

Lumping vs. Splitting Nutrients, Foods and Diet Patterns in Nutrition Research: Science Dialogue Mapping of Origins, Uses and Knowledge Gaps

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Lumping vs. Splitting Nutrients, Foods and Diet Patterns in Nutrition Research: Science Dialogue Mapping of Origins, Uses and Knowledge Gaps

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Abstract

Background: The practices of lumping together and splitting apart foods, nutrients, and diet patterns shape the interpretation of nutritional evidence and guidance.

Objective & Methods: To discuss the inherent complexity of ‘lumping’ and ‘splitting’ decisions, we held an in-person colloquium in December 2024, where we utilized dialogue mapping to summarize the discussion in real-time. Knowledgeable early-career researchers explored the contexts for lumping and splitting with the goal of beginning a conversation among the scientific community on the topic.

Results: Six key themes emerged when discussing when to lump and when to split foods, nutrients, and diet patterns: definitions and history, population heterogeneity, consumer behavior, policy and public health messaging, frameworks and categorization, and measurements and methods. The overall discussion illustrated how the rationale for lumping or splitting often diverges based on the purpose of the categorization (e.g., mechanisms, health effects, public health messaging, and food labeling), as well as data availability and the intended audience.

Conclusions: Panelists emphasized that lumping and splitting are not inherently right or wrong, nor are they inherently a binary approach; rather, the appropriateness to lump or split depends on the purpose of the analysis, public health message, or decision. Future work is needed to operationalize lumping and splitting decisions in the field of nutrition science, and to enhance transparency in the rationale of lumping and splitting decisions.

Significance: despite their foundational role in evidence interpretation and policy translation, the rationale, implications, and inconsistencies behind lumping and splitting practices have never been examined or mapped. Our work initiates the conversation about this ambiguity in lumping and splitting practices in nutrition.

Keywords: dialogue mapping, nutrients, foods, dietary patterns, lumping, splitting

77 Introduction

78 “People don’t eat nutrients; they eat food” (1). Yet, foods and food groups are often encouraged
79 or discouraged based on their nutrient content (e.g., consume red and orange vegetables as sources
80 of vitamin A; consume less sugar-sweetened beverages to reduce added sugar intake) and dietary
81 patterns are recommended to meet nutrient needs (2-4)(5-8). Foods are frequently defined,
82 categorized, and interpreted in terms of their nutrient contents. The duality between the practices
83 of lumping (or aggregating together foods, nutrients, or diet patterns into broader categories) and
84 splitting (or disaggregating them into narrower or more specific components) reflect
85 methodological and conceptual choices that shape the interpretation of nutritional evidence and
86 guidance. The consequences of lumping and splitting extend far beyond semantics. For example,
87 grouping red meats and processed meats¹ into a single category provides a parsimonious
88 framework to examine shared nutrient and exposure profiles expected to have similar health
89 consequences. However, such aggregation obscures meaningful biological distinctions that may
90 modify health outcomes (9, 10). Similarly, slogans such as “Pork. The Other White Meat” (11)
91 embody perceptions about the inadequacy of red meat as a singular category. Others argue that all
92 animal products (e.g., red and processed meats, poultry, eggs) should be considered in the same
93 category given that they share a similar nutrient profile across animal products, a common practice
94 for plant-based diet indices (12). Inherently, this implies plants are lumped together, with some
95 researchers proposing there are ‘healthy’ and ‘unhealthy’ plants (12). These decisions to lump or
96 to split extend to numerous examples in nutrition, such as splitting types of fiber versus lumping

¹ The lumping or splitting of red and processed meat was the nucleating example that inspired this project, funded by the National Pork Board.

all fibers as dietary fiber or splitting amino acids versus lumping all amino acids as protein. Which approaches (if any) are correct for lumping (or splitting), and for what purposes?

The methods, logic, history, and future of lumping and splitting nutrients, foods, and diet patterns for scientific and public health purposes are many, and need to be articulated carefully to enable evidence generators and users to clearly define at least two questions: “What nutrition-related question is being asked?” and “Why?” There is a rich set of arguments about how to decide which foods to consider as a category for different health-related goals that are often not explicitly considered or articulated in research and policy discourse.

The current project uses a method for exploring expert opinions known as “issue mapping” or dialogue mapping (13) to address the question “For what purpose is it appropriate to lump nutrients, foods, or diets into (or split them apart from) various categories?” among a colloquium of knowledgeable early-career researchers. Dialogue mapping uses a simple yet powerful framework for clarifying group deliberation and decision making by representing issues, ideas, and arguments, also known as an “Issue-Based Information System.” Dialogue mapping employs a trained facilitator to document and summarize a meeting in real-time in a way that captures the relationships between the statements and questions made by the meeting participants. It explicitly, logically, and visually connects thoughts, propositions, points, and counterpoints, even if they are discussed at different times, which contrasts with other approaches of summarizing such as *a priori* topics (e.g., proceedings documents) or temporal approaches like meeting minutes.

The results of this colloquium are presented herein, which highlight points of interest, remaining questions, and future areas of research that can ostensibly be clarified to determine when it is appropriate to lump or split nutrients, foods, or diet patterns. Subsequent input from mid-to-late career researchers was sought to refine or expand the concepts developed at the colloquium. The purpose of this project was to catalyze a discussion on lumping and splitting and to develop a shared understanding on the topic, rather than to make explicit recommendations on when to lump or split nutrients, foods, and dietary patterns.

Methods

Overall structure of the project

This project was conducted in three phases based on the methods from a previously published science dialogue mapping project on dairy intake and health (14). The first phase consisted of the dialogue mapping session, in which the participants met at an in-person colloquium held in December 2024 to discuss the initial root question, “For what purpose is it appropriate to lump nutrients, foods, or diets into (or split them apart from) various categories?” The second phase focused on refining the dialogue map with the participants and verifying that the map represented the meeting discussions, through virtual meetings held in 2025. The third phase consisted of sharing the dialogue map with a group of mid-to-late-stage career experts for feedback, and construction of the present article in January 2026.

Phase 1: Dialogue Mapping

Dialogue mapping emerged in response to interest in ill-defined, socially complex problems (so-called “wicked problems”). The Issue-Based Information System for clarifying group deliberation

and decision making by representing issues, ideas, and arguments forms the basis of dialogue mapping, a specific trademarked method of facilitation (13, 15). Dialogue mapping mitigates the limitations of typical conversational structure as it transforms the linear, sequential "string" of comments into a coherent, non-linear visual issue map that reveals the deep structure and complexities of a topic, enabling a better shared understanding in discussing these “wicked problems”. Additional details of the process, approach, and results as used herein are described throughout. For more information about the history of the approach, including a demonstration of the approach, please see (13, 14, 16).

Selection, invitation and role of participants

The early-career researchers (referred to as panelists; KAH, CJV, JE-M, AEC-P, and LC) who engaged in active research and public dissemination (e.g., peer-reviewed publications) of nutrition research related to this topic were invited to the colloquium. Panelists were considered from any sector (e.g., academia, industry, government). These researchers with varied viewpoints and expertise have opined about and conducted research where the question of lumping or splitting of any nutrients, foods, and dietary patterns has emerged. Panelists were identified based on expert networks, and snowball recruitment (i.e., those who declined often recommended someone else). The investigative team also solicited recommendations from the sponsor on panelists but retained final authority to invite and select the panelists. In addition to the panelists, a map facilitator, scientific facilitator, scientific support team, and an observer were invited to attend the colloquium. The Map Facilitator (AK) actively mapped the issues discussed in the sessions, connecting the ideas in real-time using the Compendium software (version 1.7.1, Milton Keynes, United Kingdom). The facilitator projected the working map on a large display, so it was visible throughout the sessions. As the discussion was ongoing, he asked clarification questions, reiterated

statements, and confirmed the appropriate relation among the nodes for clarity. Along with the Map Facilitator, the Scientific Facilitator (AWB) clarified relations of comments to the existing map nodes, clarified terminology used in the dialogue maps, asked questions, and attempted to identify and save papers and other materials in real-time so the conversation could continue without interruption. However, the Scientific Facilitator remained neutral to the panelists' points of agreement and disagreement. The Scientific Support (SA-C) worked collaboratively with the panelists to arrange the sessions, provide literature searches and references or other information to clarify points of confusion or contention, and drafted summaries. She also worked with the Map Facilitator and Scientific Facilitator to clarify ideas and abbreviations. One attendee (Dr. David Church) agreed upon by the funding agency (the National Pork Board) and the principal investigator (AWB) was invited to observe the dialogue mapping meetings without participation in the formal dialogue. He was not included as a coauthor and had no editorial authority over this manuscript.

Setting and meeting structure

Prior to arriving, participants were provided with instructions and guidelines (see Supplementary Material). The dialogue mapping session was held at the Winthrop Rockefeller Institute in Morrilton, Arkansas. The session began with a general orientation, including a review of the dialogue mapping process, the charge of the panel, and a reminder to remain focused on the session (e.g., electronic devices were to be used only to support the dialogue). The mapping session included a full day (8 hours) of discussion surrounding the single root question. Panelists were free to carry the conversation as they scientifically saw fit.

Defining lumping and splitting in the context of nutrition

Box 1 reviews how we defined nutrients, foods, and dietary patterns (refined post hoc after the dialog mapping session). The panelists considered lumping as aggregating nutrients, foods, or dietary patterns into broader categories based on biological, practical, historical or convenience similarity. Splitting was defined as disaggregating nutrients, foods, or dietary patterns into narrower or more specific components for the same purposes. **Table 1** describes examples of lumping and splitting foods, nutrients, and diet patterns commonly observed in nutrition science. These examples are presented as discrete, binary examples, but the practice of lumping and splitting is a continuum. For example, the distinction between a group of individual nutrients together in a food vs. a group of foods lumped together in a dietary pattern are not always clear.

Box 1: definition of nutrients, foods and dietary patterns used to structure this summary¹

Nutrients: “A chemical compound in food that is used by the body to function and maintain health. Examples of nutrients include proteins, fats, carbohydrates, vitamins, and minerals.” (17)

Food groups: “Groups or subgroups that have been comprised of foods and beverages that share a similar nutrient profile.” (18)

Dietary pattern: “...the quantities, proportions, variety, or combination of different foods, drinks, and nutrients (when available) in diets, and the frequency with which they are habitually consumed.” (19)

¹ These conceptual definitions were established after the dialog mapping during preparation of this manuscript to aid in summarizing the findings from the dialogue map.

Table 1: Examples of Lumping and Splitting of Nutrients, Foods, and Dietary Patterns

	Example of Lumping	Example of Splitting
Nutrients or food components	Lumping vitamins: e.g., all B vitamins as B-complex, colloquially discussed as “B- vitamins”	Splitting vitamins: e.g., B vitamins each having specific metabolism, excretion, and functions in the body
Food or food groups	Lumping red meat: e.g., grouping beef, pork, lamb, veal, goat, and non-bird game	Splitting dairy products: e.g., splitting high- and low-fat dairy

Dietary/diet Patterns	Lumping diets: e.g., perceived “healthy” diets (Mediterranean), planetary healthfulness index, perceived “unhealthy” (Western)	Splitting diets: e.g., splitting dietary patterns with distinctions such as Low carb diets vs. Keto diets
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Phase 2: Consolidation and distillation of map

After the colloquium, emails and virtual meetings were held to refine the map. The objective was to refine and clarify what was discussed, not to adjudicate agreement on specific lines of evidence. Thus, the map and the text represent an agreement that perspectives were discussed, not a consensus on the appropriateness of the details. All panelists agreed that the topics reflected on the map were discussed in the Phase 1 meeting. The points of conversation were consolidated and distilled into nodes (i.e., a branching point ending in a question, an idea, a pro or a con etc.) by AWB, AWK, and SA-C with consultation from the panelists to organize and summarize the map into emerging themes without loss of content. In addition, throughout the map refinement phase, similar ideas arose multiple times but in different contexts; therefore, similar or related nodes in different areas of the map were consolidated, where appropriate.

Phase 3: Consultation with mid/late-stage career experts

The selection of panelists was designed to emphasize the perspectives of early-career researchers and to gain their insights on what they see as the current state and future of the field. However, the perspectives of more experienced experts who have contributed to these discussions over the course of their career may have additional insights to provide, including context to historical or current practices, or enthusiasm for and identification of efforts presently underway to address current limitations. Therefore, a group of established, mid/late-stage career experts were recruited based on recommendations from the Panelists to review and provide commentary on the draft

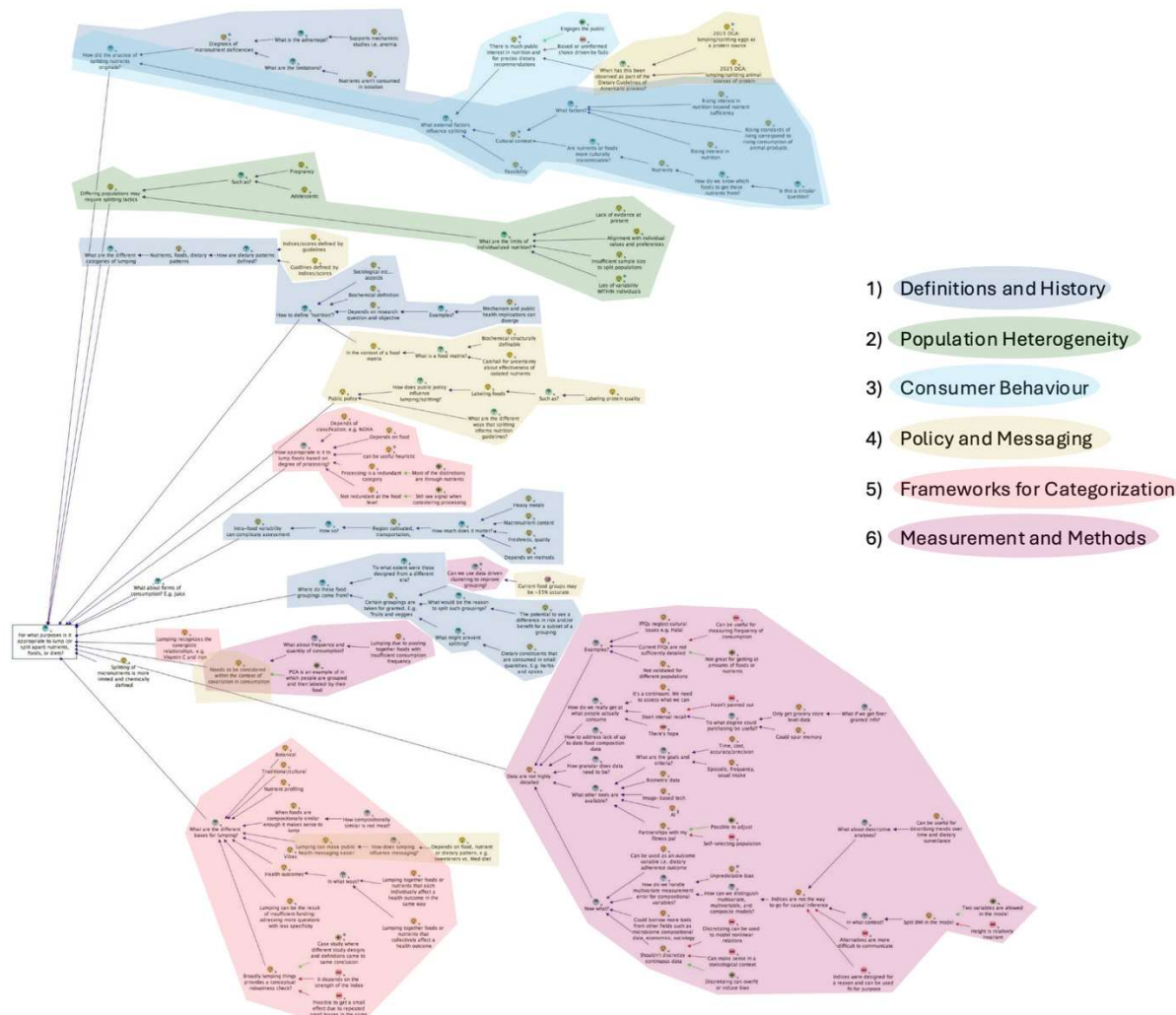
manuscript. Experts who provided feedback were acknowledged in this manuscript, offered an honorarium for their time, and their comments and remarks were included. To distinguish the results of the colloquium from the expert feedback, we considered feedback two ways: 1) feedback that related to manuscript structure and flow; or 2) feedback that clarified perspectives already addressed by the colloquium; both of which were incorporated into the manuscript directly; for additional suggestions and perspectives that expanded on the colloquium, we articulate those separately herein (in Commentary on phase 3: expert review and feedback).

Results and Discussion

Dialogue map

The dialogue mapping session produced a highly interconnected structure of ideas surrounding the central question, “For what purposes is it appropriate to lump (or split apart) nutrients, foods, or diets?” The consolidated, static map (**Figure 1**) comprised six major thematic node groups, or themes, determined by panelists after the meeting, each corresponding to a portion of the discussion on the practice of lumping and splitting: 1) Definitions and History (dark blue), 2) Population Heterogeneity (dark green), 3) Consumer Behaviour (light blue), 4) Policy and Messaging (chartreuse), 5) Frameworks for Categorization (coral), 6) Measurement and Methods (maroon). Themes are not described in any order; they were numbered for simplicity of communication, but do not necessarily reflect order of importance or the order in which the themes were discussed. Throughout the following sections, quotes taken directly from the map will be contained in quotation and underlined.

250 **Figure 1: Static image of the consolidated dialogue map**



251

252 The discussion originating from the root question is represented by nodes. The root question is included in the box

253 to the left of the figure. Nodes represent an idea (lightbulb icon, in yellow), issue/question (question mark icon, in

254 blue), con argument i.e., arguments disagreeing with the parent node (minus sign, in red), pro argument i.e.,

255 arguments supporting the parent node (plus sign, in green), notes (note pad icon, in purple), and decisions (hands

256 shaking icon, in orange). The arrows are oriented with the arrow tip pointing toward the parent node (i.e., the node

257 from the origin of the arrow is in response to the node at the tip of the arrow). Themes were formed in the

258 consolidation phase of the map refinement, after the initial dialogue mapping session. Circles of different colours

259 were overlayed on the map manually to orient the readers to which nodes belonging to each themes (Theme 1:

260 definitions and history (dark blue); theme 2: population heterogeneity (dark green); theme 3: Consumer behaviour

261 (light blue); theme 4: policy and messaging (chartreuse); theme 5: frameworks for categorization (coral) and theme

262 6: measurement and methods (maroon)). Themes are not described in any order; the map layout (e.g., left-to-right or

263 top-to-down) is not indicative of the flow of conversation. A high-resolution version of this figure can be found at

264 https://osf.io/7n6xv/overview?view_only=39724a0a416444189f4a74fe5752bc89. Expanded portions of the map are

265 presented with each section below as separate figures.

Several nodes extended across themes, as is evident by overlapping colours. For example, the node “How did the practice of splitting nutrients originate?” connected to both the “Consumer Behavior” and “Definitions and History” themes, illustrating the permeability of disciplinary boundaries in this mapping process. Overall, the dialogue and the map revealed tension between inclusivity (favoring lumping) and specificity (favoring splitting). In fact, across the dialogue, panelists emphasized that lumping and splitting are not inherently right or wrong; rather, their appropriateness depends on the purpose of the analysis (i.e., validity of the underlying evidence, communication, or decision).

The discussions consistently returned to the importance of question framing, data and methodological limitations, and intended audiences. However, the dialogue also revealed, firstly, that there is no consensus or clear basis for making lump/split decisions and secondly, there is uneven attention to lumping and splitting within or across domains. For instance, legal and regulatory implications were seldom discussed, and specific examples of how nutrients, foods, or dietary patterns are lumped or split based on population heterogeneity were not discussed, suggesting potential areas for further discussion and exploration. Additional context to each of these themes is summarized below.

To contextualize lumping versus splitting within each of the key map themes into practice, **Table 2** illustrates examples derived from the map. Rows capture whether lumping or splitting was discussed at the level of nutrients, foods, food groups, or dietary patterns, and columns discuss the rationales discussed for lumping or splitting for each level. Post hoc additions to the map and its contents were included in italics.

287 **Table 2: Applications and examples of splitting or lumping nutrients, foods/food groups, or dietary patterns identified from**
 288 **dialogue mapping.**

Rationale and Examples of Lumping or Splitting:			
	Example	Rationale for lumping	Rationale for splitting
Nutrients or Food Components	Vitamin C and iron; calcium and vitamin D (Theme 5: Frameworks for Categorization)	Each pair of nutrients exhibit synergistic relationships Can be found together in a supplement	Supports mechanistic understanding of role of the nutrient in the body Splitting of micronutrients is chemically defined
	Low- and no- calorie sweeteners (LNCS) (Theme 4: Policy and Messaging)	Aggregates food additives for a specific purpose (i.e., sweetness) with similar properties (i.e., low or no energy, sweet taste) Easier for public messaging	Fails to distinguish the differences in metabolic fate and volume of research between individual LNCS
	Diagnosis and prevention of micronutrient deficiencies (Theme 1: Definitions and History)	Nutrients are not consumed in isolation but in a matrix (i.e., foods) with other nutrients	Supports mechanistic understanding of role of the nutrient in the body
	Population heterogeneity (Theme 2: Population Heterogeneity)	Lack of evidence to make individual level recommendations (e.g., based on individual's DNA, microbiome)	Lots of variability within <i>and between</i> individuals Certain life stages require different nutrient requirements (e.g., pregnancy, adolescence, infant feeding window, <i>older adulthood, cultural preferences, dietary restrictions</i> (

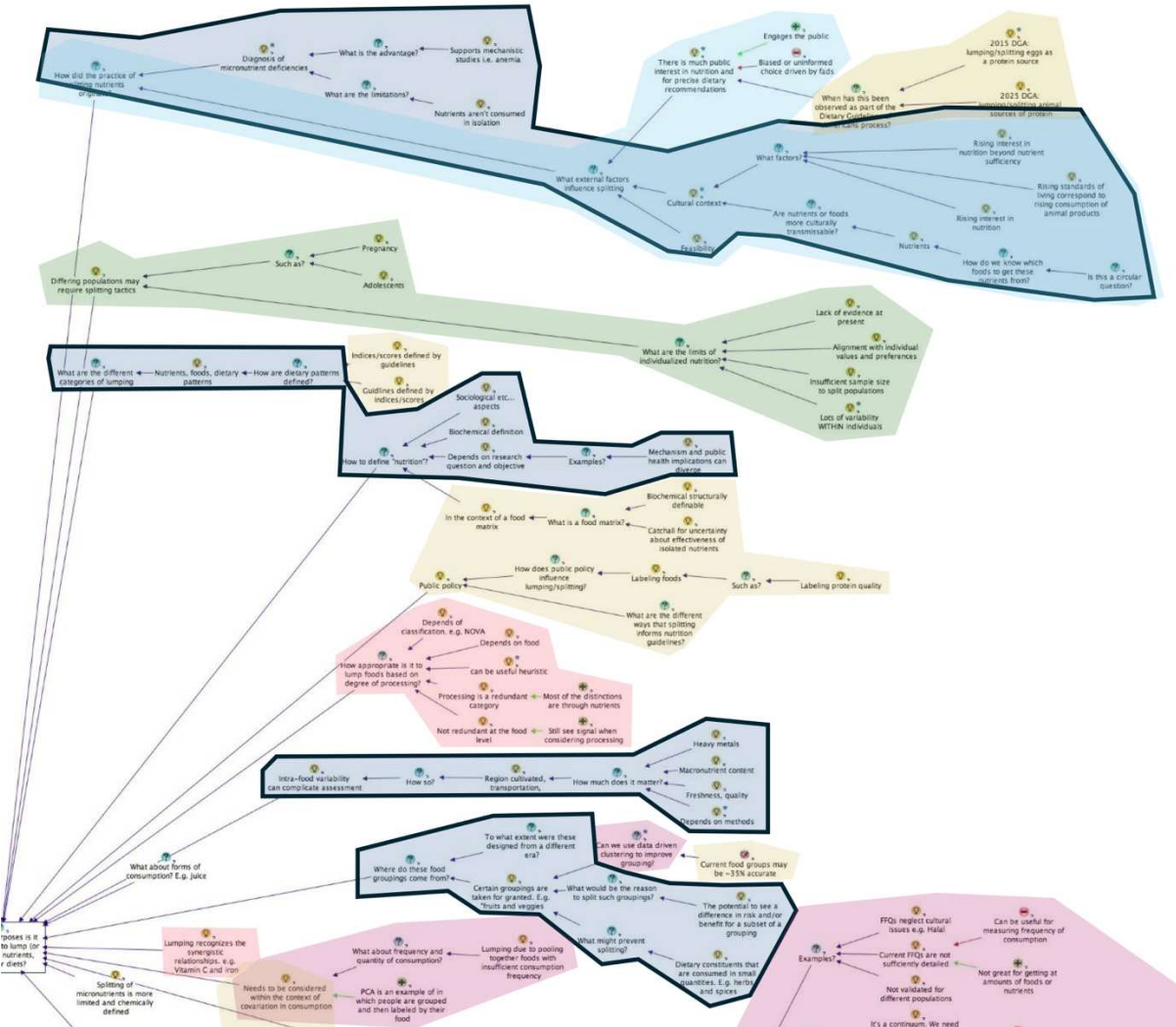
			<i>vegan/vegetarian, food allergies)</i>
Foods /Food Groups	Animal sources of protein (e.g., 2025 Dietary Guidelines for Americans (DGA)) (Theme 4: Policy and Messaging)	Make public health messaging easier to aggregate foods to consume more or less of (e.g., plant or animal protein, red and processed meat) depending on guidelines	Split protein sources with distinct nutrient profiles (e.g., within the animal protein sources, split eggs, poultry, red meat, processed meat)
	Fruits and Vegetables (Theme 1: Definitions and History)	Lump foods based on their episodic and/or habitual consumption frequency	Intra- and inter- food variability results in varying levels of food components and properties (e.g., heavy metals, nutrients, freshness, quality). Potential to see difference in risk and/or benefit for a subset of foods
	Categorization by degree of processing (Theme 5: Frameworks for Categorization)	Foods are grouped on the basis of categories of processing (20) with no further differentiation necessary.	Further differentiation can be driven by e.g., number of unit operations, formulation, nutrient profile, hedonics,
	Lumping together foods or food groups that act synergistically or are consumed concurrently to affect health outcomes (e.g., Mediterranean Diet) (Theme 5: Frameworks for Categorization)	Dietary patterns are easier to follow and communicate than nutrients or foods	Fails to recognize covariation of consumption <i>Avoids error of assuming that all aspects of the pattern are equally important to health</i>

Dietary Patterns	Indices/scores defined by guidelines (e.g., Healthy Eating Index) (Theme 4: Policy and Messaging)	All positively scored foods are lumped as healthful; all reverse scored foods are lumped as unhealthful	Fails to recognize covariation of consumption Indices have unclear causal inference properties
	Data driven clustering or reductionist techniques to improve grouping (Theme 6: Measurements and Methods)	Principal Component Analysis (PCA) to group consumption patterns Broadly lumping things provides a conceptual robustness check	Aggregation without scientific justification can pick up on correlations but not causation.

289 Italicised text indicates additions made after the dialogue mapping meeting (Phase 1).

Theme 1: Definitions and History

Figure 2: Static image of nodes related to Theme 1: Definitions and History



Enlarged portion of the map with node groups related to Theme 1: Definitions and History. Nodes represent an idea (lightbulb icon, in yellow), issue/question (question mark icon, in blue), con argument i.e., arguments disagreeing with the parent node (minus sign, in red), pro argument i.e., arguments supporting the parent node (plus sign, in green), notes (note pad icon, in purple), and decisions (hands shaking icon, in orange). The arrows are oriented with the arrow tip pointing toward the parent node (i.e., the node from the origin of the arrow is in response to the node at the tip of the arrow). Themes were formed in the consolidation phase of the map refinement, after the initial dialogue mapping session. A high-resolution version of this figure can be found at https://osf.io/7n6xv/overview?view_only=39724a0a416444189f4a74fe5752bc89

Figure 2 shows the node groups related to the discussion of Theme 1. The initial discussion of this theme explored how nutrition, foods, and nutrients have historically been delineated, surrounding

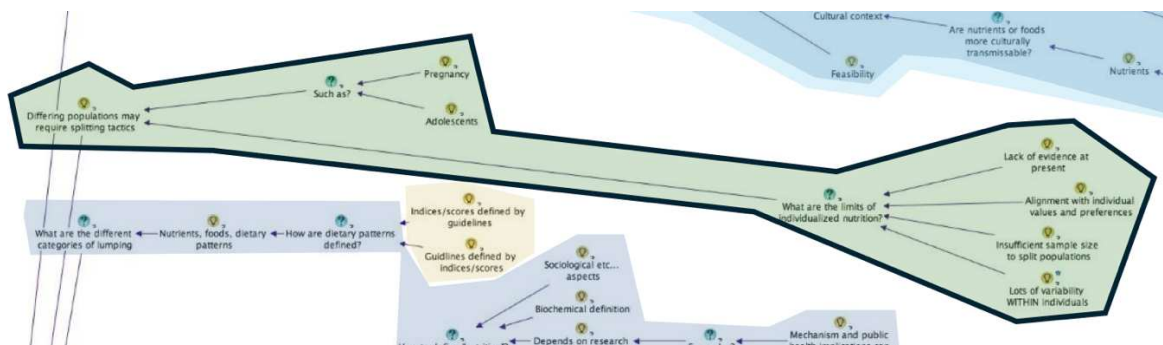
how nutrition is defined, as well as the conceptual nature of splitting or lumping nutrients, foods/food groups, or diet patterns. As outlined in the upper portion of the map (dark blue), “How to define “nutrition?”” may vary across settings, including whether the emphasis is on the biochemical definition of nutrition, sociological aspects of diet, and/or the basis of the research question and objective (e.g., mechanistic, public health basis).

The node “How did the practice of splitting nutrients originate?” led to discussions about examining micronutrients in isolation for the purposes of diagnosing and preventing micronutrient deficiency disorders, emphasizing the early “splitting” orientation of nutrition science (2, 3), as well as the evolution of the field of nutrition science since that point. For example, administration of diets deplete of a specific nutrient was used to isolate the nutrient’s role in the body (21, 22). While panelists recognized that such mechanistic studies can be advantageous from a scientific perspective (e.g., iron deficiency anemia (23), pellagra manifested by niacin/tryptophan deficiency (24)), we also noted limitations of research where nutrients are split, including the fact that nutrients, unlike foods, are not consumed in isolation. Therefore, examining nutrients in isolation may not adequately capture the complexity of the human diet or nutrient requirements. For example, consumption of vitamin C in tandem with iron (e.g., an iron supplement taken with orange juice) can enhance the absorption of iron (as discussed in “lumping recognizes the synergistic relationships”). Conversely, parallel nodes traced how policy frameworks such as the DGA transitioned from splitting foods and nutrients to progressively “lumping” nutrients into recognizable food categories, in response to the question, “What external factors influence splitting?” Panelists also expanded on this conversation via the node, “What are the different categories of lumping?”, and highlighted the differences between nutrients, foods, and diet patterns (in “how are dietary patterns defined?”, “indices/scores defined by guidelines” and “guidelines

defined by indices/scores”). The panel also touched on “to what extent were these [food groupings] designed from a different era?,” given that certain food groupings are consistently grouped together (e.g., fruits and vegetables) based on a historical perspective rather than strong scientific rationale for doing so.

Theme 2: Population Heterogeneity

Figure 3: Static image of nodes related to Theme 2: Population Heterogeneity



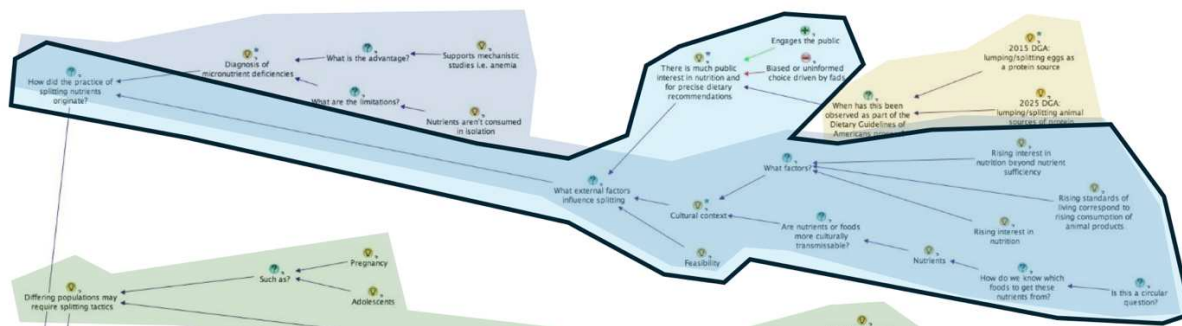
Enlarged portion of the map with node groups related to Theme 2: Population Heterogeneity. Nodes represent an idea (lightbulb icon, in yellow), issue/question (question mark icon, in blue), con argument i.e., arguments disagreeing with the parent node (minus sign, in red), pro argument i.e., arguments supporting the parent node (plus sign, in green), notes (note pad icon, in purple), and decisions (hands shaking icon, in orange). The arrows are oriented with the arrow tip pointing toward the parent node (i.e., the node from the origin of the arrow is in response to the node at the tip of the arrow). Themes were formed in the consolidation phase of the map refinement, after the initial dialogue mapping session. A high-resolution version of this figure can be found at https://osf.io/7n6xv/overview?view_only=39724a0a416444189f4a74fe5752bc89

Figure 3 shows the node groups related to the discussion of Theme 2. Nodes under this theme centered on variability between and within individuals that may warrant different degrees of splitting. Participants cited physiological, life-stage, and cultural examples - such as pregnancy, adolescence, or population-specific food traditions - where splitting categories could improve relevance or accuracy, noting that “Differing populations may require splitting tactics.” Sub-nodes such as “Pregnancy” and “Adolescents” reflected discussions about when individualized or life-stage-specific considerations justify finer-grained categorization, challenging lumped dietary guidance. Nodes also pointed to “lots of variability within individuals” and “what are the limits of

individualized nutrition,” illustrating the tension between biological variability, measurement feasibility, and implementation feasibility. For example, the difference in mineral absorption by race/ethnic groups (25), iron requirements for reproductive-aged and pregnant women (26), and lactose intolerance were discussed as contexts where nutrient-level heterogeneity challenges lumped dietary guidance.

Theme 3. Consumer Behavior

Figure 4: Static image of nodes related to Theme 3: Consumer Behaviour



Enlarged portion of the map with node groups related to Theme 3: Consumer Behaviour. Nodes represent an idea (lightbulb icon, in yellow), issue/question (question mark icon, in blue), con argument i.e., arguments disagreeing with the parent node (minus sign, in red), pro argument i.e., arguments supporting the parent node (plus sign, in green), notes (note pad icon, in purple), and decisions (hands shaking icon, in orange). The arrows are oriented with the arrow tip pointing toward the parent node (i.e., the node from the origin of the arrow is in response to the node at the tip of the arrow). Themes were formed in the consolidation phase of the map refinement, after the initial dialogue mapping session. A high-resolution version of this figure can be found at https://osf.io/7n6xv/overview?view_only=39724a0a416444189f4a74fe5752bc89

Figure 4 shows the node groups related to the discussion of Theme 3. This theme captured how public understanding, habits, and perceptions shape and are shaped by how foods are lumped or split. In the dialogue map, a prominent node labeled “Rising interest in nutrition” among the general public connected to sub-nodes “Engages the public” and “Based on uninformed choice driven by fads.” These connections illustrated that consumer engagement can both support and distort scientific categorization. Consumers and the general public often lump foods around simplified heuristics or “vibes”, typically centered around grouping foods that are “good” versus

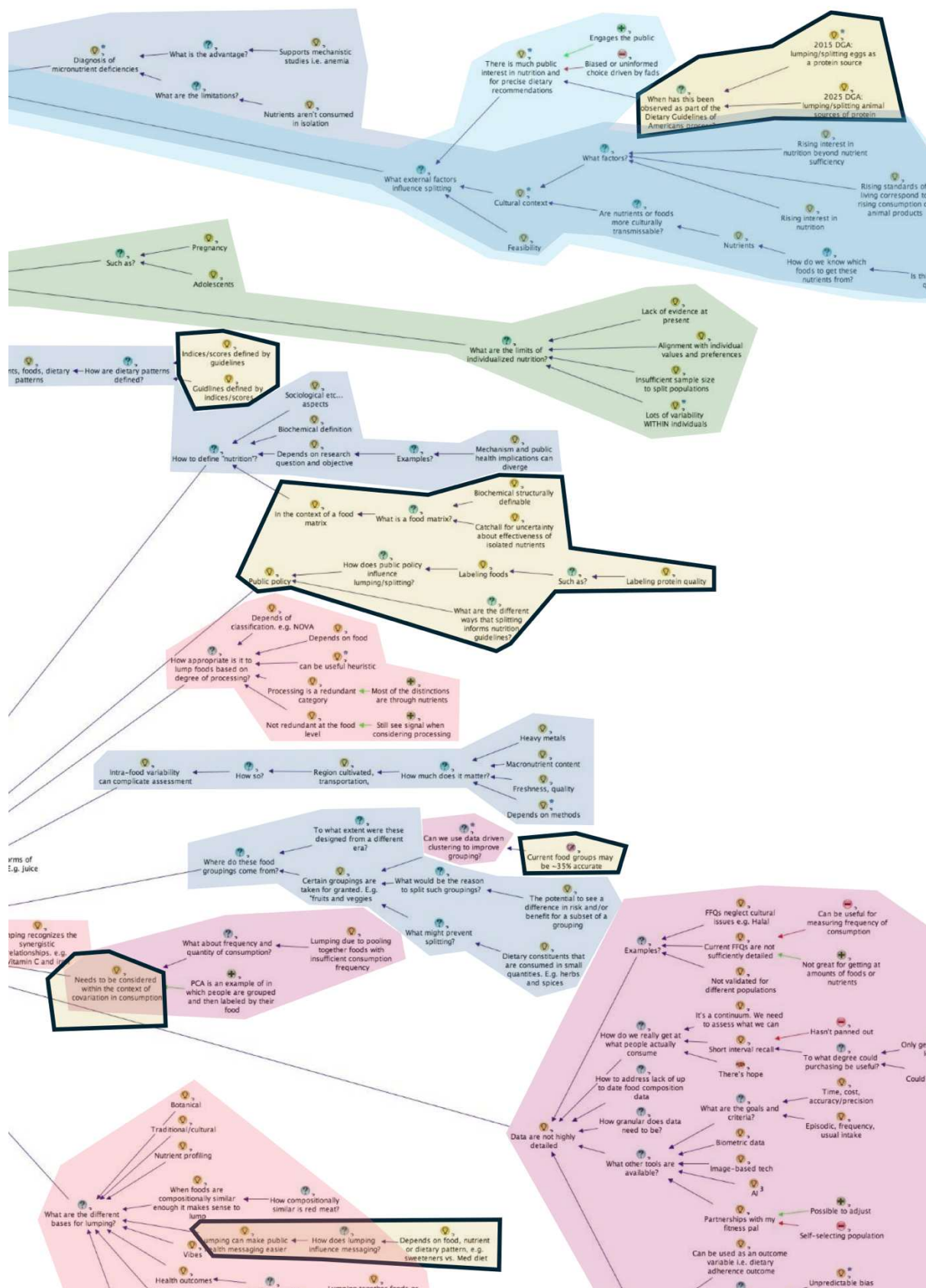
foods that are “bad”. These categorizations can best be described as “you know it when you see it” opposed to being categorized by a clear definition. These heuristics often fail to capture the nuanced differences between foods or food groups that are often grouped as good or bad.

The role of consumer behaviors in determining if and how to lump and split foods has recently been exemplified by the movement to avoid consumption of foods considered to be “ultra-processed” (27) or “highly processed”. However, there is no consensus among the scientific or regulatory community on how these foods should be defined or categorized based on processing (28). Some classification systems focus on product formulation (e.g., presence of specific food ingredients or additives) while other focus on the nutrient profile or sensory properties as means to lump or split foods. These differences in what foods are lumped as “ultra-processed” has important implications for future regulatory policies at the state and federal level as well as the nutritional status of the U.S. and global population (29).

Other nodes, including “Depends on cultural context” and “Different populations may demand different splitting tactics” emphasized that behavioral responses to dietary guidance vary across social and economic settings. The map’s linkages between this theme and Theme 4: Policy and Public Health Messaging (below) underscore the reciprocal relationship: consumer preferences and behaviors influence nutrition policy, which in turn reinforces the lumping or splitting of certain nutrients, foods, and diet patterns.

Theme 4: Policy and Public Health Messaging

Figure 5: Static image of nodes related to Theme 4: Policy and Public Health Messaging



Enlarged portion of the map with node groups related to Theme 4: Policy and Public Health Messaging. Nodes represent an idea (lightbulb icon, in yellow), issue/question (question mark icon, in blue), con argument i.e., arguments disagreeing with the parent node (minus sign, in red), pro argument i.e., arguments supporting the parent node (plus sign, in green), notes (note pad icon, in purple), and decisions (hands shaking icon, in orange). The arrows are oriented with the arrow tip pointing toward the parent node (i.e., the node from the origin of the arrow is in response to the node at the tip of the arrow). Themes were formed in the consolidation phase of the map refinement, after the initial dialogue mapping session. A high-resolution version of this figure can be found at https://osf.io/7n6xv/overview?view_only=39724a0a416444189f4a74fe5752bc89

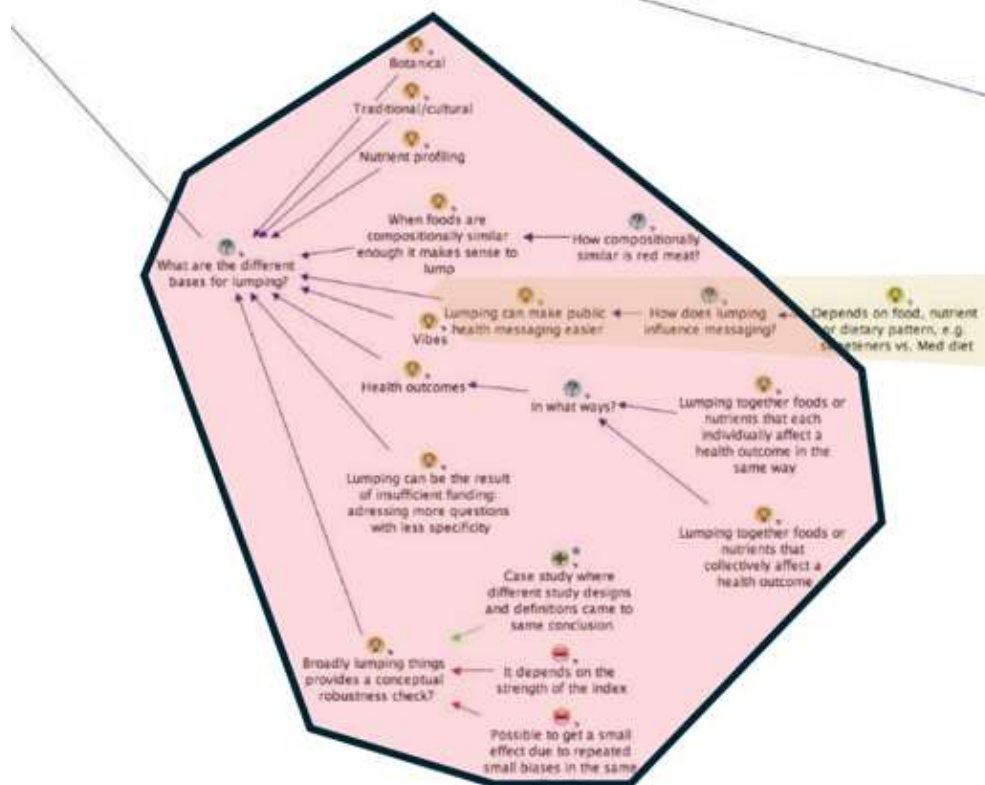
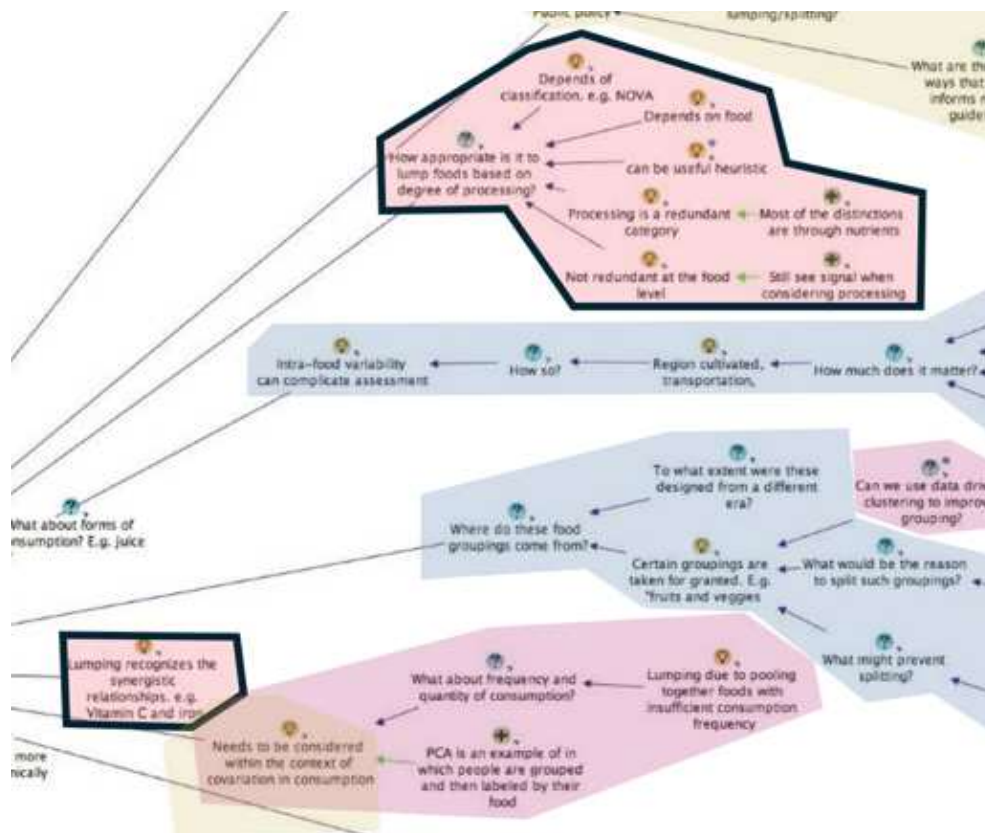
Figure 5 shows the node groups related to the discussion of Theme 4. Lumping can simplify messages (e.g., “eat more fruits and vegetables”) and facilitate broad alignment with dietary guidelines and recommendations, but may be inappropriate for some cases (e.g., specific subgroups of the population with specific dietary needs); public messaging where nutrients, foods or diet patterns are split are generally the exception. However, the panelists noted that oversimplified lumping has the potential to mislead consumers or alienate audiences. Examples included the “lumping and splitting of all animal sources of protein in the 2025 DGAs” (30), including eggs (which had previously been split in the 2020 DGAs), or “labeling protein quality” (31). Different strategies to lump or split protein sources is exemplified by the research questions addressed by the 2010, 2015, 2020, and 2025 Dietary Guidelines for Americans Advisory Committees (DGAC) (31-34). For example, in the 2010 and 2015 DGAC food pattern modeling, animal protein sources split meats, poultry, seafood (high omega-3 fatty acids and low omega-3 fatty acids), and eggs, but aggregate red and processed meat as a food group. In the most recent iteration (2020 and 2025 DGAC food pattern modeling) these foods have been lumped into “meat, poultry, eggs” and split from “seafood”. (30-34) This is in contrast to the extensive diet pattern modeling conducted in the 2020 DGAC, which highlighted the unique contribution of eggs as a source of choline for women of childbearing age (33). Overall, these nodes illustrate how historical precedent (see Theme 1: Definitions and History, above) and practicality have shaped current categorizations of foods and food groups. When considering the broader map, it may be debated whether such lumping facilitates public health messaging or conceals biologically meaningful

heterogeneity between nutrients, foods, and diet patterns. It is also important to note that these food groupings change over time with evolving science, politics, and public perceptions and may represent a somewhat arbitrary and inaccurate food-group classification system, such as the claim that “Current food groups may be ~30% accurate” (35). It is currently unknown whether and to what extent lumping in public policy and public health messaging may be promoting consumer misconceptions or promote adverse nutrition or planetary health/sustainability behaviors.

One subtheme was the circularity of lumping in policy: pre-defined guidelines are often used as a metric to construct indices and measure adherence to a healthy dietary pattern (e.g., the Healthy Eating Index) (36), and those indices may be subsequently used to validate future iterations of dietary guidelines or recommendations (“indices/scores defined by guidelines” and “guidelines defined by indices/scores”). Lumping is frequently used to propose dietary patterns that are feasible for the public, such as aggregating “sweeteners” (specifically LNCS) to simplify advice, even if their metabolic fate and volume of research differ between LNCS (37). This simplification can backfire if lumped items obscure important nutrient or mechanistic differences. Thus, while lumping may aid interpretation and compliance, it often forces a trade-off between messaging and specificity.

Theme 5: Frameworks for Categorization

Figure 6: Static image of nodes related to Theme 5: Frameworks for Categorization



Enlarged portion of the map with node groups related to Theme 5: Frameworks for Categorization. Nodes represent an idea (lightbulb icon, in yellow), issue/question (question mark icon, in blue), con argument i.e., arguments disagreeing with the parent node (minus sign, in red), pro argument i.e., arguments supporting the parent node (plus sign, in green), notes (note pad icon, in purple), and decisions (hands shaking icon, in orange). The arrows are oriented with the arrow tip pointing toward the parent node (i.e., the node from the origin of the arrow is in response to the node at the tip of the arrow). Themes were formed in the consolidation phase of the map refinement, after the initial dialogue mapping session. A high-resolution version of this figure can be found at https://osf.io/7n6xv/overview?view_only=39724a0a416444189f4a74fe5752bc89

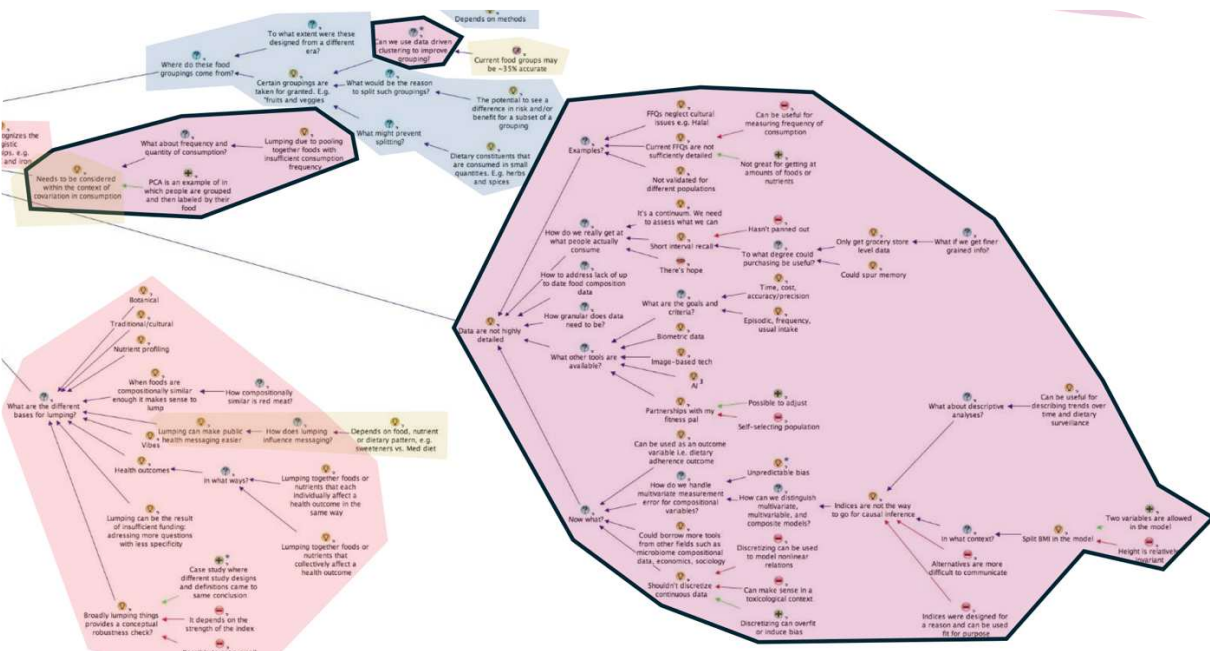
Figure 6 shows the node groups related to the discussion of Theme 5. Panelists identified multiple conceptual bases for grouping foods and nutrients, including but not limited to biochemical composition, sociocultural relevance, degree of processing, intent of use, and dietary role. For example, the map contained nodes across themes labeled “What are the different bases for lumping?” and “Depends on the research question”, and “Depends on classification e.g., Nova,” (38) depends on the “food matrix,” (i.e., “biochemical structurally definable” and/or “catchall for uncertainty about the effectiveness of isolated nutrients”) (39) and depends on the way the categories will be used (e.g., “mechanistic and public-health interpretations may diverge”). These nodes illustrate how different frameworks coexist within nutritional science which promote the lumping or splitting of nutrients, foods, and diet patterns.

Nutrient profiling systems were discussed as an additional framework that operationalizes different logics of lumping and splitting, challenging the degree to which various lumping/splitting decisions may really coexist or can agree with one another with regards to healthfulness (“lumping together foods or nutrients that each individually affect a health outcome in the same way” or “that collectively affect a health outcome”), similar to the discussion on processing. Further, this lumping or splitting based on healthfulness could be relevant particularly in cases like “red and processed meats,” where it is unknown to what extent nutrients and processing exposures overlap but are not identical, signified by the question, “how compositionally similar is red meat?” that was surfaced (40).

Each individual nutrient profiling system, processing, or other framework reflects and encodes a series of researcher choices and/or decisions (e.g., whether to privilege nutrient composition, degree of processing, or other food group consideration). While “Lumping recognizes the synergistic relationships (e.g., vitamin C and iron)” was identified as a reasonable way to justify aggregation by capturing biological interdependence, it is notable that few nutrient profiling models incorporate this information explicitly or with clearly justified rationale, but supplements do have that feature (e.g., some iron supplements contain vitamin C to help facilitate iron absorption).

Theme 6: Measurement and Methods

Figure 7: Static image of nodes related to Theme 6: Measurement and Methods



Enlarged portion of the map with node groups related to Theme 6: Measurement and Methods. Nodes represent an idea (lightbulb icon, in yellow), issue/question (question mark icon, in blue), con argument i.e., arguments disagreeing with the parent node (minus sign, in red), pro argument i.e., arguments supporting the parent node (plus sign, in green), notes (note pad icon, in purple), and decisions (hands shaking icon, in orange). The arrows are oriented with the arrow tip pointing toward the parent node (i.e., the node from the origin of the arrow is in response to the node at the tip of the arrow). Themes were formed in the consolidation phase of the map refinement, after the initial dialogue mapping session. A high-resolution version of this figure can be found at https://osf.io/7n6xv/overview?view_only=39724a0a416444189f4a74fe5752bc89

Figure 7 shows the node groups related to the discussion of Theme 6. A large node of the map explored methodological trade-offs that influence the extent to which nutrients, foods, and diet patterns can or should be lumped or split (“Data are not highly detailed”). Discussions in this node focused on the practical implications of lumping and splitting for dietary assessment, food-group classification, exposure estimation, causal inference, and dietary pattern modeling, highlighting the resource and precision constraints that drive practical lumping and splitting decisions. It was noted that much of the current evidence base relies on self-reported dietary data, which are prone to systematic and random measurement error (41). For example, lumping foods via a food frequency questionnaires (FFQ) can simplify data collection and may be useful to obtain information on usual consumption frequency, but are typically poor at capturing the frequency of consumption of specific foods or the amounts of food consumed and often neglect the consumption patterns of minority populations (42) (“FFQs neglect cultural issues e.g., Halal”, “not validated for different populations”). Conversely, splitting through usage of a 24-h dietary recall or record increases granularity in food and nutrient consumption patterns. However, dietary recalls and records are time and resource intensive and without proper statistical modeling techniques (e.g., the National Cancer Institute Method), poorly represent usual intakes due to the often-short periods of data capture (e.g., one or two days); thus; they have historically been left out of large-scale nutrition studies with a few exceptions (e.g., U.S. National Health and Nutrition Examination Survey, Interactive Diet and Activity Tracking in AARP Study, Multiethnic Cohort and Women’s Health Initiative substudies). Other outstanding questions identified were “how granular does data need to be?” and “how to address the lack of up-to-date food composition data”.

Lumping was seen as necessary for large-scale exposure modeling or surveillance, whereas splitting (e.g., disaggregating vegetables by type or processing) was feasible only when supported

by detailed data or biomarker calibration. To move beyond historical groupings or the “vibes-based” heuristics often seen in consumer behavior (Theme 3: Consumer Behaviour, above), the panel discussed the role of data-driven clustering methods. Techniques such as PCA or cluster analysis offer ways to lump nutrients and foods based on high-dimensional data structures rather than intuition. This offers reproducible, quantitative categorization, provided that underlying food composition databases are sufficiently granular to support such algorithms.

Future Directions and Research Gaps

Several nodes reflected interest and potential in methodological innovation pertaining to data acquisition and analysis. Improved data acquisition methods suggested by the panel included image-based dietary assessment (43), biometric data (44), and receipt-based dietary assessment (e.g., purchasing data) (45). Improved computational analyses included both food-group classifications and diet-disease explorations. On the food-group definition side, “to what extent are these from a different era”, “improving clustering”, and “better defining food groups” were discussed, indicating that lumping and splitting are often driven as much by unclear historical (and perhaps theoretical and computational) considerations rather than clear data, evidence, and rationales. Whether improving data granularity and performing innovative computational analyses on these data may offer clarity on lumping and splitting should be considered in future work. On the analytical side, indices and composite scores were described as practical for public health messaging and dietary surveillance and monitoring but “not the way to go for causal inference” as aggregation without rationale can pick up on correlations but not causation.

Panelists cautioned, however, that methodological precision of an approach must still align with the research question: not every study benefits from disaggregation if the measurement error or sample size constraints outweigh the gains in specificity (46, 47). The discussion also acknowledged potential issues of self-selection and population representativeness resulting from potential partnerships with crowd sourced data sources (e.g., dietary and physical activity-based mobile applications). Importantly, the networked nature of this process emphasizes how methodological feasibility and progress links back to conceptual definitions and policy considerations, and improvements in methodology should thus impact definitional and policy considerations.

Several open-ended questions were highlighted in the dialogue map including "what are the different ways that splitting informs nutrition guidelines?," "what about forms of consumption?" referencing liquid versus solid foods, and "How to address lack of up-to-date food composition data?" Finally, the legal implications of lumping and splitting as a theme were only tangentially mentioned, representing a potential area for further exploration.

Commentary on phase 3: expert review and feedback

Expert reviewers highlighted the value of the dialogue-mapping exercise while noting several areas where additional clarity and refinement would strengthen the manuscript (e.g., costs, consumer understanding of guidance, marketing and lobbying by industry, topics related to over-lumping in the context of a meta-analysis with high unexplained heterogeneity). Reviewers also encouraged addressing methodological considerations more explicitly, including the potential for facilitator bias, the limitations of dialogue mapping as an interpretive tool, and the importance of

distinguishing the method (i.e., Dialogue Mapping) from the substantive findings about lumping and splitting. Historically oriented critiques underscored the importance of situating lumping and splitting practices within longer trajectories of dietary guidance, noting that earlier frameworks were shaped by evolving science, economics, and food availability. Content-related feedback pointed to gaps in examples, the influence of politics and stakeholder interests, and the need to better acknowledge factors such as cost, cultural variation, and changes in food systems. Notably for Theme 6: Measurement and Methods, even with perfect intake data with minimal errors, expert reviewers highlighted that nutrient composition would remain variable due to factors like seasonal variability, lot-to-lot variability, differences in sourcing, manufacturing and shelf-life. In addition, individual differences in absorption, digestion, metabolism and excretion further complicate the challenges faced with dietary intake and nutritional status assessment. Generally, reviewers identified that the work would benefit from clearer articulation of how the map informs broader questions and actionable recommendations in nutrition science. These points were addressed in the current version of the manuscript. Collectively, reviewers saw the work as useful and identified future questions which could utilize this method.

Limitations

This article summarizes discussions about lumping and splitting of nutrients, foods, and dietary patterns from the December 2024 colloquium. As such, literature that was available prior to the meeting was available for reference. We recognize additional relevant work may have been completed since the meeting, and included such references, where appropriate, in the body of this manuscript. This document should be interpreted considering 1) the methodological approach of using dialogue mapping, including the choice of the root question; 2) the dates of data available to be considered for discussion; 3) the potential for bias in the selection of cited publications; and 4)

the value of early-career expert evaluations in determining the present topic while also identifying research priorities for future investigations.

This dialogue map was not intended to be a systematic evaluation of the evidence, but rather an evidence-informed discussion among a team of early-career researchers. The map and nodes are also by no means exhaustive but are a visual representation of the real-time open-ended discussion that occurred in December 2024. This dialogue map is not to be interpreted as a consensus document; the panelists were asked to confirm whether they recalled the information herein to be a representation of what was discussed, not whether they agreed with all opinions and facts shared. Finally, the panelists were a group of researchers from the U.S. and Canada; therefore, the map was generated and topics were discussed in a North American context, although global research and perspectives were considered. This caveat may have resulted in a limited North American perspective. We attempted to mitigate this by the inclusion of additional expert opinions.

The Dialogue Mapping method itself is limited by the fact that a group of participants are required to come together in a single environment in real-time, which is logistically challenging and limits the number and locations of participants that can attend.

Recommendations and conclusions

This work represents an exercise in critical thinking and introspection on the assessment and reporting of lumping and splitting decisions to increase rigor, reproducibility, and applicability in nutrition science. Expert review of this body of work recommended future topics be explored with Dialogue Mapping, and that the lumping and splitting discussion should be continued to develop guidance and recommendations on best practices. It was not the purpose of this project to make

explicit recommendations on when to lump or split nutrients, foods and diet patterns. Future work, such as a Delphi approach, should focus on 1) making actionable guidance to advise researchers and policy- or guideline-makers on when it is most appropriate to lump together or split apart nutrients, foods or diet patterns, and 2) a more robust and well-defined vocabulary to distinguish types, levels, and purposes of lumping and splitting.

Panelists noted that the rationale for lumping often diverges between scientific and policy domains: mechanisms of action and/or health effects may suggest one grouping, while public health messaging or food labeling requires another. The dialogue underscored that any categorization system carries implicit assumptions about causality and comparability. When viewed as a whole, the map and Table 2 reveal that lumping and splitting function less as opposites and more as complementary heuristics situated within different epistemic and practical contexts. In fact, lumping and splitting decisions can be seen as a spectrum or continuum rather than black-or-white decisions. Like all wicked problems, for which this topic remains, there's no clear-cut solution. While the dialogue clearly emphasized that lumping and splitting decisions should be made relative to the research or policy question, rather than by default or tradition, it also identified the need for clearer operational criteria to guide when lumping or splitting is appropriate across these contexts. In other words, the appropriateness of lumping or splitting depends on the question being asked, the available data, and the intended audience, and these decisions and their rationale should be made transparent.

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Declaration of Generative AI in Scientific Writing

The authors declare that no generative AI or AI-assisted technologies were used in the writing of this manuscript.

Author contribution

Conceptualization: AWB
Data curation: all authors
Formal analysis: all authors
Funding acquisition: AWB
Investigation: all authors
Methodology: AWB, AWK
Project administration: AWB, CDD, SA-C
Resources: AWB, AWK
Supervision: AWB
Visualization: AWK and all authors
Writing – original draft: all authors
Writing – review and editing: all authors

Conflicts of interests

SA-C has received an honorarium from the international food information council (IFIC) for a talk on artificial sweeteners, the gut microbiome, and the risk for diabetes. LC has received research funding from the Canadian Institutes of Health Research (CIHR), Protein Industries Canada (a Government of Canada Global Innovation Cluster), the United Soybean Board (The United States Department of Agriculture Soybean “Check-off” Program) and the Alberta Pulse Growers. She has received honoraria from the Arkansas Children’s Hospital and Plant-Based Health Professionals UK. AEC-P is a member of the Journal of the Academy of Nutrition and Dietetics Board of Editors, serves as a consultant to the General Mills Bell Institute, and has previously served as a consultant to the National Pork Board and Think Healthy Group. KAH is an employee of Exponent, Inc., which provides scientific consulting to the food and beverage industry, and was previously employed by the USDA-ARS. In the 36 months prior to the initial submission, CJV has received honoraria from The Alliance for Potato Research and Education, National Cattlemen's Beef Association, and American Pistachio Growers. The institution of CJV, Indiana University, has received funds to support his research from: National Cattlemen’s Beef Association; Alliance for Potato Research and Education; UKRI, Hevolution Foundation, and NIH. JE-M is the founder

of Bespoke Analytics, LLC, and cofounder of The Human Flourishing Collaborative, PBC. AWB: In the 36 months prior to initial submission, Dr. Brown has received travel expenses from Alliance for Potato Research and Education, Indiana University, Institute for the Advancement of Food and Nutrition Sciences, International Food Information Council Foundation, Juice Products Association, National Academies of Science, Engineering, and Medicine, Soy Nutrition Institute Global, Toronto 3D Knowledge Synthesis and Clinical Trials Foundation, UAB Nutrition Obesity Research Center, and University of Copenhagen; speaking honoraria from Alliance for Potato Research and Education, American Society for Nutrition, Arkansas Academy of Nutrition and Dietetics, Eat Well Global, Indiana University, Juice Products Association, National Restaurant Association, and UAB Nutrition Obesity Research Center; editorial board payments from American Society for Nutrition Statistical Review Board, and Springer Publishing Company (International Journal of Obesity); consulting payments from International Food Information Council Foundation, and Soy Nutrition Institute Global; and grants through his institution from American Egg Board, National Pork Board, NIH, and NSF. He has been involved in research for which his institution or colleagues have received grants or contracts from ACRI, Alliance for Potato Research & Education, Childhood Arthritis and Rheumatology Research Alliance, NIH, and UAMS. His wife has been employed by Mead Johnson. CDD and AWK reports no conflicts of interests.

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