or determined by external forces. The implications for health may differ under these 2 conditions. Where food is readily available and an individual chooses to adopt a particular eating pattern comprised of healthful foods, body weight and nutritional status goals may be achieved. In contrast, where access to food is limited in amount and quality (e.g., food insecurity), the challenges to health maintenance are greater. The complexity of the latter condition is compounded because food insecurity may vary over time (e.g., beginning versus end of a pay period). The prevalence of food insecurity is high and worsens with economic downturns and limitations to feeding programs. If frequency of eating holds independent effects on health, understanding the implications of food insecurity on the frequency of eating occasions and health outcomes will be essential for dietary guidance. Clarifying the role of food insecurity on the frequency of eating occasions will also aid in future analyses that must determine whether this condition should be incorporated into models as a moderator, mediator, or confounder.

- Examine the timing of eating occasions and health.

  Rationale: Continued public interest exists as to whether skipping a morning meal affects health and well-being. Although multiple scientific and medical organizations support the daily consumption of breakfast to reduce the risk of cardiometabolic

diseases, reduce obesity, or to improve diet quality and healthy dietary habits, others have challenged[35,36] these positions due to limited long-term RCTs[37,38]. Timing of eating occasions, including late-day/evening eating, snacking, intermittent fasting, and/or time-restricted eating are also of high public interest. Because timing of eating occasions is a sub-component of eating frequency, this topic was within the current scope of this Committee. However, most published studies focusing on breakfast, late day eating, snacking and intermittent fasting, report daily energy and/or macronutrient content but do not assess or document eating occasions across the day and were thus excluded from the analyses. Future questions that specifically address timing of ingestive events separate from frequency of eating may provide helpful guidance when implementing the healthy eating pattern recommendations set within the Dietary Guidelines.

- Continue to address questions on frequency of eating and health.

  Rationale: Although this Committee was unable to find sufficient evidence on which to summarize the evidence between frequency of eating and health, frequency of eating remains a growing body of scientific literature that is of great interest to the nutritional status of the American population. Therefore, this Committee urges the next Committee and the Departments to continue to prioritize questions on frequency of eating and health for the 2025 Dietary Guidelines Advisory Committee.

Chapter 14: USDA Food Patterns for Ages 2 Years and Older

- Develop methods to incorporate beverages that are not contributors to the USDA food groups or subgroups, into USDA Food Patterns.

  Rationale: Current methods do not incorporate beverages into the USDA Food Patterns and therefore do not account for the calories or nutrients provided by them. Many Americans consume energy-containing beverages and therefore require specific guidance surrounding beverage choices.

- Employ statistical techniques such as linear programming or stochastic modelling to food preferences for individuals and to capture population-level intakes and shortfalls.

  Rationale: The 2017 NASEM report, *Redesigning the Process for Establishing the Dietary Guidelines,*[12] recommended that food pattern modeling should be enhanced "to better reflect the complex interactions involved, variability in intakes, and range of possible healthful diets." Improving and using novel statistical techniques in deriving food patterning could enhance food pattern modeling to help tailor healthy dietary patterns for individuals and populations.

- Develop methods to incorporate diversity into USDA Food Pattern Modeling.

  Rationale: The American dietary landscape is very diverse and the Committee observed dietary intake patterns that differed by age, race and ethnicity, and by income. The U.S. continues to become more racially and ethnically diverse, and rates of poverty are high, especially among children. Thus, it is imperative to develop food patterns that are context specific and flexible to fit dietary constraints and choices. By 2055, the United

States will not have a single racial or ethnic majority.[39] The percentage of foreign-born individuals will increase from 14 percent (2016) to 19 percent by 2060.[39] Immigration from Latin America and Asia is expected to account for most of this change.[40] The dietary patterns commonly consumed by racial-ethnic and cultural groups often have unique characteristics (such as the lack of dairy intake by some groups) that differ from the Healthy U.S.-Style Pattern. These differences may cause the patterns from these groups to appear inadequate because some of the unique foods consumed in these populations that provide the missing nutrients are not represented in the food item clusters used in food pattern modeling. It is now, and will become even more, imperative that dietary guidance reflect dietary patterns of growing demographic groups, particularly LatinX and Asian populations. In addition, the inclusion of the most nutrient-dense forms of foods that are included in the patterns may be difficult for some populations to obtain, either due to cost or due to low availability as a result of geographic location (e.g., in rural areas or food deserts). How demography shapes food patterns is an important area of scientific inquiry that could be included in the future work of other Committees.

- Develop methods to allow application of DRI recommendations for individuals more broadly at the population level.

  Rationale: Currently USDA food pattern modeling methods compare anticipated nutrient intakes from food groups and subgroups to the RDA or the AI when an RDA is not published. The patterns are intended for use by individuals, which provides a rationale for using the RDA. However, the EAR is used when evaluating intakes of a population. Groups that are planning or implementing nutrition programs for populations, such as nutrient-based standards for food pantry offerings, should be able to use food pattern modeling as a means to identify appropriate strategies in their planning efforts that are consistent with healthy dietary patterns. Thus, at the group or population level, the existing patterns should be examined relative to the EAR, and would contribute more toward the recommendations.

- Continue to apply age-sex group specific nutrient profiles to food pattern modeling exercises.

  Rationale: Food pattern modeling by life stage is useful for identifying areas of needed improvement in food patterns to achieve nutrient adequacy and maintain energy balance. Such awareness is necessary to use the socio-ecological model systems-based approach, such as that identified by the *2015-2020 Dietary Guidelines for Americans*, to identify strategies that promote and advance public health.

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