



Critical Review

Examining Effective Translation and Implementation Methods for Equitable Access and Scaling of Nutrition Programs—A Report From the “Biomarkers of Nutrition for Development: Knowledge Indicating Dietary Sufficiency (BOND-KIDS)” Project Working Group 4

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ABSTRACT

School-age years (5–19 y) are a critical development period, bridging early childhood and adulthood. Nutrition during this stage is essential for supporting physical, cognitive, and socioemotional/psychological well-being. Moreover, nutritional status in these years has lasting effects on lifelong health, well-being, productivity, and human capital. In 2022, the National Institutes of Health “Biomarkers of Nutrition for Development: Knowledge Indicating Dietary Sufficiency (BOND-KIDS)” Project was launched to explore how to advance the assessment and impact of nutrition programs and policies for school-age children. The aim of this study is to use an ecological approach and available evidence to develop actionable tools for policymakers and program planners that support the design, implementation, and evaluation of equitable, effective, and scalable nutrition programs for school-age children.

The BOND-KIDS project convened 4 expert working groups (WGs) to explore biological, environmental, assessment, and implementation dimensions of nutrition during school-age years. WG4 focused on translation and implementation and applied an ecological lens to identify strategies that are fair, effective, and adaptable to meet the needs of communities. WG4 developed 2 tools to support effective nutrition programming for school-age children: 1) a set of 6 overarching principles—equity, developmental relevance, transdisciplinary collaboration, contextual adaptation, sustainability, and systems thinking, and 2) the BOND-KIDS implementation framework. Together, these tools serve as resources for designing, implementing, and evaluating the process and outcomes of nutrition interventions and programs across diverse settings and populations. Strategic investment in nutrition during school-age years is necessary to secure early gains, enable catch-up growth, enhance cognitive development, promote long-term health, and optimize individual and societal productivity. Using the overarching principles and the BOND-KIDS implementation framework can ensure that programs achieve their goals—promoting early nutrition gains, supporting catch-up growth, enhancing cognitive development, and driving human capital transformation.

Abbreviations: BOND, Biomarkers of Nutrition for Development; BOND-KIDS, Biomarkers of Nutrition for Development: Knowledge Indicating Dietary Insufficiency; NSLP, National School Lunch Program; PCORI, Patient-Centered Outcomes Research Institute; WG, working group.

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Introduction

The NIH launched the “Biomarkers of Nutrition for Development (BOND)” Program in 2010 to identify, develop, and implement reliable and valid biomarkers to assess nutrient exposure, status, function, and effect in nutrition-specific and nutrition-sensitive programs and interventions [1]. Nutrition-specific interventions are defined as those that address underlying causes of malnutrition. Nutrition-sensitive interventions are those that have the potential to improve the food and nutrition security of beneficiaries as defined by the Scaling up Nutrition initiative [2].

Introduced in 2022, the “Biomarkers of Nutrition for Development: Knowledge Indicating Dietary Sufficiency (BOND-KIDS)” Project used the BOND process and ecological approach and was organized into 4 working groups (WGs) to understand and harmonize biomarkers for school-age children (5–19 y) and support efforts to meet the nutritional needs and outcomes of school-age children (5–19 y). WG1 focused on biology, WG2 on environmental influences, WG3 on assessment methods, and WG4—highlighted in this paper—on translating and implementing evidence into practice. This paper presents WG4’s findings, including guiding principles and a framework to help design and evaluate nutrition programs and policies that are fair, effective, and tailored to diverse communities.

Methods

WG4 convened and deliberated over a 6-mo period (early to mid-2022). The deliberations were informed by the evidence provided on biological and environmental factors affecting the nutritional needs and assessment of school-age children, informed by the findings from WG1 (biology), WG2 (environment), and WG3 (assessment); WG4 focused on translating and implementing evidence into practice to address the nutritional challenges facing school-age children [3–6]. WG4 also developed overarching principles and an implementation framework for translation and implementation of current and emerging evidence and developed an implementation framework to support decision-makers in evaluating and improving nutrition interventions and programs for school-age children across diverse settings.

The group used the ecological framework and a systems-based approach, drawing on models from translational and implementation science. This included examining how evidence moves from research to real-world practice, identifying barriers and facilitators, and considering equity in context. New innovations have been shown to take an average of ~17 y to go from bench to bedside to community [7]. This process, as illustrated in the Breastmilk Ecology: Genesis of Infant Nutrition translational research framework [8], proceeds from discovery to human health implications, to clinical and public health implications, to implementation to population level impact. Despite these progressions, evidence-based practices require multisector efforts to move along the continuum [9], and contextual factors both interact with and are a consideration in this translation and

implementation process [10]. Translational science seeks to accelerate this process, whereas implementation science employs methods to increase the adoption, implementation, scaling up, and maintenance of these evidence-based practices, policies, programs, and guidelines [9].

Results

Overarching principles

The WG4 identified 6 overarching principles integral to translation and implementation of current and emerging evidence to measure the impact of nutrition programs and policies for school-age children.

Overarching principle 1: Intervention design and evaluation must purposefully target developmental stages, equity, and need

As highlighted in reports from WG1 and WG2, focusing on school-age children necessitates the incorporation of the role of stages of development and other contextual factors specific to children, such as the roles of parents and schools [4,5].

Nutrition is essential during the school years to support critical transformative stages of physical, cognitive, and socio-emotional/psychological development [11,12]. This period serves as a bridge between early childhood and adulthood, presenting an opportunity to influence both short- and long-term health, well-being, and productivity. The school years encompass 3 distinct periods of growth: early childhood (5–9 y), middle childhood (10–14 y), and late childhood or adolescence (15–19 y).

Each of these periods requires a clear understanding of the role of nutrition in promoting healthy growth and development, consequences of malnutrition, and effective evidence-based approaches to prevent and address nutritional disorders at the individual and population level. Sufficient and equitable access to, and consumption and utilization of, nutritious food throughout childhood and adolescence are key to ensuring a healthy global population now and in the future [4,5].

Nurturing care, which starts in the prenatal period and extends through adolescence, is based on 5 interrelated components: good health, healthful nutrition, safety and security, responsive caregiving, and opportunities for learning [13]. Its immediate effects are on the child’s internal environment, but its long-term effects go well beyond that, influencing the child’s external environment of family and community. Addressing the need of nurturing care appropriately across developmental stages is a critical factor for enabling individuals, families, and societies to survive, thrive, and transform, and is a primary goal of the work being done with food in school systems.

School environments are one of many important settings and contributors to food security, healthy nutritional habits, and child development. In the United States, federal programs such as the National School Lunch Program (NSLP) are designed to reduce food insecurity and promote healthy eating. Studies have shown that participants in the NSLP eat more healthful lunches than nonparticipants and receive low-quality food, although

some disparities in overall diet quality (over a 24-h period) by socioeconomic status, race, and ethnicity have been observed [14]. The USDA has recently focused on prioritizing equity in its plans to achieve nutrition security through school meals that close gaps in health, economic, and educational outcomes [15]. For example, the USDA intends to strengthen support for American Indian and Tribal School Food programs, illustrating that interventions must be specific and not one-size-fits-all.

Schools provide meals during the week, but families have inconsistent food access whenever school is not in session. Key questions remain regarding how to deliver effective interventions and assess the impact of the interventions across various contexts. It is important to focus on nurturing care in helping children reach their full potential. Appendix A provides a case study from Guatemala, on the importance of targeting nutrition programming and evaluating the needs of the intended population.

Overarching principle 2: transdisciplinary science facilitates collaboration and considers biology, ecology, and implementation sciences to accurately assess impact

High-level indicators of physical, cognitive, and emotional outcomes are needed to understand the role of food in integrated human development, including nutritional and health outcomes (see WG1 report [4]). Interpretation of the impact of nutrition programming on these complex indicators requires expertise from a range of transdisciplinary professionals. Experts in biological sciences are needed to identify valid assessment measures and methods to guide the use of indicators for nutrient status at various stages in the school years. These include biomarkers of function for nutrient bioefficacy (i.e., biological homeostasis due to internal and external ecologies), biomarkers of status for nutrient bioconversion (e.g., interactions among metabolites, coexisting disease, and genetics), and biomarkers of nutrient intake and absorption (see WG3 report [6]). Researchers in implementation science should determine how research methods, including evaluation measures, can be incorporated into specific, real-world settings. Finally, interventionists such as dietitians and school staff are needed to facilitate dietary intake, education, and evaluation methods in the target population.

Diet is the critical factor in health because it provides absolute intake and bioavailability of nutrients; without the diet and the nutrients it provides, there are no interactions within the body. Only after dietary intake is assessed can biomarkers of nutritional intake, status, and function be interpreted to determine physiological and anthropometric changes.

Overarching principle 3: equitable engagement of diverse partners fosters inclusion, develops relationships, builds buy-in, and cocreates context-specific customization of interventions

Health equity is often implied, but not presented as a specific consideration of implementation frameworks [10,16–19]. However, some recent articles present a model of implementation science that includes health equity as an overarching concept [20,21]. The causes of nutritional disparities, such as food insecurity and diverse internal and external nutrition ecologies, are complex and often result from structural inequalities and a lack of efforts to promote equities—which can

occur across place, time, and generations—as well as policies and systems that impact food environments [22]. Thus, disparities in child and adolescent health and nutrition likely cannot be addressed without focusing on underlying inequalities and inequities.

Every community has its own needs and resources, as well as its own culture, social structure (including relationships, history, strengths, and conflicts), and economic factors that influence health and nutrition. Collaborating with the community to identify specific problems, concerns, and values helps ensure equitable and diverse partnerships that foster inclusion, develop relationships, build buy-in, and cocreate context-specific customization of interventions to improve children's diets.

Additional benefits of collaboration with diverse partners include opportunities to leverage existing resources in community creating the opportunity for broader impact, ability to avoid unnecessary duplication of programs or services, and ability to strengthen the agency and community capacity to engage in collaborative problem solving, thereby positioning the community to empower, build upon, and sustain health improvement activities.

Key partnerships for sustainability and resiliency in nutrition, health, and well-being—both symbolically and practically—children are an obvious rallying point to focus on a vision of future community well-being [23,24]. Involving people in interventions who care about and for children, and involving children themselves, especially those who are natural role models, provides motivation and a view toward sustainability and resiliency. When planning nutrition interventions, it is important to prioritize partnerships, cost recovery mechanisms, and policies that will sustain the program when the intervention is over [25].

Key partnerships may include “an individual or group who is responsible for or affected by health-related decisions that can be informed by research evidence” [26,27]. Key partnerships and policies play an essential role in building and sustaining programs that improve the nutrition and health of children. Key partnerships that should be considered for effective collaboration primarily fall within 3 broad categories: 1) nonparticipation (i.e., education and outreach), 2) symbolic participation (i.e., members have a place at the table allowing them to have a voice but they do not have shared decision-making authority), and 3) engaged participation (i.e., community members who traditionally have limited power are given shared decision-making authority with more powerful members, and decisions are made collaboratively based on member priorities).

Overall, effective collaboration and community engagement typically consist of communication, partnership exchange, community capacity building, leadership, and collaboration [24]. Levels of partner engagement can fall along a spectrum which can have implications for sustainability, effectiveness, and outcomes. The ideal is engaged participation which emphasizes “trust among partners, respect for each partner's expertise and contributions, mutual benefit among all partners, and a community-driven partnership with equitable and shared decision-making” [28]. Several evidence-based resources describe the best practices for community engagement. One that is commonly used is the Patient-Centered Outcomes Research Institute (PCORI)'s Patient and Family Engagement Rubric and

Hoffman's best practices for community engagement for community effectiveness studies.

PCORI provides the following foundational principles in planning diverse partner engagement [29]: 1) reciprocal relationships (i.e., researchers and partners decide together how decisions will be made and team member roles in decision making are clearly defined); 2) colearning: researchers and partners learn from each other, researchers help partners learn about the research process, and partners share their ideas, knowledge, and experiences; 3) partnerships (developing partnerships starts with valuing and respecting others, partners receive reasonable requests and payments for their time, and their diversity and cultural differences are respected and valued); 4) transparency, honesty, and trust: transparency is sharing information and making decisions together, and honesty and trust result from open and respectful communication. Hoffman's best practices of community engagement for comparative effectiveness studies emphasize: 1) balanced representation through attention to the number and participation of different members, 2) acceptance of roles, 3) use of expert facilitators, 4) building connections, and 5) sustained engagement [26,29].

Appendix A provides an illustrative case study from Haiti on how collaboration with participants, community, and federal partners resulted in the successful implementation and evaluation of a nutrition program for school-age children.

Overarching principle 4: a range of contextual drivers impact nutrition programming and must be considered when determining efficacy

Contextual drivers that can influence effective methods for assessing the impacts of nutrition programs include social, religious, political, ethnic, racial, cultural, historical, public

health, and economic factors [5]. Thus, employment of the ecological approach is needed to optimally assess the impact of programs supporting the nutritional needs of school-age children. Figure 1 highlights a social ecologic multilevel multicomponent framework that shows how individuals, partners, organizations, and policies work together based on key points from existing systematic reviews examining the sustainability of public health interventions [30,31]. Each level of the social—ecological framework must be considered as key partners determine how to best translate this evidence to inform the implementation of nutrition program assessment.

At the individual level, involvement of community members (including children, where appropriate) can help to ensure that culturally appropriate interventions, which are more likely to be sustained, are implemented. Identifying and developing relationships with passionate local leaders who are already working in this arena can also support sustainability. Focusing on supporting local leaders to do more of what they are already doing affirms their work and builds partnership. Seeking indigenous leaders and developing an understanding of local and indigenous ways as frameworks for working and for talking about child well-being affirms local ways of thinking and builds sustainable approaches. In addition, building capacity among people from the community with informal and formal (including degree seeking) training helps to set a program up for sustainability and resiliency by developing future leaders who will both sustain and innovate. Organizations, structures, and long-term funding also play a key role in the sustainability and resilience of programs and interventions to improve child nutrition. Identifying a backbone organization that will coordinate people and manage data in the short and long term is essential. Securing long-term funding or a cost recovery mechanism is also

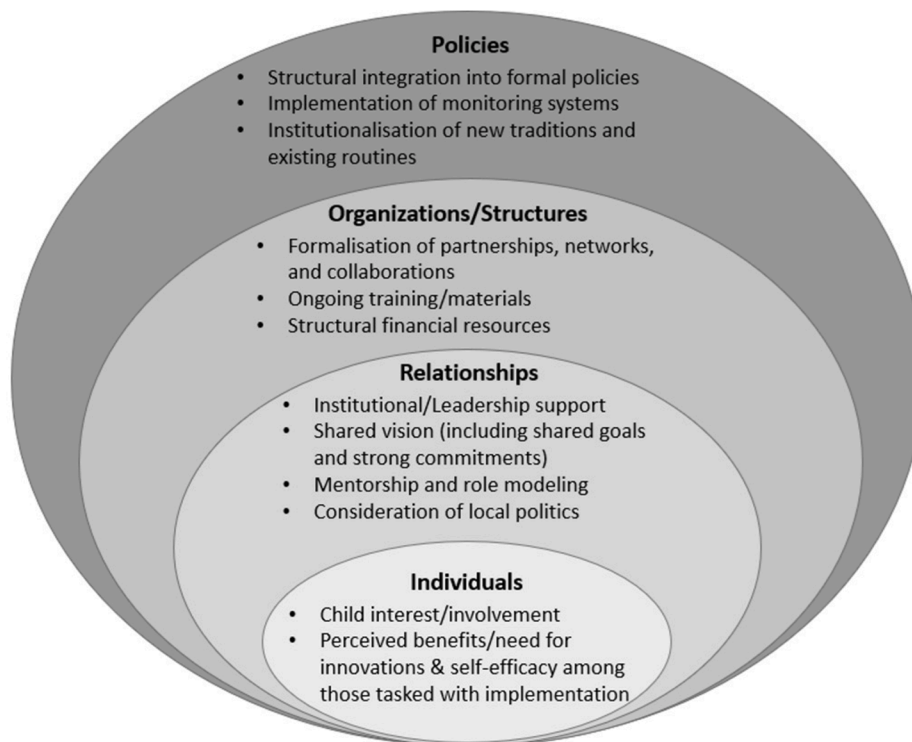


FIGURE 1. Social ecologic multilevel multicomponent framework [32].

essential. These organizations and structures are integral in identifying sustainable financial resources for ongoing impact.

Policies play a critical role in creating sustainable change at all levels and often call for cost-effective approaches. Building relationships for effective policy allows for responsiveness and resiliency in the face of disasters, such as the frequent typhoons in the Pacific, the COVID-19 pandemic, or economic crises (e.g., 2009). A collaboration readiness framework can be used to guide thinking about willingness to collaborate, capacity for change, and how to work together [33]. Appendix A presents a case study from Venezuela describing the importance of contextual factors when determining which nutrition programs should be implemented and how to determine their efficacy.

Overarching principle 5: policies, interventions, and procedures developed in one setting may not be applicable to different contexts

The nutritional biology and ecology of populations are affected by many factors, and these differ markedly between and across countries in the global north and south, especially regarding issues around historical experience and trauma, culture, race and ethnicity, public health, climate change, food environment, equity, and economics [5,6]. These factors provide both opportunities and challenges and have been extensively explored as both determinants and consequences of the relative development of populations globally [34,35].

Variations in the proportion of persons aged 5–19 y relative to the total population (Table 1 [55,56]) and their identified needs require tailored policies and programs with an eye toward creating optimal and equitable national human capital. School-age children (5–19 y) may represent as little as 13% of the total population in Japan or as much as >40% of the total population in Niger and Chad, with massively different implications for needs and costs in these countries, both now and into the future. The Human Capital Index—which is derived by combining health and education indicators and is strongly correlated with the Gross National Income—reflects that 70%–80% of the wealth of high-income countries results from the human population, whereas in low-income countries, the contribution is as low as 30% [36]. Thus, the context of population demographics influences the population's nutrition needs and programming, as well as evaluations to determine whether this programming is effective. Investments in 5–19 y olds—including programs addressing nutrition, health, and education—set the

TABLE 1

Illustrative country examples of the size of the BOND-KIDS target populations and the implications for human capital [37,38]

Country	Median population age (y)	Proportion of total population aged 5–19 y (%)	Human Capital Index
Japan	48.4	13.2	0.80
United Kingdom	40.5	17.3	0.78
France	42.3	18.1	0.76
United States	38.3	18.9	0.70
Sierra Leone	19.4	36.8	0.36
Niger	15.2	40.8	0.32
Liberia	19.4	36.7	0.32
Chad	16.6	40.0	0.30

Abbreviation: BOND-KIDS, Biomarkers of Nutrition for Development; Knowledge Indicating Dietary Sufficiency.

foundation for lifelong practices (good or bad) and determine the ability of individuals to not only achieve their own individual potential but also contribute to and benefit from the nation's wealth and productivity.

Overarching principle 6: building for sustainability includes economic and financial analyses, appropriate fit within existing systems, and flexible adaptation

Sustainability requires that programs be safe, effective, cost-effective, and have a reliable, consistent source of support (e.g., government funding). If there is already a sufficient supply of particular nutrients, additional interventions are not needed, as doing so could result in an unbalanced diet.

As highlighted throughout the BOND-KIDS series, effectiveness requires being aware of the conditions affecting the population and tailoring interventions that impact relevant nutrition-specific and nutrition-sensitive bioindicators of child health and development [5,6]. It is critical to understand the basics of the diet in the population to enable the provision of the types of foods or interventions that will complement the community diet. This could include interventions such as supplying school meals with ready-to-use supplementary foods or fortified foods, or providing students with micronutrient supplements, depending on need. Nutrition interventions should aim to supply the dietary intake that drives bioavailability and absorption. Doing so requires a focus on systems, interventions, and approaches to evaluations that are feasible, effective, and sustainable. For example, the implementation of programming adapted to be more reliant on local agriculture and growing healthy foods can benefit both health and economic development while adjusting to climate conditions that affect food systems. These factors may be relevant considerations when evaluating program efficacy.

Measurements of evaluation at each level—including the sustainability and resiliency of a program and its outcomes—should be carefully considered. This usually means measuring system changes in an ever-evolving program that is embedded in a system. Some important components to consider when measuring sustainability and resiliency include: 1) diet and activity patterns at the individual level; 2) income and food security at the household level; 3) readiness to change, food and activity environment, collective efficacy, and social networks at the community level; and 4) cost of basic needs, especially food, fuel, and housing at the jurisdiction level.

Appendix A provides an illustrative case study from the community randomized trial—Children's Healthy Living conducted in jurisdictions of the Pacific.

Implementation framework for BOND-KIDS

The framework created for the BOND-KIDS project was informed by several implementation models and frameworks that have been adapted for nutrition-focused programming (Table 2) [10,16–19,39]. Perhaps the most influential model for WG4 was the nutrition-focused integrated framework for implementation science developed by the Society for Implementation Science in Nutrition [19]. By incorporating more community involvement and a global perspective, this model highlights the importance of making frameworks, guidelines, and tools more accessible through capacity building, knowledge brokering, and technical assistance [19].

Developing an implementation framework is important and sets the stage for an effective program and evaluation. However, the next step is to plan and select implementation strategies, which can be done with a systematic and theory-based process such as implementation mapping. This can further ensure an evidence-based transition from bench to bedside to community for BOND-KIDS.

To address the need for implementation of context-specific evidence-based nutrition programs across the globe and drawing from previous work, a BOND-KIDS implementation framework was developed. This framework illustrates both the interplay and potential implementation and process indicators between 3 tiers of influences affecting child and adolescent health and nutritional status which are systems, settings, and nutrition and food interventions. The complex interactions between these influences are illustrated in Figure 2. The framework centers around the child, surrounded by ever-wider layers. The layer immediately next to the child represents the mechanism of food delivery or nutrition education. The next layer represents the settings and environments where the child receives these foods or education. The final layer represents the larger systems that affect the efficiency and effectiveness of the food and its delivery to the child. This holistic systems model captures dynamic interactions between and across levels and components. As a result of these interactions, specific components may exhibit complex, nonlinear behaviors from higher-order interactions, feedback loops and tipping points that may either magnify or attenuate responses. They also highlight the existence of multiple causal pathways.

Pragmatically, using this framework must include planning for individual variations in timing, order, exposure, attention, adherence, and motivation. The mindset and experiences that the audience bring with them and the context of when individuals encounter planned intervention components should

TABLE 2

Nutrition-focused implementation science models informing the BOND-KIDS implementation framework

Model	Description
Diffusion of innovations [11]	Explores the role of innovators, early adopters and laggards in the process of adoption
RE-AIM [12]	Considers the number or proportion of people the innovation reaches, as well as the number or proportion of settings or implementation agents willing to deliver the innovation
CFIR [10,13]	Simplifies the task by using a systems-oriented approach to split the process into 5 functional domains
Sarma et al. Conceptual framework [40]	Evaluation of nutrition interventions in real-world settings, including a course-correction model, which uses data from rapid assessments or monitoring efforts to make iterative changes as the innovation is implemented
Society for Implementation Science in Nutrition [14]	Incorporates contextual knowledge and experience, which is implicit in some of the prior models; contextual implementation research, which focuses on formative research from community partners; and global knowledge and experience

Abbreviations: BOND-KIDS, Biomarkers of Nutrition for Development; Knowledge Indicating Dietary Sufficiency; CFIR, Consolidated Framework For Implementation Research; RE-AIM, Reach, Effectiveness, Adoption, Implementation, Maintenance

also be included. Systems thinking also plays an important potential role in monitoring and evaluating interventions. A systems model may help evaluators plan more comprehensively for measuring a broader selection of potential population benefits as well as unintended consequences or side effects [10,18].

Many implementation indicators are needed for each layer to make the complex system work. Indicators at the child level relate to the measurements needed to assess whether the nutrition program or policy is being effectively delivered to meet identified needs and improve the child's health. Indicators at the nutrition and food interventions level (e.g., food delivery) include cost, food quality, the shelf life or stability of the food, and the sustainability of the system as they relate to assessing needs in unique contexts [4,6]. Indicators at the settings level (e.g., environment) include equity, reach, adoption, implementation with fidelity to the program, training for people to do the implementation, capacity and infrastructure needed, and equitable distribution. The indicators for the systems level include political will, the economic landscape, diffusion of innovations, and the conditions and context for scale and sustainability of these programs (Figure 2).

Discussion

The report from BOND-KIDS WGs highlights the critical need to improve how nutrition programs for school-age children are translated from research to practice. The 6 guiding principles and the BOND-KIDS implementation framework developed by WG4 offer a roadmap for designing, evaluating, and scaling nutrition programs and interventions that are equitable, context-specific, and scalable. Specific emergent themes and recommendations are given as follows.

Recognizing the unique needs of school-age children

The collective analysis of the 4 BOND-KIDS WGs provides an overview of the ecology of nutrition and its assessment during the period connecting early nutrition intervention in the "first 1000 days" of life with early adulthood. In the nutrition literature, the "first 1000 days" are a well-established priority but the role of nutritional intervention during school years has been largely neglected. The analysis here emphasizes the importance of nutrition for school-age children and suggests a strong role for school-based nutrition programs to address this challenge. School-age children represent a unique population with distinct developmental, social, and nutritional needs as they undergo rapid physical growth, cognitive development, and emotional changes. Unlike younger children, they can exercise autonomy in food choices but are still reliant on caregivers, schools, and community systems for access to nutritious foods.

Securing the gains of earlier nutrition investments made as part of the first 1000 d and as early of Early Child Development Programs is a key aim of investing in the 5000-d period during the school-age years. These investments provide an opportunity for catch-up growth when earlier programs may have failed, and for sustaining good nutrition during phases of nutritional vulnerability, especially around puberty and adolescent growth sport, which are key determinants of health and development into adulthood [41]. Investing in nutrition during the 5000

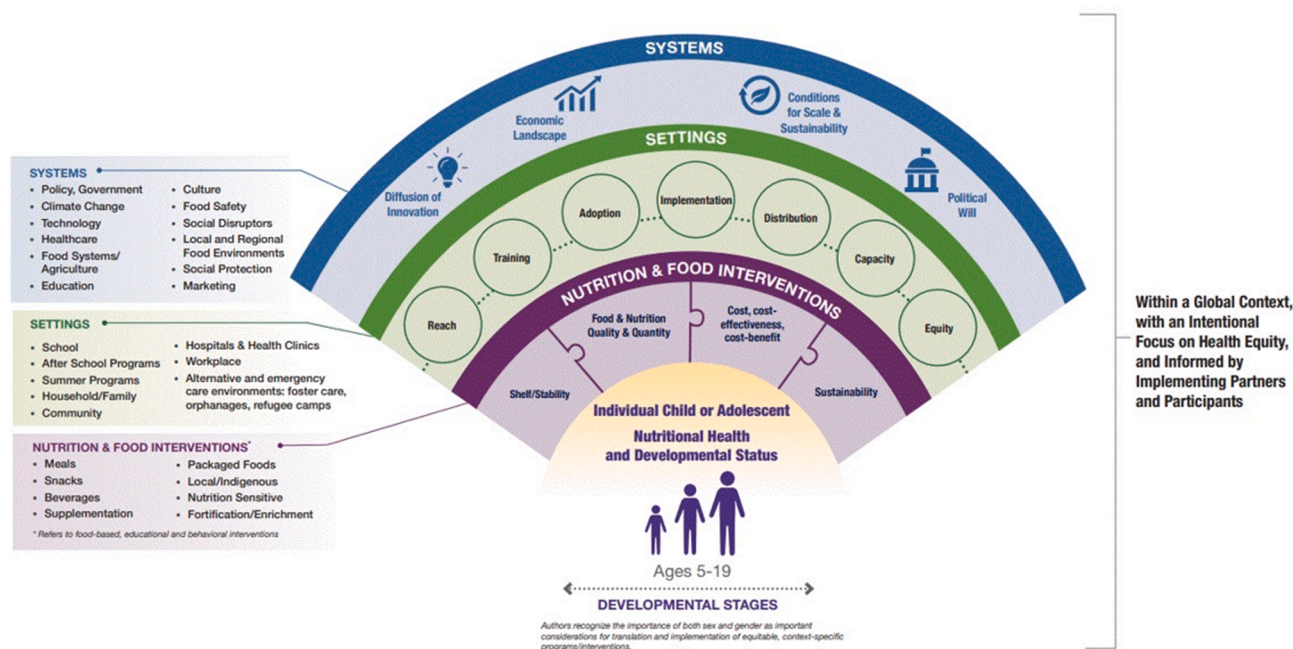


FIGURE 2. Implementation framework to assess impact of nutrition programs and policies for children aged 5–19 y.

d from ages 5 to 19 y makes a key contribution to the ability of individuals to achieve their full potential in life, and to the creation of a nation's human capital.

Bridging the gap between evidence and practice

Despite growing evidence on the effective strategies to address nutrition challenges, there is a significant gap in translating this knowledge to real-world programs. The principles identified by WG4 are both theoretical and grounded in practical examples (case studies) and demonstrate the importance of tailoring interventions to developmental stages, engaging diverse stakeholders, and considering the broader ecological context to lead to measurable improvements in nutritional outcomes for school-age children.

Equity as a central consideration

Structural inequalities such as poverty, racism, and geographic isolation shape the food environments and access to resources. Programs that disregard these disparities may inevitably risk reinforcing existing inequalities. The BOND-KIDS implementation framework integrates equity at every level—from individual dietary behaviors to national policy decisions—and recognizes the importance of culturally responsive and inclusive strategies that reflect the lived experiences of children, families, and the communities.

Systems thinking for sustainability

Nutrition programs are embedded within complex systems comprised families, schools, markets, and governments. The BOND-KIDS implementation framework emphasizes systems thinking and recognizes that coordination across multiple sectors and levels is critical for sustainable change. For example,

understanding the population composition can inform national strategies for human capital development. Similarly, recognizing that interventions are effective only when adapted for specific settings with input from relevant stakeholders. Additional research is needed to refine the implementation strategies and develop tools for evaluating program effectiveness across diverse contexts. To this end, the indicators of success must include process measures such as reach, adoption, and fidelity along with short- and long-term outcomes/impact.

Implications for policy and practice

The WG4 principles and BOND-KIDS framework can guide policymakers and program designers in decision making and resource allocation in real-world conditions. The overarching principles for translating and implementing evidence to measure the impact of nutrition programs and policies stress equity, transdisciplinary approaches, and systems thinking. Further, the BOND-KIDS framework serves as a resource to evaluate the impact of nutrition programs and policies.

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Author contributions

The authors' responsibilities were as follows – DJR, DAPB, DD: helped conceive the BOND-KIDS project and provided oversight for all phases of the project; CDE, MR: led the manuscript writing effort with critical review and input from the other authors; and all authors: read and approved the final manuscript.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used Microsoft copilot in order to ensure consistency in writing style throughout the document. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Conflict of interest

CDE reports administrative support and writing assistance were provided by Tufts University School of Nutrition. CDE reports a relationship with Tufts University that includes: employment. All other authors report no conflicts of interest.

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Appendix A. Supplementary data

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