

# Expanding the Frontiers of Population Nutrition Research: New Questions, New Methods, and New Approaches<sup>1,2</sup>

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## ABSTRACT

Nutrition research, ranging from molecular to population levels and all points along this spectrum, is exploring new frontiers as new technologies and societal changes create new possibilities and demands. This paper defines a set of frontiers at the population level that are being created by the increased societal recognition of the importance of nutrition; its connection to urgent health, social, and environmental problems; and the need for effective and sustainable solutions at the population level. The frontiers are defined in terms of why, what, who, and how we study at the population level and the disciplinary foundations for that research. The paper provides illustrations of research along some of these frontiers, an overarching framework for population nutrition research, and access to some of the literature from outside of nutrition that can enhance the intellectual coherence, practical utility, and societal benefit of population nutrition research. The frontiers defined in this paper build on earlier forward-looking efforts by the American Society for Nutrition and extend these efforts in significant ways. The American Society for Nutrition and its members can play pivotal roles in advancing these frontiers by addressing a number of well-recognized challenges associated with transdisciplinary and engaged research. *Adv. Nutr.* 4: 92–114, 2013.

## Introduction

The nutritional sciences span a broad spectrum of organizational levels, from molecular to population (1), all of which are exploring new questions and applying new tools in keeping with advances in scientific knowledge and investigative technologies. For example, advances in omics, informatics technologies, and systems biology have been major drivers of new questions and possibilities at the molecular, metabolic, and organismic levels (2–4), and advances in mobile technologies, telemetry, social networks, and “serious games” have the potential to revolutionize research and behavior change interventions related to diet and physical activity (5–9). This paper identifies an emergent set of research frontiers at the population end of the nutrition spectrum, with a particular focus on the new research questions, methods,

and approaches required to respond effectively to an expanding set of food- and nutrition-related problems and emergent opportunities. The paper is an outgrowth of a recent symposium on this topic sponsored by the American Society for Nutrition. It outlines 6 arenas that characterize frontier research with populations and proposes a framework for mapping the overall landscape of population research in nutrition. The paper then presents case examples from policy development, program evaluation, and community-based research and a description of several research frameworks that inform these cases. The paper concludes with a summary of challenges and opportunities for advancing these frontiers in population nutrition research.

## The context for highlighting new frontiers

Unlike the technological advances that are creating new research possibilities at the molecular, organismic, and behavioral levels, the population level frontiers identified here are being created largely through changes in society. Prominent among these are the following: 1) Heightened awareness, interest, and/or concern for food and nutrition on public and private agendas, as seen in the attention given to the obesity epidemic (10,11), the global spread of noncommunicable

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diseases (12), undernutrition and food insecurity in low-income countries (13), and the expanding global influence of the multinational food companies (14); 2) Recognition of the interconnected nature of nutrition and health problems with agriculture, food systems and environmental sustainability, poverty and social justice, and the social, organizational, and political processes that seek to maintain or change these (15–18). The explosion of semipopular books on food, nutrition, and the food system (19–30) indicates that the awareness is at the cultural level in addition to the scientific and policy levels; 3) Emergent opportunities for researchers to engage in these issues at local, national, and global levels (31–34); 4) Increasing demand for evidence of the effectiveness of interventions when implemented at scale (35–38); and 5) Growing interest in and funding of “action-oriented research” such as implementation or translational science and community-based participatory research (CBPR)<sup>7</sup> (39–44).

A central theme emerging from these trends is the need for research programs that are action oriented, transdisciplinary, conducted in real-world conditions, interactive with external actors and institutions, and working at various scales, with nutrition being examined in its broader social, ethical, economic, and political contexts.

These themes bear some similarity to Mode 2 research described in the sociology of science literature (45,46) and, for this reason, is referred to as the Mode 2 Frontier in the following. The societal production of knowledge in Mode 2 is highly interactive and socially distributed, in contrast to Mode 1 knowledge production that takes place primarily in academic and scientific institutions and is governed by the norms of scientific disciplines. Mode 2 knowledge production is considered an emergent and socially robust form that supplements Mode 1 and is better suited for addressing complex social problems. Its emergence is due to external (societal) trends and pressures as well as internal forces and incentives within universities and other research institutions. Mode 2 knowledge production differs from that of Mode 1 in several ways: 1) it takes place in the context of application or problem solving (vs. theoretical or strictly academic contexts); 2) it is transdisciplinary (vs. disciplinary or even interdisciplinary); 3) it is heterogeneous in its sites, including mission-focused research centers, government agencies, think tanks, nonprofit agencies, communities of practice, epistemic communities, and community organizations. (vs. traditional universities and research centers); 4) it arises from mutual interaction among these sites (vs. interaction among disciplinary peers); 5) it involves novel forms of quality control based on economic, political, social, ethical, and utility criteria (vs. discipline-based peer review alone); and 6) it as a result of this interaction, is reflexive (embracing of multiple perspectives on problem solving vs. search for a single truth) and more intentionally socially accountable (vs. accountable to scientific and disciplinary norms).

Originally advanced as a way of describing and understanding recent transformation of science systems in society as a whole, these 2 modes of knowledge production are also readily observable in the emergent practices of universities and other knowledge-producing organizations, epistemic communities, and research programs.<sup>8</sup> The next section describes 6 dimensions by which Mode 2 research differs from conventional research in the particular case of population nutrition and why this represents a research frontier.

### Six dimensions of the mode 2 frontier

**Table 1** proposes 6 dimensions along which Mode 2 research can be defined in the context of population nutrition research and contrasts this with Mode 1 conventional tendencies.

In many cases, the distinctions shown in this table are a matter of degree or emphasis rather than discrete categories. Individual studies or research programs may possess many or few of these characteristics, to a greater or lesser extent. Thus, the table is intended to convey a sense of where some of the frontiers are moving or can move in the future rather than a rigid typology for classifying individual studies or research programs

### Why study

The most fundamental difference between the conventional tendencies and the Mode 2 frontiers relates to the motivation for the research (“why”). Although the primary motivation for the former is to generate theoretical or generalizable knowledge and fill gaps in scientific knowledge, the primary motivation for the latter is to create actionable knowledge, that is, knowledge that can help identify, characterize, and solve real-world problems (48–50). These are not pure types nor are they mutually exclusive. Theoretical knowledge can play an important role in addressing real-world problems, as in Kurt Lewin’s (51) quote that “there is nothing more practical than a good theory.” However, conventional academic efforts to address real-world problems typically reveal the limits of disciplinary and interdisciplinary knowledge, indicating a need to integrate theoretical or technical knowledge with contextual, practical, and ethical knowledge through interaction with social actors affected or engaged with the problem. This highlights the possibility of generating new questions and new forms of fundamental knowledge and theory about problem solving in society that transcend the disciplines. Thus, in principle, both forms of research can contribute to problem solving, both can uncover difficult intellectual challenges and both can contribute new fundamental knowledge and theory. The fact that these ends often are not achieved in practice may be partly a function of institutional separation, norms, and incentives rather

<sup>7</sup> Abbreviations used: CBPR, community-based participatory research; DE, developmental evaluation; PSF, policy sciences framework; RCT, randomized, controlled trial.

<sup>8</sup> Mode 1 and 2 account is only one of several theories or descriptions of changes in the practice of science and is not universally accepted in the field of science and technology studies (47). It is considered most applicable to certain scientific fields, notably those with links to policy and societal applications such as nutrition and therefore is used as a organizational heuristic in this paper.

**Table 1.** Six dimensions of mode 2 frontiers<sup>1</sup>

	Mode 1/conventional	Mode 2/frontiers
Why we study	To create generalizable or fundamental knowledge that answers scientific questions	To create actionable knowledge of issues and problems of concern to stakeholders, organizations, communities, or publics at various scales
What we study	Nutrients, food and nutrient intake, consumer behavior, determinants and consequences of nutritional variation, efficacy of interventions	Food and nutrition issues, causes and solutions in a broader social and action context, including: Food systems Social and public health programs and policies Processes of policy development, implementation, scaling up, and evaluation Community organization and change processes Organizational behavior and change processes
Who we study	Mothers, infants, children, individuals, consumers, patients	Policy makers, analysts, managers, implementers, frontline workers in the public sector; global, national, state, and local Leaders and members of communities, civil society organizations, universities, networks, and coalitions; global, national, state, and local Private sector actors and entities Citizens, academics
How we study Methods	Measurements of knowledge, attitudes, beliefs, behavior, biology, individual and environmental characteristics, and their interrelationships, using a limited range of quantitative and qualitative methods	More eclectic range of qualitative and quantitative methods to inquire into the new objects and subjects noted above, including mixed methods, social network analysis, discourse analysis, narrative policy analysis, Q methodology, process tracing, stakeholder analysis and influence mapping, program impact pathways, organizational ethnography, systems dynamics group modeling
Approaches	Generally detached, objectivist, positivist, reductionist, behaviorist, hypothesis testing	More engaged, participatory, action research, CBPR <sup>2</sup> , participant-observer, reflection in action, embedded, critical, social construction, emergent, systems and complexity oriented
Disciplinary foundations	Nutritional sciences, epidemiology and biostatistics, biomedicine, psychology, social psychology, consumer behavior	Transdisciplinary, drawing on our traditional disciplines but also a greater role for economics, sociology, anthropology, policy analysis, law, urban planning, political science, organizational behavior, management sciences, systems sciences

<sup>1</sup> In many cases, the distinctions shown in this table are a matter of degree or emphasis rather than discrete categories. Individual studies or research programs may possess many or few of these characteristics, to a greater or lesser extent.

<sup>2</sup> CBPR, community-based participatory research.

than an inherent incompatibility between the 2 (46). Differences in the primary motivation for research leads to enormous differences in the what, who, and how dimensions shown in Table 1.

### What and whom to study

The Mode 1 conventional tendency concerning *what* to study relates to the measurement, determinants, and consequences of variations in nutrient status, food and nutrient intake, and consumer behavior and the testing of the efficacy of interventions to address these. The conventional tendency in terms of *who* is to study those affected by nutrition problems as defined by life stage (women, infants, children, adolescents, adults, seniors), health or disease status, physiological status (pregnant, lactating), genetics, or other individual characteristics. Together, the various permutations of these *what* and *who* characteristics account for the vast majority of papers in leading nutrition journals.

Various versions of the socioecological model are widely referenced and used as guiding frameworks for research at the population level (52–66), and this would seem to

contradict the above assertion that the individual is the primary unit of analysis in conventional research. However, even in this context, the unit of analysis (the dependent variable) is the individual. The other levels of the socioecological model (interpersonal, institutional/organizational, community, and social structure/policy/system levels) are primarily used to identify explanatory factors (independent variables) in the empirical analysis or to ensure that intervention and control groups are balanced in these characteristics. The knowledge created in this way does have utility for guiding certain actions (e.g., individual screening, targeting, and choice of individual interventions). But, to the extent that these higher level factors and entities must be modified to resolve food and nutrition problems, these conventional analyses leave a host of important theoretical, ethical, and practical questions unanswered.

Mode 2 research, in contrast, focuses on these higher level factors and entities and their interactions as primary units of analysis and/or a major focus of intervention. This includes such entities as the food system and any of its components; social and public health programs and

policies; organizations in the public, private, or civic sectors; and social or geographic communities and their institutions. Key questions for any of these entities relate to their origins, structure, function or performance, governance, and their interaction with the broader sociopolitical, economic, and natural environment; the influence that their policies, perspectives and practices have on food and nutrition outcomes and/or proximate factors (such as food availability, access, and utilization); their openness or resistance to change and factors that influence this; and the effectiveness of various strategies to improve the performance, food/nutritional effects, and/or broader social, economic, or environmental consequences of these entities.<sup>9</sup>

Individuals included in Mode 2 research could be legislators, bureaucrats, policy analysts, program managers, program implementers, or frontline workers in the public sector. In civil society, it might be leaders and members of communities, nonprofit organizations, universities, networks, and coalitions or citizens at the global, national, state and/or local levels. In the private sector, it may be executives, managers, workers, shareholders, or overseers at the global, national, state, and local levels. Such individuals may be engaged because their perspectives, practices, and experiences are of interest in their own right; their knowledge and experience can help reconstruct and understand how their internal and external dynamics and decisions relate to a given set of food and nutritional problems; and/or their cooperation or collaboration in a change effort is desired. In other words, participants in Mode 2 research also work as experts, actors, and gatekeepers.

### How to study (Methods)

Conventional research uses a fairly limited range of qualitative and quantitative methods in keeping with disciplinary norms (Table 1). For example, this might include using interviews, focus groups, and surveys to measure the knowledge, attitudes, beliefs, behavior, and biology of individuals and to examine their relationships with sociodemographic and environmental characteristics via multiple and logistic regression and analysis of variance or factor analysis. Mode 2 research might use such methods, but it also uses a more eclectic range of qualitative and quantitative methods. The methods include mixed methods (67), social network analysis (68), narrative policy analysis (69,70), discourse analysis (71), Q methodology (72), concept mapping (73), practitioner profiles (74), process tracing (75), stakeholder analysis and influence mapping (76,77), program impact pathways (78), organizational ethnography (79), and systems

dynamics group modeling (80,81). Several authors have documented a large and growing number of social science methodological innovations, adaptations, and extensions based on new technologies for data collection and analysis, cross-fertilization across disciplines, and the need to engage social actors and social issues in more rigorous and appropriate ways (82–85).

### How to study (Approaches)

The overall methodological approach or orientation is another dimension that distinguishes Mode 2 research from conventional research. In keeping with its goal of generating new scientific knowledge that conforms to disciplinary norms, Mode 1 conventional research uses an overall approach that values objectivity and detachment from the object of study, positivism, prediction, reductionism, mechanistic causality, hypothesis testing, replication, and generalizability. These methods implicitly presume that a stable reality exists in the social world (enabling prediction), that this reality can be studied with methods similar to those classically used in the natural sciences (detached, objective, mechanistic), that social and political dynamics and relationships among actors can be separated from context, that selected aspects of these dynamics can be understood separately from the whole and from history, and, if claims are made for the utility of the research, that community and policy actors will use scientific evidence generated via Mode 1 approaches to help address the problems that they face (86,87). These tacit assumptions have been extensively critiqued and falsified (45,88). Mode 2 research, by contrast, uses approaches based on the desire to produce actionable knowledge, a view that the social world has open systems properties (complex, multilayered, dynamic, nonlinear, and emergent), that the structure of problems and the preferred solutions are socially constructed, and that social actors have varying degrees of autonomy, agency, power, and intimate contextual knowledge relevant to understanding and addressing the problem at hand. Accordingly, Mode 2 research uses approaches that tend to be more engaged, participatory, and holistic, such as action research (89), community-based participatory research (90), prospective policy research (91,92), participant-observer (93), reflection in action (94), and others.

Although these methodological orientations are presented here as 2 distinct categories, it is important to note that the boundaries are not as clear. For example, some of the methods of conventional research (e.g., surveys, quasiexperimental research) can play a role in Mode 2 research when they have the potential to help resolve real-world problems. However, even in such cases in Mode 2, these would tend to be negotiated and chosen through an interaction among scientists, analysts, and/or social actors. A second example is that properties of open systems (such as complexity, nonlinearity, and emergence) that have been attributed here to Mode 2 research are also being recognized and applied in systems biology (95,96), population-level systems dynamic modeling (97), and an integrative view of systems science at NIH (98). However, the distinctiveness of

<sup>9</sup> As detailed in the paper, research on these questions should draw on knowledge and theories from varied social science disciplines, such as community psychology, organizational behavior, management, anthropology, sociology, and political science. But the motivation in Mode 2 research is to generate actionable knowledge for the ultimate improvement of food and nutrition environments, influences, and outcomes in populations rather than to test or develop disciplinary theory per se. An effort to test or develop disciplinary theory in Mode 2 research likely would compromise the ability to create actionable knowledge because the latter requires the integration of knowledge from many disciplines with detailed contextual knowledge and contextually relevant ethical or normative considerations.

Mode 2 research is not simply that a systems perspective is brought to bear. Unlike in the natural or population sciences, Mode 2 research often requires varying degrees and forms of interaction between researchers and social actors because the latter have problem-relevant knowledge, their engagement is often crucial for fostering the use of findings, for generating usable findings, and for normative reasons (99–101). These fundamental differences between social and biological worlds require different theories, methods, and research orientations.

### Disciplines

The disciplinary foundations of Mode 2 research are broader than those in conventional research (Table 1) and, most importantly, are used from a transdisciplinary rather than a multi- or interdisciplinary perspective. The difference between the 2 categories is fundamental. As discussed in detail elsewhere (102), health problems (and proposed solutions) can be defined by a single discipline, multiple disciplines working independently (multidisciplinarity), or multiple disciplines working together (interdisciplinarity). The latter is an improvement over the first 2 but still is dependent on the following: 1) the perspectives associated with the particular disciplines “at the table”; 2) the particular theories or subtheories selected from each of these disciplines (of which there are many); and 3) the assumption that this particular combination and integration capture all the dimensions and features relevant for addressing the problem. Interdisciplinary approaches begin with disciplinary perspectives and use them to define and understand problems. It can be conducted purely through discussions and negotiations among academics and may not fully represent the problem as manifested in a particular context. Transdisciplinary approaches, by contrast, begin with an exploration of the problem in its full contextual complexity in collaboration with social actors (100) and seek a shared (and often transformed) understanding of the problem not fully captured by disciplinary frameworks. Throughout this process, the contextual knowledge of social actors and a variety of disciplinary insights, theories, and methods can be consulted to gain a deeper understanding of selected dimensions of the problem. The social actors bring enormous contextual knowledge to this process, which ultimately informs the types of disciplinary insights and methods that would be most useful and relevant, and their participation is crucial for deciding where to place boundaries on the scope and scale of the problem in light of political, practical, ethical, and other considerations (99,101).

### A framework for population nutrition

The landscape of population nutrition research includes a diverse range of topics, such as epidemiologic analysis of NHANES data (or its equivalent in other industrialized countries or low-income countries); development or evaluation of local programs related to school food, farmers markets, WIC or food stamps; testing of innovative nutrition education and behavior change interventions; interviews

with decision makers in local, state, or national programs or policy institutions; evaluation of consumer comprehension of nutrition labels on foods; and much more. Often these disparate research efforts are undertaken with insufficient attention or reflexivity concerning the purpose (e.g., to understand vs. describe vs. test theory), the guiding discipline, theory, or framework; the boundaries and dynamics of the social system implied by the problem; or the way in which the knowledge is to be applied to solve a problem. As a result, the current research and literature on population nutrition research do not form a coherent and cumulative body of knowledge and may lack relevance or utility for problem solving. Figure 1 provides a framework for comprehending and situating nutrition research within this broad and diverse landscape.

The figure depicts 7 dimensions and is a 2-dimensional representation of a 7-dimensional matrix, such that any given study could be located within a given cell or set of cells in this matrix. The first dimension identifies particular food or nutrition problems of concern (e.g., obesity, food insecurity). Dimensions 2 through 4 map levels of society being studied, the sectors being studied, and stages of social problem solving (from agenda setting to termination). The last 3 dimensions reflect diversity in research approaches in disciplines and methods (dimension 5), purposes or motivations for the research (dimension 6), and features of the social change process (dimension 7) that could be the focus of research.<sup>10</sup> To illustrate, a study of local school food policies (dimension 1) could be undertaken through a transdisciplinary collaboration (dimension 5) with school stakeholders (dimension 3) for the dual purpose of improving (dimension 6) the school food environment and understanding (dimension 6) the social change dynamics in this context (dimension 7). This represents a case in which a local government (dimension 2) attempts to implement (dimension 4) a policy developed at the national level (dimension 2) by participants whose goals, perspectives, and knowledge (dimension 7) were distinct from those at the local level. The practical outcome of such engaged research may be the adaptation of national school food standards to better meet the values and conditions in the local school, whereas the intellectual outcome may be a better understanding of how various school stakeholders (e.g., students, food service staff, and parents) deployed some unexpected sources of power (dimension 7) to shape the adaptation and implementation process (dimension 4). This example illustrates the ways in which the framework in Figure 1 can help locate a given study within the overall landscape, bring to light multilevel connections and dynamics that might otherwise be overlooked, and add to a growing body of knowledge about the nature and role of stakeholder power in social change related to nutrition. The latter insight, in turn, can help design more effective strategies for implementing national policies in future cases.

<sup>10</sup> The social change features shown here are part of a generic framework applicable to each of the problem-solving activities (103) and are useful for gaining an initial transdisciplinary orientation to the context. This framework is described further in a later section of this paper.

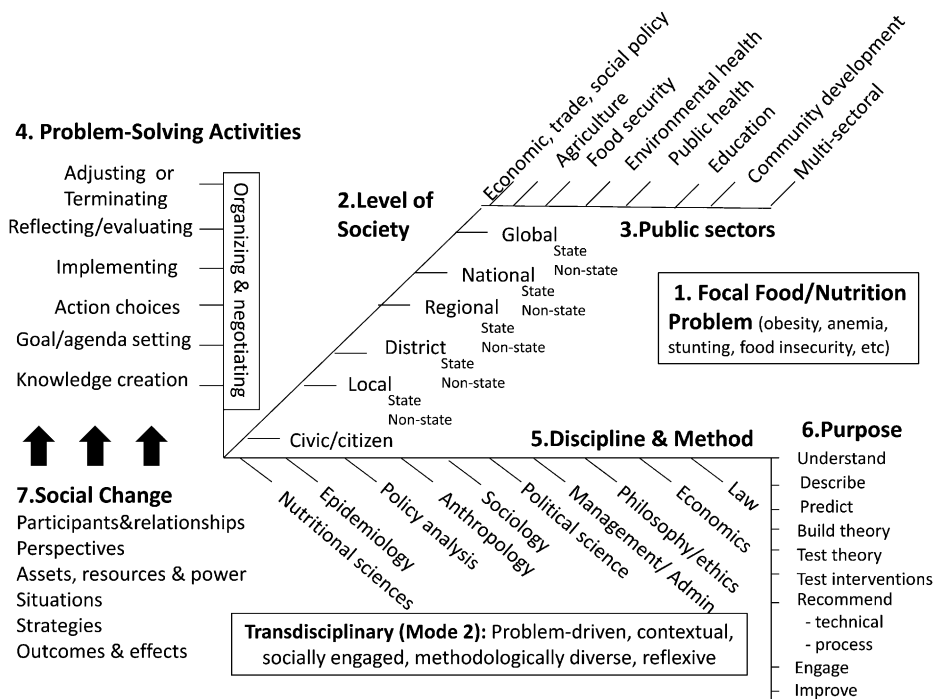


Figure 1 The landscape of population nutrition research.

With the benefit of this framework, researchers, funders, and social actors can more readily identify gaps and priorities in knowledge, research agendas, and action agendas (e.g., inadequate attention to the ways in which agenda-setting strategies can limit action choices or an overemphasis of prediction-oriented research relative to engaged research); they can be more reflexive and explicit in their choice of purposes, disciplinary foundations, theories/framework, and methods; they can more readily analyze and identify commonalities in findings across settings [e.g., by reference to a common set of categories in the social change process (dimension 7)]; and they can be more intentional in exploring the ways in which dynamics at 1 level of society can affect other levels (e.g., the influence of the local food system activism on national food policy discourse).

In addition to the above, the framework can further clarify the differences between Mode 1 and Mode 2 research frontiers. Specifically, research related to 6 of the dimensions (focal problem, sector, level of society, problem-solving activities, social change features, and purpose) in principle can be undertaken under either the conventional Mode 1 or the Mode 2 paradigm. The 2 modes of research in this landscape are distinguished by how the discipline/method axis is combined with the purpose axis. For example, Mode 2 research proceeds with a greater commitment to the characteristics shown in the transdisciplinary box, whereas conventional research is grounded in 1 or more of the disciplines and its associated methods and assumptions. The variation of individual studies and research programs is illustrated in this section, with examples related to national policy, the evaluation of large-scale programs, and community-based initiatives.

## Illustrations

### Nutrition policy

The 5-paper *Lancet* Nutrition Series has had a large impact on the policies and strategies of action agencies at global and national levels. Three of the papers summarized evidence concerning the magnitude and consequences of undernutrition and the efficacy of certain interventions (104–106). To make technical recommendations, these 3 papers and the underlying research drew on research in nutritional sciences and epidemiology to test interventions. The recommended core interventions were predominantly biomedical and judged to be “core” because they were supported by randomized clinical trials, the type of evidence favored in Mode 1 research for establishing causality and efficacy. These recommendations were made despite the virtual lack of peer-reviewed evidence of the effectiveness of these interventions when implemented in real-world conditions (105), the broad recognition that undernutrition has its roots in many sectors (107–109), a strong interest in broader multisectoral strategies on the part of the larger nutrition policy community (110,111), extensive gray literature, and the fact that nutrition interventions often are implemented within broader multisectoral strategies (112).

A fourth paper in the *Lancet* series (113) was tasked with providing “process recommendations” for effective action at the national level, implicitly building on and perhaps going beyond the randomized, controlled trial (RCT)–driven and discipline-based recommendations in the earlier papers. The authors stated

“The challenge is to make recommendations that are specific, actionable, and based on the best evidence, while recognizing the limitations in the available

evidence, the distinctions between efficacy, effectiveness, and transferability, the need to adapt action strategies to national contexts, and the dynamics of the nutrition policy process.”

In meeting this challenge, the paper noted the need to consider context, draw on broader bodies of knowledge and experience, and adopt a different standard of evidence. For instance, the paper stated that countries should not implement the core biomedical interventions unless or until they have the capacity to do so well (but did not offer guidance on how to make that assessment); they should draw on the extensive reservoir of practical experience in building commitment, scaling up, and addressing numerous other “process” challenges; and, in addition to biomedical interventions, they should consider multisectoral actions that are “associated” with reductions in undernutrition. This last recommendation lowers the evidence standard in favor of highlighting the best available knowledge concerning effectiveness rather than efficacy studies alone. These and other suggestions in the paper were based largely on the extensive country-level experiences, either known to the authors personally or available in the gray literature, rather than efficacy studies or explicit disciplinary models or theories.

This example illustrates differences and relationships between Mode 1 and Mode 2 knowledge and the ways in which these must be “negotiated” when creating actionable knowledge (in this case, in the form of recommendations to countries and their international partners). The first 3 papers in the series drew on Mode 1 conventional research to characterize the problems and make recommendations. That research focused on the causes, consequences, and efficacy of interventions in relation to the nutritional status of young children, prioritized epidemiologic methods and clinical trials, had limited disciplinary breadth, and had little or no engagement of social actors in the research. In contrast, the authors of the fourth paper implicitly were working in Mode 2 fashion: they considered broader framings of the problem, confronted varied real-world context(s) of application, transcended discipline-based knowledge and standards of evidence, and worked with knowledge created “in the field” even if it was not published in peer-reviewed journals. In addition, the diverse perspectives of the authors (policy-engaged academics and senior technical staff of UN agencies, all with extensive real-world experience) had to be negotiated based on a broader range of disciplinary, economic, political, social, and utility criteria. These dynamics and the need to negotiate forms of knowledge and diverse perspectives when creating “actionable knowledge” are similar to what has been described elsewhere (99,114–116).

The gaps in knowledge noted by the *Lancet* authors (notably concerning effectiveness at-scale, transferability, adaptation to national contexts, and the dynamics of the nutrition policy process) are not unique to nutrition. In 1994, Walt and Gilson (117) raised awareness of a similar neglect of research on the policy process (as distinct from

policy content) in health policy research in low-income countries (117). A review of several thousand papers 14 y later still identified only 164 empirical papers on the policy process, scattered across a large number of countries and topics, long on description and weak on the use of theories, frameworks, and rigorous methods (118).

A similar comprehensive analysis has not been undertaken for nutrition policy, but a review of papers in 3 journals reported here combined with a more comprehensive study reported in the *Lancet* Nutrition Series are indicative. For the period January 2010 to August 2012, the Community and International Nutrition section of the *Journal of Nutrition* contained 80 research papers, none of which focused on the policy process and all of which focused on individuals as the unit of analysis. Proceedings from 2 sponsored symposia published in that journal did focus on policy and program levels of analysis (119,120). A search of empirical papers in *Food Policy* (restricted to papers with “nutrition” occurring in any field) during the same period yielded 130 papers, 6 of which approximated a Mode 2 Frontier focus (121–126). A search of all titles in the *Journal of Nutrition Education and Behavior* during that same period yielded several descriptive papers on the efforts, accomplishments, challenges, etc., of schools, food service staff, retail food outlets, and other community entities attempting to change practices and food/activity environments (127–129). The *Lancet* Nutrition Series reported on a bibliometric analysis of the CABI© nutrition and food science database, which identified 1240 abstracts focusing on developing countries in the second half of 2005 (130). Only 1.2% of these papers dealt with nutrition policy in some manner, and none had an explicit policy focus. This analysis provisionally indicates little attention to Mode 2 policy research.

In contrast to these trends, a scan of work published or referenced by application-focused organizations reveals a different picture. For instance, the Healthy Eating Research Program funded by the Robert Wood Johnson Foundation has assembled a bibliography (131) of multidisciplinary, obesity-related research on agricultural policy, child care/preschool food access, general nutrition policy, marketing and promotion, menu labeling, pricing and economics, and schools/after schools. This research program illustrates many of the “why, what, who, and how” characteristics of Mode 2 research shown in Table 1. In a similar fashion, the research and knowledge products from the International Food Policy Research Institute (132) take a broad and multidisciplinary view of the determinants and consequences of the interrelated problems of undernutrition, food insecurity, poverty, and natural resources; include a focus on the content of policies and the processes of policy development and management; range from global to local in geographic scale; and produce actionable knowledge for policy audiences at global and national levels. A third example is a series of papers produced by a group of UN and nongovernmental development organizations that integrated knowledge from each of 6 Sahelian countries to characterize the nutrition problems, the current status and gaps in policies,

programs and capacities and the priorities for action (133). A fourth example is the integrated program of research that led to the successful introduction of the orange-flesh sweet potato in drought-prone regions of Mozambique (see Appendix).

A fifth example is the study of successful initiation and coordination of multisectoral nutrition programs in Senegal and 1 state in Colombia (134). A sixth example (funded by the World Bank for the explicit purpose of creating actionable knowledge) is the Mainstreaming Nutrition Initiative, which conducted engaged, prospective research in 5 countries for the explicit purpose of developing “process guidance” on how to elevate and sustain nutrition on national policy agendas. That research was guided by broad, transdisciplinary conceptual frameworks of the policy process (103,135), the findings of earlier work on global health (136,137), and the principles of grounded theory (138). These methodological strategies identified broadly relevant dynamics and strategies in the policy process that received inadequate attention in earlier work (93,139–143).

These examples of nutrition policy research reveal some complementarities and some sharp differences between Mode 1 conventional research and Mode 2 knowledge production. In general, Mode 1 conventional research, with its central focus on causality, prediction, and efficacy (144), seeks to identify interventions with the potential to be effective if and when they might be implemented in the real world. The Mode 2 examples begin with a motivation to produce actionable knowledge in that real world and therefore are sensitive to the context of application; the complex, emergent, and multidimensional nature of the focal problems; and the shortcomings of decontextualized and RCT-driven recommendations. These commitments, in turn, tend to foster greater methodological diversity, social engagement, and transdisciplinarity. One of the enduring challenges, as revealed in the examples from the *Lancet* Nutrition Series, the Mainstreaming Nutrition Initiative, and others (99), is to move beyond an abstract appreciation of the complementarities and to institutionalize mechanisms for negotiation of the differences in the knowledge (and recommendations) produced under these 2 paradigms.

### **Program evaluation: Oportunidades**

For decades, the evaluation field has struggled with 2 inter-related problems: the black box and the utilization crisis. The black box refers to the need to understand a wide range of processes, pathways, and bottlenecks that enable or limit the implementation and effectiveness of programs and policies (145). The utilization crisis refers to the observation that evaluation findings, even those based on rigorous designs and methods, commonly are not used by policy and program stakeholders (146). Both of these problems are traceable to the overreliance on Mode 1 approaches to evaluation (147). Mode 1 evaluation typically is summative (focusing on outcomes and impacts rather than processes), seeks objectivity and rigor, and often is an opportunity for

outside experts to acquire funding, conduct high-quality and publishable external evaluations, and answer outcome-oriented questions of interest to funders and senior policy makers. However, the utility of the findings for program improvement and the use by decision makers both are compromised because these traditional approaches neglect the roles of contextuality, complexity, diversity of information needs, and the sociopolitical dimensions of decision making.

Mode 2 approaches are ideally suited to inform and facilitate decisions related to the need for improvements in design and/or implementation. With a Mode 2 approach, priorities for formative and summative evaluation are decided jointly with evaluators, program designers and implementers, beneficiary communities, and other stakeholders; a wide range of studies and methods are used; and there is extensive collaboration between evaluators and social actors to translate the findings into actionable knowledge for improving programs and policies. Few examples of this approach exist in nutrition, but the evaluation of the nutrition component of the Human Development Program, Oportunidades (formerly Progresá), in Mexico illustrates many of the principles.

From its inception as Progresá in 1996, impact evaluation was an integral aspect of the program in Mexico (148). The initial impact evaluation had a rigorous design (randomized, controlled effectiveness trial) and was implemented by renowned external experts. Positive effects of the program were found on poverty, education, health, and nutrition (149). Although these results were instrumental to ensuring program continuity when the government changed 3 y after the program began, they did not provide any assessment of whether the impacts were adequate to meet the longer term program objectives, nor did they provide evidence of whether changes to the design and/or implementation of the program could increase its impact. The recognition of these gaps, by both the program evaluation team and the program staff in charge of the evaluation, led to a dialogue on information needs and priorities between program staff and evaluators. A number of small studies were implemented to inform decisions about increasing the potential of the program to improve the nutrition of the population. Three examples are illustrative: 1) The bioavailability of the iron form used in the nutritional supplement was compared with others and tested for acceptance with the new form among beneficiaries (150). Based on the findings, a recommendation was made, and the type of iron used in the product was modified (151); 2) The acceptance and pattern of use of the fortified food supplement provided by the program for pregnant and lactating women and small children was recognized as a concern based on experience in the field. This stimulated research with direct involvement of program personnel in communities and beneficiaries to explore factors and barriers related to acceptance and use and strategies to improve these (152,153); 3) With cost-effectiveness being a perennial concern in large-scale programs of this type, a randomized trial was



conducted to determine whether alternative types of supplements may be more suitable based on acceptance, use, efficacy, and cost-effectiveness (L. Neufeld, unpublished data).

It is important to note that most of the studies done to improve the Oportunidades program have used conventional research designs and methods typically associated with Mode 1 research. What makes this an example of Mode 2 evaluation is the application of these methods within the program and the close involvement of program stakeholders in defining research priorities and interpreting the implications of the findings for the program. This process required the existence and cultivation of a number of important conditions, including strong and long-term working relationships between researchers and program staff, a mission-oriented research institution, commitment to prioritize programmatic information needs over academic questions, budgetary support for the agreed-on studies, agreement of program staff to recognize the time lag before research results are available, and a culture of openness and learning (rather than defensiveness) on the part of program staff (154). These conditions are rare in large public programs but illustrate the stark difference between Mode 1 and Mode 2 approaches to evaluation and the types of conditions and capacities to be strengthened in other settings.

### Building healthy community food systems

Within the field of community nutrition in the United States, the reductionist tendencies in conventional research listed in Table 1 have obscured 2 otherwise obvious realities that, on the whole, nutrients come from food and food comes from agriculture. Perhaps this decontextualized perspective explains why community nutrition researchers in the United States have begun embedding their work within food systems only recently (155–158).<sup>11</sup> Now, papers in nutrition journals that include food system perspectives have grown increasingly common (17,159–169), and food systems approaches to nutrition are beginning to be integrated into degree programs (170–172).

Food system perspectives nest nutrition within the larger web of inputs and processes involved in food. For example, these would include the manufacturing and transporting of the substrate used by commercial mushroom growers through to the disposal of the mushroom box and plastic wrap (and unused mushrooms) after consumption. Studying nutrition from food systems perspectives inherently includes some “frontier” tendencies in what and whom we study, in taking multidisciplinary approaches, and, usually,

in working to create actionable knowledge. However, much of the emerging food system work in nutrition still uses conventional approaches and methods for *how* we study. These approaches and methods are appropriate for many research questions, such as estimating fuel inputs to producing particular foods, and the research questions are often driven by Mode 2 public problems. However, understanding and building food systems that are healthy and equitable will also require a more participatory, action-oriented, blended method and trans- and supradisciplinary approaches than traditional research toolboxes provide.

This section describes the work of a food system action research project called Food Dignity. As discussed in the following, this project is an example of an effort to work at Mode 2 frontiers on a radically axiological foundation in nutrition-related research at the community level. Porter directs the Food Dignity project, in collaboration with Pelletier and dozens of others. Food Dignity is a 5-y endeavor supported with \$5 million from the USDA’s Agriculture and Food Research Initiative funding, with 5 community food initiatives, 2 universities, a college, and an “action think tank” (173).

### Why study

Food Dignity starts with ethical (axiological) goals, which in turn guide the project’s scientific aims and methods (epistemology). Also, as in all Mode 2 research, Food Dignity aims to tackle core social problems; in this case, food insecurity and environmental sustainability. The social-problem premise of Food Dignity is that the planet is precipitously close to peak oil (174), peak soil (175,176), and a tipping point for atmospheric carbon dioxide concentrations (177). More than a billion people were undernourished in 2009, the highest number in the 40 y for which comparable statistics have been available (178). Within the United States, wage inequality has been increasing (179), today’s SNAP (food stamp) participation rates are breaking records with ~1 in 8 Americans enrolled (180), and we face an obesity epidemic.

Community and social movements for food justice and sustainability suggest alternative paths for addressing these interrelated system problems, and they are making these paths by walking. Thus, Food Dignity is tracing the paths taken by 5 US communities and collaborating in mapping and exploring the most appropriate and effective roads forward. The project aims to “trace the paths” of these communities by conducting case studies of their community-led food systems work to date and providing and tracking the impacts of financial and technical support over 5 y to help them build on their successes and to identify most promising practices.

In keeping with food justice and sovereignty movements within the United States and globally (181,182), Food Dignity envisions a society where each community exercises significant control over its food system through democratic negotiation, action, and learning in ways that nurture all of our people and sustain our land for current and future generations and where universities and cooperative extensions are

<sup>11</sup> Exceptions exist, of course (155). Feenstra (156), who wrote about the ecological sustainability of diets since the 1980s, and Hugh Joseph are among US nutrition pioneers in this arena, although Feenstra has done her work from within an agriculture center and neither has a tenure track position, perhaps indicative of the marginalization of this perspective within nutrition. Unlike in US community nutrition, international nutrition research and action agendas have developed in the context of (and often contention with) food production and regulation practice, policy, and research. See, for example, the 1937 “Final Report of the Mixed Committee of the League of Nations on the Relation of Nutrition to Health, Agriculture, and Economic Policy” (157) and the establishment of the Joint FAO/WHO Expert Committee on Nutrition in 1949 (158).

supportive partners in this process. These ethics and values foundations guide the scientific research questions that the project team is asking and the ways of working together to answer them. Because of the local control and democratic negotiation goal, one of Food Dignity's core research questions is how to engage food-insecure communities as agents in shaping their local food system. The team is using and evaluating strategies such as mini-grants and Photovoice. Universities, as a "supportive partners" element, have led the team to conduct a sixth case study: the 5 community food system organizing case studies plus a study of the Food Dignity collaboration (and contention) between community and university partners.

Another community food system example can be used to illustrate how the different knowledge production of Modes 1 and 2 and explicit ethics (axiological) versus knowledge (epistemological) foundations impact the framing of research questions. Some debates exist in Detroit concerning the use of the city's vacant land (183) where Hantz Farms is proposing a large-scale corporate (and mostly nonfood) model of urban agriculture. Meanwhile, small-scale production initiatives led by community-based organizations such as D-Town Farms and Earthworks Urban Farm are building locally controlled and largely nonmonetized models for food provision in Detroit communities. A Mode 1 approach to knowledge generation would likely not even engage with such an inherently social problem-based issue. Perhaps, in Mode 1, one would ask whether the "straight, evenly spaced rows" that Hantz Farms proposes for its "high value trees" (184) would be the most productive growing strategy or what the wages for the farm workers would need to be to return maximum profit for the owners or how much the price of their acquired urban land would be expected to increase in the next decade and the opportunity costs of using it for urban agriculture. In contrast, a Mode 2 research question might ask which approach would lead to the most economic development or create the most jobs. Food Dignity's values-based stance would go even further; it would prioritize the goal of increasing local control over food production and might examine the most effective and appropriate methods with which to do so. Mode 1 and 2 questions in this example both are founded on values considerations, but they differ profoundly in the starting assumptions and whose values receive attention in the research.

### **What and whom to study**

The primary focus of Food Dignity research is documenting the food system change effort with each of the 5 community initiatives and conducting process and outcome evaluations of the "community organizing support package" that the grant provides to each over 5 y. Secondary objects of study include the nature and evolution of the university-community relations in the project, the process and outcomes of \$30,000 mini-grant programs in each community, and the quantities of food grown in home and community gardens.

Of all these objects of study, the garden harvest measures best fit a conventional tendency, in both modes of knowledge production, to study what can literally be counted.

However, the ultimate goal is to embed and interpret those data in larger case studies of the values (e.g., spiritual, cultural, nutritional, economic, social) that such gardens have for gardeners and communities, to more fully elucidate the many ways in which these gardens "count." More conventional (although not inherently less important) research in this arena might be more likely to measure, for example, how gardens influence nutrition knowledge (185) or eating behavior (186,187).

### **How we study**

The social problems and ethical goals described in the why study section guide the Food Dignity team's answers to each question discussed here. This determines not only whom and what are studied, but who does the studying. The question "who studies?" immediately raises related questions such as who has the power to define and answer research questions and what counts as truth or knowledge. In Food Dignity, each community partner commands its own research budget. Leaders of some are choosing to be primary authors of their community initiative's case study. Some are working with the academic research partners in review and revise roles. Part of the project's "sixth case study" of community-academic relations is examining team negotiations and decisions on truth and knowledge questions in the collaborative research. The team is studying itself to glean lessons on how to improve our own and similar collaborations. Case studies are the primary research method in Food Dignity. Data collection methods include Photovoice (188), narrative inquiry interviews (189,190), document analysis, and participation in and observation of daily work, meetings, and events of each community organization.

The USDA/Agriculture and Food Research Initiative program is supporting 4 other 5-y action research initiatives in the same funding stream that Food Dignity received, all of which share Mode 2-compatible aims of improving sustainable regional and local food systems (191). Methodologically, however, the public descriptions of these projects (192–195) suggest tendencies toward more conventional research approaches than those that Food Dignity is using, mainly in aiming for creating generalizable food system models and value chain quantifications through methods such as surveys. Also, in some cases, the projects cast the academics as the experts on community food systems and the communities as the learners, although first-year progress reports tend to amend that. These differences among approaches to food system research are one of the reasons Food Dignity has increased the priority of the sixth case study of the project collaboration itself.

### **Disciplinary foundations**

The academic team in Food Dignity is multidisciplinary, with representatives from public health nutrition, anthropology, development sociology, education, economics, agroecology, medicine, and planning. However, the research relies less on disciplinary foundations than on the practice-

based experience of the community partners in community engagement and in food system development. This “adisciplinary” base helps the team sidestep language barriers and silos that can plague multi- or interdisciplinary projects and increases the community partners’ power in the project (100,196). For example, after an unsuccessful attempt by academic partners to design an acceptable protocol for quantifying garden food harvests in 1 community, Porter and the community lead in another location decided to reopen the garden research questions and research design and put them in the hands of 8 experienced community gardeners. That team is now piloting harvest measures and other instruments for gathering data that they prioritized.

This reliance on community- and practice-based expertise with academics as learners and colearners is a key tenet of participatory research frameworks. As discussed below, such frameworks are 1 place to seek guidance in conducting community-level nutrition research. Academics still bring their disciplinary tools and design rigor to problem-oriented Mode 2 participatory research, but these tools and associated conventional “expert” knowledge complement and serve community members’ expertise and priorities.

### Guiding frameworks, principles, and approaches

The previous examples were chosen to represent contrasting regions in the population research landscape (Fig. 1) and the ways in which Mode 1 and 2 research relate to each other and apply in these examples. The examples most clearly illustrate the importance of transdisciplinarity when working in Mode 2 versus Mode 1: addressing a problem in its full complexity (vs. theory or discipline driven), contextual (vs. universal), socially engaged (vs. objective and detached), and methodologically diverse (vs. discipline-based). These similarities are important to articulate because Mode 2 researchers working in different regions of the landscape (e.g., national policy vs. community, health vs. agriculture sector, domestic vs. international) often do not appreciate their shared commitment to this form of research and the opportunities to strengthen the practice and the outcomes of such research through greater exchange of experiences, frameworks, and methods (86,197).

The development of common frameworks and methods or, at a minimum, explicit reflexivity in the choice of these, is an important process in the maturation of new fields or new modes of research. The widely used UNICEF conceptual framework for the causes of malnutrition in developing countries and the socio-ecological model of nutrition problems as often applied in industrialized countries are good examples (107,198). To that end, this section introduces a selected number of meta-frameworks, principles, and approaches that can facilitate Mode 2 research when working in different regions of the population nutrition landscape. The emphasis is on meta-frameworks and broad principles and approaches because, by definition, these transcend the particular theoretical assumptions and

boundaries of the disciplines and are applicable in a wide range of contexts.

The examples presented here are robust and widely applicable to objects of study and to processes *above* the level of the individual, to complement the well-developed body of knowledge and behavioral theories at the individual level (199). However, these examples do not exhaust the range of possibilities, and Mode 2 research in nutrition will benefit from continued development and dialogue regarding these and other models.

### The policy sciences framework

The policy sciences framework (PSF) was developed nearly a half century ago before the hyperspecialization of social science disciplines and theories (200). It was explicitly developed as a generic framework, or stable frame of reference, applicable to all contexts in which collective action is required or mobilized to address public problems. Although the name appears to denote formalized and governmental policy it actually is applicable to the full range of social situations, from global to community and organizational levels. It originated with Harold Lasswell (201,202) and has since been reintroduced and applied primarily in natural resource policy (103,203–207).

The population nutrition landscape presented here (Fig. 1) was partially inspired by and possesses several of the features of the PSF: the problem-solving activities (axis 4), the social change elements (axis 7), the various elements of transdisciplinarity (axis 5), and the multiple purposes for which inquiry might be undertaken (axis 6). The broad applicability of this framework arises from the recognition of the following. 1) All efforts to address public problems involve certain recurrent activities, such as generating and seeking agreement on knowledge concerning the problem, agreeing on goals, choosing among many possible actions, implementing actions, reflecting or evaluating progress, and adjusting or terminating the actions and possibly the goal itself. 2) Each of these activities is influenced by social diversity and dynamics involving the nature of the participants (individuals, organizations, and/or states) and their relationships; their perspectives on the issue (beliefs, goals, values, and interests); their respective assets, resources, and sources of power; the strategies by which these assets are deployed; the situations or venues in which participants interact (or from which they are excluded); the immediate outcomes of these interactions; and the longer term and perhaps broader effects of these interactions. One of the features of the PSF that distinguishes it from mainstream tendencies in policy analysis and political science is the attention given to any and all features of the social change process in a given context (axis 7) that may influence the problem-solving process (axis 4). Discipline-based approaches provide more detailed examination of certain aspects (e.g., agenda setting, advocacy coalitions, policy choices), but a broader perspective is needed when there is a concern for ultimate outcomes and effects and not simply these dynamics per se (202,208).

The broad applicability of these 2 dimensions of the PSF can be readily grasped by relating it to the dynamics seen in varied examples: developing and implementing a school nutrition policy or a community food policy, revising the core nutrition curriculum for nutrition graduate students at a university, agreeing on the recommendations to include in the *Lancet* Nutrition Series, designing the implementation plan for a national nutrition program, and many more. All of these examples would involve the elements and the dynamics depicted in axes 4 and 7 of the population nutrition landscape. The PSF articulates several layers of detail and complexity beneath each of these elements to deepen the examination and understanding of the dynamics in specific contexts. The analysis and understanding of these dynamics can be further deepened by consulting carefully chosen specialized theories and constructs from appropriate disciplines in an iterative fashion (200) as the meta-framework reveals the features of greatest interest or concern.

The various elements of transdisciplinarity shown in [Figure 1](#) are fundamental features of the PSF that further distinguish it from the more discipline-based tendencies in mainstream policy analysis and political science (202). The application of these elements is made possible by the use of the generic framework described above (axes 4 and 7) in particular social contexts, which, together with the engagement of social actors, permits the problem to be examined and understood in its full complexity without the distortion of disciplinary boundaries. The social engagement itself can vary from minimal (when the researcher only seeks the contextual knowledge and perspectives of social actors and/or the social actors do not seek or provide further involvement) to highly intensive (when the researchers and social actors both may shape the design, implementation, interpretation, and use of the findings). The examples described earlier illustrate this wide range of involvement, with the Food Dignity project representing the highly engaged end of the spectrum.

### Implementation frameworks

“Implementation” is one of the regions of the population nutrition landscape that has emerged as a critical frontier within nutrition practice communities and is beginning to receive attention from researchers and funders (119,209,210). The major impetus for this is the recognition that the promising interventions arising from efficacy trials have proven very difficult to implement and to demonstrate effectiveness in large-scale programs (211,212). This is a general phenomenon observed in many sectors and is occurring in the context of increasing demands for results and accountability by governments and funders (213,214).

This interest in implementation has led to several distinct types of research in the context of nutrition programs. These include impact and process evaluations of large-scale programs and in demonstration or feasibility trials (154,215,216); formative or operations research to understand or address specific implementation issues or bottlenecks (217,218); retrospective “lessons learned” exercises (219–221); the

development and application of tools to strengthen program design and/or implementation, such as log frames, program impact pathways, and program assessment methodologies (222–224); a large number of descriptive accounts of efforts to implement interventions, programs, or policies at organizational, local, and/or national levels (225–230); and the development of new evaluation approaches sensitive to the needs and realities of implementation (35,231). This work often is driven by the needs of program implementers (and some funders) to strengthen the extent and quality of implementation and often involves collaboration between researchers and implementers. It is an emerging frontier ripe for Mode 2 research in all of its dimensions.

While the emerging interest in the implementation frontier is encouraging, the continued intellectual and practice-based development of the field is likely to face the same challenges as those experienced over the past several decades in the field of health policy research (86,232–234). One of these is the lack of an overarching meta-framework that could guide the design of implementation strategies, facilitate the selection and prioritization of research questions within and across contexts, and support an accumulating body of knowledge and mid-range (transdisciplinary) theory concerning micro-, macro-, and meso-level implementation dynamics (232). This cumulative body of knowledge and theory is especially important because of the general consensus in the literature that multicomponent implementation strategies are needed to ensure effective implementation (235–239), but the details concerning the design, combinations, sequencing, and intensity of various components in various contexts remain to be elucidated. Nutrition has the potential to benefit from and contribute to further research on these issues.

An emerging body of empirical research has occurred in recent years, largely outside of nutrition, on the science of dissemination and implementation in health (214) as well as in organizational development (237), business (240), and mental health (241), education (213), and public administration (242). Among the many factors receiving attention in terms of theoretical development and measurement are organizational climate and culture (243), organizational and staff readiness to change (244–247), implementation fidelity (248), and leadership (247,249–253), among others (254). The relevance of these topics to nutrition implementation is readily apparent yet they have received little or no attention in nutrition research.

Given the diversity of topics receiving attention in implementation research, the nutrition community would especially benefit from the work of several researchers who have developed robust and more comprehensive frameworks for implementation. Three in particular have the potential to enrich conceptualization, research, and practice related to nutrition implementation.

The Consolidated Framework for Implementation Research identifies and integrates 39 factors, in 5 core dimensions, that can affect the extent and quality of implementation (255). The 5 dimensions relate to characteristics of the following: 1) the intervention, innovation, policy, or practice that is

to be implemented; 2) the inner (organizational) context; 3) staff (including frontline workers, supervisors, and managers); 4) the outer context (including the policy and political environment, professional and organizational networks, and social and cultural features); and 5) implementations strategies and processes. Two related efforts are under way to develop a comprehensive taxonomy of constructs and quantitative measures of these for use in research (256,257).

A second framework distinguishes implementation outcomes (such as fit, feasibility, cost, quality, penetration, coverage, and sustainability) from client/consumer outcomes (258). This is a particularly useful contribution for nutrition because of the current overemphasis on client outcomes such as behavior change or nutritional status and the paucity of efforts in nutrition to conceptualize, measure, and improve more intermediate implementation outcomes. A third framework distinguishes 4 overlapping and often iterative phases of implementation (exploration, preparation, implementation, and sustainment) and highlights that the different aspects of the outer and inner context included in the consolidated framework may be more prominent or may manifest differently during different phases (259). Together these 3 frameworks provide the nutrition community with valuable entry points and elaborations of theory, concepts, and measurements related to the research and practice of implementation.

Quite apart from these comprehensive frameworks of implementation processes, influences, and outcomes, the approach to implementation research spans Mode 1 and 2 forms along several dimensions. One dimension relates to the entity being implemented, with some work focusing on the implementation of evidence-based interventions (232) and other work focusing more broadly on the implementation of a wide range of innovations, practices, policies, and programs (213,242). Another dimension relates to the disciplinary foundations, with some work being grounded firmly in certain disciplines such as psychology (260) and management (244) and other work being explicitly inter- or transdisciplinary (214). A third dimension relates to social engagement, with some work proceeding in a more detached and objectivist mode and other work engaging implementers to greater or lesser degrees in the research questions; the design, execution, and interpretation of the research; and the application of findings (261). Finally, some research focuses more narrowly on particular implementation constructs or processes [such as leadership, climate, or employee readiness (250,253,262,263)], whereas other work focuses on the program as a whole and seeks to incrementally improve implementation processes and outcomes (e.g., through strengthened management, monitoring, and evaluation systems or quality improvement systems (264,265).

### Evaluation frameworks

Evaluations are conducted for a variety of purposes, and these will heavily influence the relative importance of Mode 1 and 2 approaches and the specific approaches and methods within each. One classification identifies 4

purposes (265): 1) assessing merit and worth; 2) oversight and compliance (and accountability); 3) program and organizational improvement; and 4) broader knowledge (and theory) development. The Oportunidades example presented earlier has used evaluation for all 4 of these purposes, although the evaluations related to program improvement were emphasized here. That example was useful in the context of this paper because it illustrated that traditional research methods (usually associated with Mode 1) were used extensively to generate information on program performance and bottlenecks, but these were part of an evolving portfolio of special studies and embedded within a well-functioning network of researchers and program actors committed to incremental learning and program improvement. It was this larger social context in which research priorities are jointly negotiated, conducted, interpreted, and used by researchers and program staff that make Oportunidades a good example of Mode 2 evaluation.

As with the policy sciences and implementation sciences discussed earlier, the evaluation field contains a wide range of frameworks, theories, approaches, paradigms, and controversies (266–270). Given this diversity, an early and pivotal stage in the process is matching the approaches and methods to the purpose of the evaluation. Three broad approaches are (147) summative evaluation (for assessing merit and worth), formative evaluation (for improving or fine-tuning the program in an ongoing manner, to establish implementation progress, or to stabilize the model and prepare it for summative evaluation), and the newly articulated approach called developmental evaluation. Summative and formative evaluations have emphasized Mode 1 research in nutrition, and both could be strengthened by greater use of Mode 2 approaches. Developmental evaluation (DE) is a more recent addition to the evaluation literature and can only be conducted within a Mode 2 framework. It has potentially wide applicability and utility in nutrition and is elaborated briefly here.

According to the architect of DE,

“Evaluation has merit and worth, processes and outcomes, formative and summative evaluation; we have a good sense of the lay of the land. The great unexplored frontier is evaluation under conditions of complexity. Developmental Evaluation explores that frontier” (142).

The basic premise of DE is that many, if not, most innovations (including new interventions, projects, programs, policies, practices, and system changes large or small) represent perturbations in existing complex and adaptive social systems, with the well-recognized system properties of multiple interdependent and interacting components, limited central control, emergent behavior, nonlinear dynamics, and conflicting interests. As such, these innovations do not respond well to highly structured implementation plans and rigid, centralized command and control management, all of which presume highly stable, uniform, and predictable implementation environments. Instead, innovations in complex

systems require adaptive management that, in turn, requires more nuanced and real-time feedback (information) linked to facilitated and systematic organizational learning and adjustment. A corollary premise of DE is that current approaches and practices for summative and formative evaluation are not suited for coping with the realities of complex adaptive systems. These realities are becoming widely recognized in global health (253–255) and have equal relevance to nutrition (271,272).

DE is said to be appropriate for 5 distinct complex situations that are familiar in nutrition (147): 1) ongoing management of an existing program, project, or policy in a particular context; 2) adapting an innovation (ranging from an intervention to a policy change or system change) to a new context; 3) exploring and identifying real-time responses to a sudden major change or crisis; 4) developing a new intervention, program, technology, etc., with the intent of future large-scale application; and 5) introducing major system changes and cross-scale evaluation. The specifics for how each of these would be undertaken vary widely and are described in detail (147), but the core principles are for the evaluator to be an integral part of the program team and guiding an ongoing inquiry process with other team members by helping to articulate key questions, deploying diverse research and assessment methods, and facilitating real-time interpretation and use. A concrete example would be to imagine such an evaluator/researcher being embedded within the Oportunidades program team in Mexico City (rather than at the research institute in Cuernavaca), participating in the ongoing planning and management meetings, stimulating discussion of critical program issues requiring investigation, deploying special studies and rapid assessments with an even more diverse set of methodological tools, and facilitating the interpretation, learning, and application of findings. This would represent an even more institutionalized and integrated version of the already successful Oportunidades example.

### Community-based frameworks

The Food Dignity action research project described in the case example above uses largely community-based participatory research (CBPR) approaches and is rooted in a “radically axiological” paradigm. These approaches and their core principles are defined and discussed below.

**Community-based participatory research.** A Surgeon General’s report in the late 1970s noted that “most communities have substantial resources, sometimes unrecognized, for prevention and health promotion” (273). Despite community participation and empowerment discourses codified in, for example, the Ottawa Charter for Health Promotion (274), these community resources remained relatively unrecognized in public health nutrition practice until recently. Now, within public health, participatory approaches have become almost standard for justice-oriented research.

Following long-standing traditions of action research and participatory action research in community organizing and the social sciences, (275,276) CBPR has emerged as the favored term within health fields, dating perhaps from a first mention of community-based research in health in the late 1990s that intended to engage community members as research partners (277). As of 2005, the NIH and CDC have dedicated small funding streams for CBPR approaches to health research, and the number of publications claiming participatory approaches has soared in the past 10 y. The director of 1 NIH institute, opening a grant review panel on which 1 author recently served, named CBPR as the most promising approach for reducing health disparities.

A review of the literature sponsored by the Agency for Health Care and Research Quality provided this definition for CBPR (278):

“CBPR is a collaborative research approach that is designed to ensure and establish structures for participation by communities affected by the issue being studied, representatives of organizations, and researchers in all aspects of the research process to improve health and wellbeing through taking action, including social change.”

To expand on this definition, the authors further suggest that CBPR involves the following: 1) colearning and reciprocal transfer of expertise by all research partners, with particular emphasis on the issues that can be studied with CBPR methods; 2) shared decision-making power; and 3) mutual ownership (278).

Lead CBPR theorists have proposed 9 principles for participatory research, including fostering a collaborative, equitable partnership in all phases of the research; involving an empowering and power-sharing process that attends to social inequalities; integrates and achieves a balance between knowledge generation and intervention for the mutual benefit of all partners; and attends to the multiple determinants of health (279). Others have noted that “CBPR is *not* a research design or method. Rather, it is a collaborative approach to research that may draw on the full range of research designs” (279).

Although CBPR frameworks can guide Mode 2 nutrition research that aims to leverage community strengths and solve community-identified problems, without explicit ethical goals, it can be used instrumentally to serve academic needs (e.g., garnering funding, improving recruitment and retention). This is not in the spirit of participatory action research, which always aims to foster action for social justice. Compare the government agency–sponsored definition for CBPR above with the following definition from a Kellogg Foundation–supported CBPR training program:

“Community-based participatory research (CBPR) in health is a collaborative approach to research that equitably involves all partners in the research process and recognizes the unique strengths that each brings. CBPR begins with a topic of importance to the community with the aim of combining knowledge and action for

social change to improve community health and eliminate health disparities” (280).

This definition includes what is notably absent from the Agency for Health Care and Research Quality definition, i.e., requiring not just action, but action for social change that improves health and equity. The Kellogg definition also emphasizes community roles in defining what counts as important. Without explicit ethical commitments, such as eliminating health disparities, CBPR may lose much of its “frontier” advantage for generating cutting-edge knowledge and improved health. Reducing community participation to review by “community advisory boards” and help with study recruitment cannot tap the (often interdisciplinary) expertise that community members bring to the table.

The enormous benefits of CBPR collaborations, however defined, come with challenges. The CBPR literature documents an array of challenges faced in participatory research processes, including determining who and what counts as “community,” (281) building trust (282), and meeting academic tenure and promotion standards (283). Because academics generate this literature, it may give shorter shrift to the challenges specific to community research partners. Experience in the Food Dignity case example discussed earlier suggests that these are at least as great as the academic partner challenges. For example, although the partner universities receive 22% indirect costs (the maximum USDA allows) on the grant funding, the 10% indirect costs requested for the community partner organizations were disallowed. These financial inequities between community and academic partners are compounded by inequities in job security, social prestige, and the risks entailed in granting access to sensitive community and organizational struggles, dynamics, and politics. Still, dozens of people from community and academic organizations have agreed to come together in this Food Dignity collaboration and face the contention, compromise, and risk. This daily struggle, to be examined through academic and community voices in future Food Dignity publications, is a delicate investment in the potential rewards for community food security and sustainability through working together.

**Radical axiology.** The paradigm of explicitly starting research with ethics and values questions, as often seen in CBPR research, is called radical axiology (279). Ontological questions ask about the nature of truth and reality, namely, “what is?” Epistemological questions ask “how can we know what is?,” also including the question “what counts as knowledge?” Axiological questions ask about values and ethics: “what should be?” and “how should we make it be?”

Conventional research normally begins with ontological and epistemological (and often technical) questions. For example, does calcium interfere with iron absorption? Can epidemiological data answer the question or is an RCT required? In an RCT, will studying a few meals suffice or must a whole diet study be conducted? In a paper entitled

“Toward a Philosophy of Public Health,” an NIH epidemiologist wrote:

“...by describing the ontological nature of causal (and other types of) hypotheses, the epistemological framework for testing those hypotheses, and the ethical foundation for applying that knowledge we will be rewarded with a better understanding and perhaps even justifications for the difficult decisions we make in the practice of public health” (284).

This view of ethics as last, as guiding the application of our knowledge about reality after the fact rather than the generation of knowledge in the first place, typify conventional views of the role that ethics should play in public health and nutrition research.

The Giessen Declaration, heralded as marking the emergence of “new nutrition science,” (285) suggests a more integrated role for ethics:

“All sciences and all organized human activities are and should be guided by general principles. These should enable information and evidence to be translated into relevant, useful, sustainable and beneficial policies and programs. The overall principles that should guide nutrition science are ethical in nature” (286).

As public health ethicist Buchanan notes, “figuring out how we should live, individually and collectively, is a moral and political process, not a scientific problem to be solved” (287). From these perspectives, ethics comes first and should guide research questions and methods. In other words, research conducted at frontiers outlined here might explicitly begin with axiological questions instead of ontological and epistemological ones.

As 2 public health professionals recently argued, public health research and practice should be “ethics-based, evidence-informed” (288). As that suggests, the radical axiology paradigm of explicitly starting ethics cannot and does not preclude truth and knowledge questions. Ethics and values guide which research questions to ask and how to answer them. For example, from a radically axiological perspective, a community nutrition researcher could choose to use CBPR approaches based on democratic values, regardless of whether CBPR had been demonstrated in conventional science terms to be the “most effective” approach in the area of focus. This is the case, for example, in Food Dignity. Similarly, that project is guided by an ethic imagined by an environmental historian: “a system of morality in which members of future generations were regarded as full human beings” (289).

In fact, all research questions and methods are rooted in values and are, therefore, axiological. Every research question is imbued with ethics and values. However, these values are often implicit or assumed. In much research, in Mode 1 especially but also often in Mode 2, producing generalizable knowledge is highly valued. In the horrifically extreme case of the Tuskegee Study, this knowledge production was valued over human life. For more temperate but also real-world examples, consider the range of nutrition efforts to reduce vitamin A deficiencies. These

include, for instance, genetically modified rice, conventional sweet potato breeding, vitamin supplements, and food sovereignty efforts to rebuild diverse and largely traditional diets. At one end, Golden Rice research aims to solve deficiency problems, a goal founded on sound values. Yet this approach tacitly accepts and enables a sociopolitical context that limits access to traditional foods that were rich in vitamin A. At the other end, the food sovereignty movement aims to change that context. Similarly, the question “what is the most effective method of teaching parents to shop for and cook healthy meals on \$5 a day?” might enable some families to improve their nutrition, but it also implicitly accepts poverty. This phenomenon of tacitly accepting narrow framings and solutions to problems that are fundamentally rooted in structural inequalities is similar to the 2 interpretations of “implementation research” noted earlier (232).

Of course, rebuilding food systems and ending poverty are not subject to single research questions, nor does either project rest mainly within the realm of knowledge generation in nutrition or any other field. However, the main claim and most important guidance that radical axiology provides for researchers is for each of us to make explicit the ethics and values driving our research questions and methods, put them on the table for examination, and open them to negotiation when working with communities or proposing to use public research funds.

### Commonalities across frameworks

The 4 research domains discussed here (policy, implementation, evaluation, community) all have extensive literature and associated theories, models, and frameworks. The ones highlighted in this paper were chosen based on their broad compatibility with Mode 2 research and, thus, they share certain similarities. These include an emphasis on generating knowledge in the context of application, contextuality, social engagement, methodological diversity, and reflexivity, i.e., all of the elements of transdisciplinarity (Fig. 1). The broader literature in each of these domains (policy, implementation, evaluation, and community) displays marked diversity in these characteristics, ranging from discipline-driven and detached study to fully transdisciplinary and full engaged with social actors. The choice of where to locate a given study on this spectrum depends in large part on the how much priority is placed on axiological considerations (research ethics, values and democratization of research, and knowledge production), instrumental considerations (maximizing the relevance and use of findings), and substantive considerations (gaining access to the contextual knowledge of social actors). Although highly engaged Mode 2 research and knowledge production has numerous axiological, instrumental, and substantive benefits, the examples provided earlier in this paper illustrate that many problems require the integration and negotiation of knowledge produced in Mode 1 and 2 fashion. This may arise because some questions can only be answered by Mode 1 research (e.g., whether a program was or was not effective in improving nutritional status) and/or to reconcile

the biases or limited understandings of various parties (e.g., the proponents and detractors of a given program). It follows that the frontiers of population nutrition research likely will exhibit diversity in the form and degree of social engagement and other attributes of Mode 1 and 2 research, depending on the express purpose of the research (axis 6 in Figure 1), and researchers should be reflexive concerning the implications and tradeoffs among these

### Conclusion

*The world has problems and universities have departments.*

Chet Bowers, quoted in (290)

This quote cogently captures the reality as experienced by students, researchers, faculties, and administrators in universities, and it captures the reality as experienced by many social actors that have sought help from universities in solving their real-world problems. In many cases, this reality does not impede the search for solutions because there is an excellent fit between the disciplinary knowledge being generated in departments and the nature of the problems facing the social actors. But in many other cases, especially those dealing with social problems, there is a poor fit. Universities and scientific/professional societies have long recognized this and have nominally promoted multi- or interdisciplinary approaches in research, education, and outreach, with the American Society for Nutrition and its progenitors being active in this area for >2 decades (1,48,96,291).

This paper seeks to expand and strengthen the scholarship and societal impact of population nutrition research in several ways. First, it identifies some broad topical and methodological frontiers (the why, what, who, and how of Table 1) that must receive greater attention if the socioecological framework is to be more fully embraced as an intellectual construct and to enhance the appropriateness and effectiveness of our efforts to solve real-world problems. The current emphasis on individuals as the unit of analysis in research does not fully serve the intellectual or practical goals of population nutrition research. Second, it provides a broad and much-needed framework (Fig. 1) for comprehending the scale and scope of population nutrition research and the potential foci and sites for research and action. The framework has the potential to bring greater intellectual coherence and rigor to research in this area, facilitate communication among researchers currently working on seemingly unrelated problems or populations, and enable the accumulation of practical as well as academic knowledge. Third, the paper highlights the need for transdisciplinary and socially engaged approaches, as distinct from multidisciplinary, interdisciplinary, or socially detached approaches, when the priority is to fully understand problems in a given context and maximize the utility, acceptance, and impact of the research. Fourth, the paper provides some intellectual bridges and selected frameworks relevant to our emerging frontiers in the areas of policy, implementation sciences, evaluation,



and community-based participatory research. Finally, the paper situates these frontiers within the Mode 1/2 framework of the new production of knowledge (46) and, as such, highlights that nutrition's movement toward these frontiers is part of much broader trends in the practice of science and the relationship between science and society.

The view taken in this paper is that Mode 1 and 2 research on population nutrition can both make valuable contributions to solving nutrition problems and be quite complementary to one another. Examples of this complementarity have been provided throughout this paper. However, there are both challenges and opportunities facing nutrition if it is to expand further toward the Mode 2 frontiers. The challenges have been extensively documented in the literature on transdisciplinary action research (100) and interdisciplinary research (292,293), community-based participatory research (294,295), health systems policy research (86,197,232,233), and implementation or translational research (44,296,297), and these are remarkably similar across all these cases. A major challenge is that research funding is heavily weighted in favor of Mode 1 despite increasing demands for translating research into effective policies, programs, and services (44,232,233,297). Additional challenges relate to collaboration, partnering, and cross-disciplinary communication and understanding; professional and institutional policies and incentives; biomedical and disciplinary perspectives and standards in training, research, tenure, and promotions; and the focus on client outcomes and the direct utility of research. The opportunities, as noted in the introduction to this paper, are no less impressive: increased salience of nutrition on public and private agendas, increasing funding for nutrition research, increasing recognition of the gap between efficacious interventions and impact at a population level, and increasing demands on universities and action agencies to produce and demonstrate results. The promotion of multi- and interdisciplinary approaches by the American Society for Nutrition and its progenitors in previous decades has been instrumental in expanding the disciplinary breadth of the field. It will require a similar effort on the part of the American Society for Nutrition and its member organizations to recognize the distinctiveness of Mode 2 knowledge production, seek further complementarities with the knowledge produced in Mode 1 fashion, address the funding and other challenges noted here, and grasp the opportunities in these new frontiers of population nutrition research.

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### Appendix: The orange-flesh sweet potato

A Mode 2 approach to the introduction of interventions is illustrated by the Mozambique experience of promoting the production and consumption of orange-flesh (relatively vitamin A-rich) and drought-resistant sweet potatoes in populations where white-flesh (low vitamin-A) sweet potatoes are traditionally cultivated and consumed (298–300). The initial question was based on a need to find drought-resistant crops to address food security concerns and extended to identifying crops that also provided some nutrients missing from the traditional diet. From the beginning, the recognition of the importance of cross-discipline interventions was demonstrated through the collaboration of research institutes in agriculture (National Institute of Agronomic Research of Mozambique, the Southern African Root Crops Research Network), university researchers (Michigan State University), the national Ministry of Health, and nongovernmental organizations (World Vision, Helen Keller International). Low et al. (299) describe the process of introducing the orange-flesh varieties of sweet potatoes into Mozambique as an “integrated approach” that positioned the production and consumption of orange-flesh sweet potatoes within the broader scope of health and agriculture activities. Beyond the collaboration of the high-level ministries, nongovernmental organizations, and research institutions, the approach assessed and addressed village-level farmers’ and consumers’ concerns through formative research and extensive education. This research and education focused on providing the necessary skills to produce the crop from year to year in drought-stricken areas, ensuring product acceptability and promoting the use of the product to improve young child feeding.