Title: Toward a better understanding of adherence to micronutrient powders: generating theories to guide program design and evaluation based on a review of published results

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1 CERQual = Confidence in the Evidence from Reviews of Qualitative research; CG = caregiver; FMOH = Federal Ministry of Health (Ethiopia); GAIN = Global Alliance for Improved Nutrition; GRADE = Grading of Recommendations Assessment, Development, and Evaluation; HEW = health extension worker; IYC = infant and young child; MISAU = Mozambique Ministry of Health; MNP = micronutrient powder(s); PIP = program impact pathway; SES = socioeconomic status; SPRING = Strengthening Partnerships, Results, and Innovations in Nutrition Globally; USAID = U.S. Agency for International Development; WHO = World Health Organization

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Abstract

Background:
The Global Alliance for Improved Nutrition (GAIN) is conducting theory-driven process evaluations of micronutrient powder (MNP) programs.

Objective:
To generate preliminary theories about factors affecting adherence to recommendations regarding point-of-use fortification of foods with MNP.

Methods:
A literature search was conducted to identify documents with content related to adherence to MNP as an intervention provided to children 6–59 months of age at home. Thirty-five studies and six program descriptions were identified. We used thematic analyses to generate a comprehensive list of factors that could influence adherence, followed by content analysis to quantify the results. We developed a Program Impact Pathway to concretize the points at which the factors identified affect the process of adherence.

Results:
In the set of documents reviewed (N=41), the most influential factors, measured by number of documents reporting the factor having effect, were: (1) caregivers’ perception of positive changes as a result of MNP use (n=14); (2) caregivers’ perceived child acceptance of food with MNP (n=12); and (3) caregivers’ forgetfulness (n=11). Behavior change communication (BCC) channels (n=13) and messages (n=12) were the most frequently reported program design features influencing caregiver knowledge and subsequently adherence. Administration regimen (n=10), which may be related to caregivers’ capacity to remember to give MNP, was also a frequently cited program design feature affecting adherence.
Conclusions:

The preponderance of knowledge and perception factors may reflect an underlying theoretical bias among researchers as to what they measure. To achieve programs that support greater adherence, we need to adopt a cultural-ecological perspective to inform program design in order to address a broader set of determinants. Studies that assess progress across the impact pathway, particularly from adherence to biological outcomes, would also provide guidance for evaluation studies, particularly when time or other constraints limit potential to measure biological outcomes.

Keywords:

Micronutrient powders, adherence, infant and young child nutrition, complementary feeding, micronutrient deficiency, cultural-ecological
Introduction

In addition to the well-known structural and economic constraints on achieving nutrient adequacy in low-income populations, adequacy during the period of complementary feeding (6–24 months) is particularly challenging because infants and young children eat in small amounts and nutrient adequacy can be achieved only through the consumption of nutrient-dense foods (1-3). In many low-resource populations, access to nutrient-dense complementary foods is limited. One intervention recommended by the World Health Organization (WHO) to improve micronutrient content of infant and young child (IYC) diets is point-of-use fortification of foods with micronutrient powders (MNP) (4, 5). MNP are single-dose packets of dry powder containing lipid-encapsulated iron and other micronutrients that can be sprinkled onto any semisolid food (6). Studies have shown that adding MNP to complementary foods reduces risk of iron deficiency anemia and retinol deficiency among infants and young children (7, 8). As of 2014, UNICEF reports that 50 countries are implementing MNP programs, including 9 at the national level (9).

The Global Alliance for Improved Nutrition (GAIN), with funding from the Ministry of Foreign Affairs of the Netherlands, is supporting the Federal Ministry of Health (FMOH) in Ethiopia and the Mozambique Ministry of Health (MISAU, abbreviation in Portuguese) to pilot the delivery of MNP for the first time in these countries. In Ethiopia, the lessons learned will inform the scale-up of MNP delivery through the FMOH’s Health Extension Program, which, since 2003, has deployed government-salaried female health extension workers (HEWs) to provide primary health care services in rural communities (10, 11). In Mozambique, free vouchers redeemable at local stores are used to facilitate MNP distribution through MISAU health facilities and community health volunteers (activistas), who are organized by the nongovernmental organization, Save the Children Netherlands. Theory-driven process evaluations, which are designed to generate learning about factors affecting program delivery systems and how MNP outcomes are achieved or not achieved (12-15), are integral to the projects in both countries.
As part of the preparation for the evaluations, we carried out a study to better understand what is currently known about the factors that affect MNP adherence. As described below we sought to generate a comprehensive list of factors that could influence adherence and then developed a Program Impact Pathway (PIP) to concretize the points at which the factors identified affect the process of adherence (16, 17). This paper presents the results of our analysis of the published and accessible gray literature. The findings are used to generate preliminary theories, conceptualized in a revised and expanded PIP, about how these factors could limit or facilitate adherence. The PIP provides a blueprint to guide MNP program evaluations to be undertaken by GAIN or others, and includes a priori hypotheses to test determinants of program impacts, to generate evidence to guide planning and decision making.

Nutrition-specific interventions, including MNP, have biological objectives that are mediated through households, and specifically caregivers. PIPs developed for nutrition-specific programs therefore need to consist of two components representing the processes of: (1) program delivery, the pathway from program inputs to the handover points during which caregivers receive the intervention; and (2) household utilization, the sequence of behaviors by household members, predominantly caregivers, that are required to lead to biological impact on child nutritional status. Similar to procedures in other nutrition program evaluations, we mapped program delivery in collaboration with program staff (16-18). This approach provided the basis for assessing the flow of program delivery and generating hypotheses about factors that could affect implementation fidelity or program integrity.

In the context of MNP interventions, the process of household utilization is grounded in adherence, which can be defined as the extent to which a caregiver’s behavior and child’s consumption is congruent with recommendations regarding MNP (19, 20). Adherence to MNP recommendations involves three basic elements: initiation (caregiver determination to feed MNP and starting to do so), appropriate use (caregiver preparing and child consuming MNP as directed), and continued use (caregiver providing and child consuming the minimum number of MNP sachets over a recommended time period).
the sequence of caregiver behaviors for the three elements based on the specific instructions provided in
the Ethiopia and Mozambique programs\(^4\) (as shown in Figure 1 for Ethiopia) augmented by interviews
with program staff. This two-pronged approach produced a depiction of the flow of the intervention from
the caregiver to the child. However, the diagram that was generated was insufficient to derive hypotheses
about factors that influence adherence. Therefore, we turned to the literature to learn from programs that
have implemented MNP interventions in other contexts and report on their experiences and evaluation
results.

\[\text{Figure 1 here}\]

\(^4\) There is no universal set of standardized instructions for MNP use. The instructions provided to caregivers in
Mozambique and Ethiopia varied. For example, caregivers in Mozambique were instructed to use MNP every day,
while in Ethiopia, caregivers were instructed to use MNP two to three times per week.
Methods

Research Approach

Systematic analysis of research evidence is commonly used to inform nutrition policies and programs, including MNP (7). Well-established procedures for quantitative, epidemiological analyses, particularly the establishment of the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach, has facilitated a consistent and reproducible assessment of quantitative evidence of effectiveness (21). More recently, the Confidence in the Evidence from Reviews of Qualitative research (CERQual) approach was developed to support analyses to examine a range of implementation issues. It is intended to provide a method for assessing confidence in findings from studies that are based on qualitative evidence syntheses (22). We considered using the CerQual approach to synthesize the evidence on factors affecting adherence to recommendations regarding MNP. However, in contrast to the purpose for which the CERQual was developed, our objectives were to create a comprehensive taxonomy of factors reported by researchers and program implementers and to generate hypotheses that could be tested through future research. We expect that, as more nutrition implementation research is conducted, the qualitative CERQual approach will be increasingly applied to assess the relationships of factors identified in adherence study outcomes. At this preliminary stage of evidence building, we felt that a combination of thematic and content analysis, following recommended procedures for qualitative data analysis, would be more productive (23, 24).

Systematic Search and Selection of Literature

In 2015, on behalf of the U.S. Agency for International Development (USAID), the Strengthening Partnerships, Results, and Innovations in Nutrition Globally (SPRING) project convened a consultation of policy makers, program implementers, donors, and global experts to share evidence and experience related to MNP programs (25). As part of the consultation and the subsequent preparation of manuscripts, an extensive systematic literature search was conducted to identify papers that had any relevance to MNP programs. Two of the authors of this paper (A. T. and L. N.) participated in this process, which used the
following inclusion criteria: (1) MNP as an intervention provided to children 6–59 months of age at home, (2) relevant learning for MNP intervention implementation, and (3) full text available in English. Details of the search strategy are described elsewhere (25). As a result of the consultation’s systematic literature search, 81 peer-reviewed articles, 19 guidance documents, and 55 program reports or conference presentations were identified with information on program implementation experiences. In the analysis for this paper, we excluded presentations, review papers, and guidance documents, and added three studies identified through an additional search of PubMed, resulting in a potential database of 55 documents.

The first author (A. T.) read the 55 documents to determine whether they contained content related to the sequence of behaviors involved in adherence to MNP (see Figure 1). For the present study, papers were excluded only if they did not contain any content related to adherence as depicted in Figure 1. We purposely choose not to exclude publications based on a rating of quality. In this step, we identified 41 documents—35 published studies (26-60) and 6 program descriptions (61-66)—that constituted the database for our analysis.

Data Analysis
Thematic analysis of a data set (individual studies or a set of studies) is a standard approach for analyzing qualitative data (67-69). When thematic analyses are coupled with coding, using content analysis procedures, the dual approach permits quantitative assessment, as well as a comparison of themes across the studies in a database. We used QSR International’s NVivo Version 11 qualitative data analysis software to organize data and facilitate coding (70). The first author read and coded the 41 documents, with all documents revisited as new codes were created. The process of revising codes as analysis proceeds is standard good practice in qualitative coding (71). The aim of this step was to generate a comprehensive list of factors that could influence adherence and a matrix of quotations that could be used to compare themes across documents. The identification of factors and themes emerged from the content.
of the documents, not from a preset list of codes. This step produced a comprehensive list of factors, including those that were theorized by researchers or program implementers to have influenced MNP intervention outcomes.

In the next analytic step, the factors were categorized according to their described effect, or valence, on MNP adherence as follows: (1) factor reported to have facilitating effect; (2) factor reported to have limiting effect; (3) factor reported to have facilitating or limiting effect depending on other conditions; (4) factor reported, but authors stated that they did not find evidence of its effect on adherence; and (5) factor reported, but authors did not comment on its effect. In this paper, we compare the relative influence of factors in our database by counting the number of documents reporting that the factor has either a facilitating or limiting effect (i.e., factor effect categories 1-3). A coding framework was created to allow the second author (C. H. S.) to validate coding on a subset (~10%) of randomly selected documents. The discrepancy rates between the first and second authors for both the identification of factors and its valence were less than 5%. The authors (A. T. and C. H. S.) reviewed and discussed the discrepancies and agreed on coding definitions for the factors in question. Frequencies were analyzed using IBM SPSS Statistics for Windows Version 24.0 and graphed using SigmaPlot Version 13.0.

In the last analytic step, we categorized the factors, drawing on the “cultural-ecological framework,” a theoretical formulation that has been used previously to examine IYC feeding from an ethnographic perspective (72, 73). We modified and expanded the framework and used it to classify the factors into broad categories, which are referred to in the original formulation as “domains.”

**Results**

A description of the documents and factors coded in each of the documents is presented in [Supplementary Table 1](#). The documents include studies and program descriptions from 26 countries. Twenty-three of the studies used only quantitative research methods (26-30, 33-41, 44, 45, 47, 49, 51, 54,
55, 57, 58), 8 studies only qualitative research methods (31, 32, 42, 43, 50, 53, 59, 60), and 4 studies used both quantitative and qualitative methods (46, 48, 52, 56). The qualitative and mixed-method studies were exploratory and permitted investigators to discover factors that were not predefined; the quantitative studies were focused on measuring coverage, utilization, and/or biological outcomes and used close-ended questions and precoded answers. The average duration of the quantitative studies was 10 months, ranging from 2 to 26 months. Six of the quantitative studies (27, 33, 40, 41, 49, 57) statistically analyzed associations among child, caregiver, household factors, and adherence outcomes. Among the 12 exploratory studies, the average duration was 8 months; 7 of the studies were short-duration (2 days to 2 months) formative research studies to assess acceptability or feasibility of a MNP intervention.

Twenty-four factors are reported to potentially influence the sequence of behaviors involved in adherence to MNP. Figure 2 shows the number of documents that are coded for each factor and the factor’s categorization, according to the authors’ description of its effect on adherence. We also identified 16 program design features that were discussed in relation to their influence on the factors affecting adherence. Figure 3 shows the number of documents that are coded for each program design feature.

In the set of documents in our database (N=41), the most frequently reported factors for adherence to MNP recommendations are: (1) caregivers’ perception of negative side effects (n=23); (2) caregivers’ perception of positive changes in their children as a consequence of consuming MNP (n=21); and (3) caregivers’ perception of organoleptic changes associated with preparation of food with MNP (n=20). However, in the full sample of studies (N=41), the list of most influential factors, based on authors stating that they had either a facilitating or limiting effect, are: (1) caregivers’ perception of positive changes as a result of MNP use (n=14); (2) caregivers’ perceived child acceptance of food with MNP (n=12); and (3) caregivers’ forgetfulness (n=11). Details of the main findings are described below.

[Figure 2 here]
Positive changes and negative side effects associated with MNP use. Positive changes and negative side effects that caregivers observed in their children that are linked to consuming MNP are the most commonly investigated and reported factors by researchers and program implementers. Fourteen of the 41 documents analyzed report that perception of positive changes facilitates continued use, and eight documents report caregivers’ perception of negative side effects as limiting adherence. Only two studies, both in Nepal and both conducted by the same research team, tested and presented the results of correlations between observed changes in children and MNP coverage and adherence (41, 49). The researchers found that caregivers who perceive at least one positive change in their child after MNP use are significantly more likely to obtain more sachets (at least two batches of 60 MNP sachets in the previous 15 months) (41) and to report greater adherence (i.e., to feed at least 45 sachets of MNP to their children within the previous 60 days) (49). Neither study found correlations in the subsample of caregivers who perceived negative side effects.

Figure 4 shows the frequency of positive changes and negative side effects reported in our database of publications (N=41). Caregivers’ perception that the child has improved health or immunity is the most influential positive change associated with MNP intake (n=14). For the most part, the reports of health improvements consist of generalized statements without specification of how or for which illnesses MNP improve outcomes, for example, “mothers also said they liked MNP because it was easy to use and had beneficial health effects for the child” (53) and “caregivers reported perceived positive changes in their children’s health, energy levels and appetite after the children started receiving Vita-Mix-It [MNP]” (63). Two studies—one in Peru and one in Kenya—provided more-detailed information, stating that caregivers observed less diarrhea (31, 42); the Kenya study also reported that “preexisting health problems” including “vomiting or swollen stomach (kwashiorkor)” resolved after using MNP (42). Increased appetite is the second most influential positive change associated with MNP intake (n=12). However, in
the context of household food insecurity, it is not always seen as a desirable change. Thus, four documents included accounts of difficulty with continuing MNP use due to the child’s increased appetite (42, 43, 53, 59). The most serious complaints about MNP increasing appetite were reported during interviews in the Kakuma Refugee Camp in Kenya (43). In a setting where food rations were inadequate, interviewees talked at length about the challenges that they faced as a result of their children having increased appetites.

In the set of documents reviewed for this paper (N=41), diarrhea or loose stools are the most reported (n=14) and most influential negative side effect (n=6) associated with MNP intake. However, the influence of negative gastrointestinal events appears to be much less influential than the positive effect of perceived improvements on health or increased appetite; no authors reported the frequency or severity of diarrhea, and the range of its prevalence varied greatly (0%–32%).

Caregiver knows MNP purpose and recommendations regarding use and possible side effects. Main themes that emerged from the analysis are the positive influence on adherence of caregivers knowing MNP’s purpose and health benefits (n=10 of 41 documents), knowing how to prepare and feed MNP (n=10 of 41 documents), and knowing about negative side effects (n=6 of 41 documents).

Mis understandings were common when caregivers are not well informed, potentially leading to poor adherence. In Peru, use of MNP was found to be limited by caregivers’ worry that MNP will sterilize the girls, cause diarrhea and vomiting, or cause cognitive impairment (31). In the Kakuma Refugee Camp in Kenya, some beneficiaries thought that MNP might be a contraceptive for women, some believed it had been derived from deleterious ingredients, and others thought it was a medicine (43). Conversely, in Nepal, caregivers who knew of one or more consequences of anemia had greater odds of seeking additional MNP sachets than caregivers who did not know of any consequences (41). We review evidence
later in this paper that child acceptance of food with MNP may be dependent on caregivers following recommendations.

The influence of negative side effects on adherence appears to depend on the counseling received by caregivers. When caregivers are forewarned about the possible negative side effects of MNP, it seems less likely that experiencing them deters continued MNP use and, paradoxically, their appearance may even encourage continued use (28, 42, 46, 47, 49, 52, 53, 59, 63). For example, in Haiti, caregivers mentioned dark stools and constipation as positive aspects of MNP consumption because they were told about it at mothers’ meetings (46) and saw these as indications that the MNP were working. Similarly, in Nigeria, several mothers reported at the start of the study that their child had darker stools and some mild diarrhea, but that this did not worry them as they were told it might happen (59). In this study, some mothers expressed the idea that the diarrhea was a sign the body was getting rid of “bad blood.” However, in Kyrgyzstan, program implementers received reports that caregivers who were not informed of side effects abandoned the use of MNP because they attributed their children’s diarrhea episodes to its consumption (64).

In the set of documents reviewed (N=41), behavior change communication (BCC) channels (n=13) and messages (n=12) were the most frequently reported program design features influencing caregiver knowledge and subsequently adherence. For example, the less than expected effectiveness of MNP to improve iron status and anemia in the Kakuma Refugee Camp is theorized to be a result of poor quality of BCC activities and subsequent misconceptions about MNP (43, 74). In Haiti, the program’s success in reducing anemia is attributed to a well-designed communication strategy, and, in turn, “excellent” maternal knowledge of the benefits and appropriate use of MNP (46, 75).

5 “BCC channels” denotes the various means (e.g. frontline workers, radio) through which information is transmitted and “BCC messages” refer to the content, clarity and culturally appropriateness of the information.
Our analysis also highlights the prominent role of interpersonal communication carried out by frontline workers whose activities may include cooking demonstrations, home visits, and counseling. The frontline worker is often the primary person responsible for program delivery. In some cases this is a health professional, such as a nurse; however, in most settings the frontline worker is either a minimally trained, paid community resident or a community volunteer. Researchers and program implementers frequently cite knowledge, skill and accessibility of frontline workers as critical for adherence; two of the most cited program design features are frontline worker frequency of contact with caregivers (n=9 of 41 documents) and frontline worker knowledge and skill (n=9 of 41 documents). For example, in Bangladesh, children whose mothers had frequent contact with BRAC (formerly known as Bangladesh Rural Advancement Committee) *Shasthya Shebikas*, female community health volunteers trained to provide health services and sell essential health commodities, were significantly more likely to have high adherence (27). In Peru, researchers found that there was greater acceptance and use of MNP by caregivers where frontline workers appropriately adapted their interaction, rapport and counselling with caregivers to the local culture, taking time to understand her situation, explaining more about the MNP to absolve their doubts and inserting their use into the family and child’s feeding routines (31).

Caregivers’ perceived child acceptance of food with MNP, perceived organoleptic changes, and strategies to encourage child to eat food with MNP. Caregivers’ perception of children’s acceptance of food with MNP plays a large role in the feeding process and positively influencing its continued use (n=12 of 41 documents). In Nepal, mothers who reported that their children did not like food mixed with MNP had significantly lower odds of high intake adherence compared with mothers who did not report it (49). Child refusal of food with MNP could be a sign of incorrect preparation of food with MNP and subsequent undesirable organoleptic changes. For example, in Peru, caregivers who reported their children refusing MNP also reported mixing it with soups or other liquids (31). In Indonesia, program implementers reported that mothers considered MNP not suitable for children because they did not
understand that MNP should be added to semisolid foods that are not too hot (62). Another problem discussed in the reports is that some caregivers added MNP to a very small amount of food or gave the MNP without food (53), which would result in a detectable metallic taste due to MNP’s high mineral concentration. In theory, MNP is a bland powder that can be added to any food, provided that it is not a liquid (because encapsulated ferrous fumarate does not dissolve or disperse) and that the food is not so hot as to melt the lipid layer that protects the iron from interacting with the food. Twenty documents were coded for caregivers reporting organoleptic changes; however, only five of those documents report that those changes had a limiting effect and the prevalence of caregivers reporting it greatly varies (0%–46%). The reported organoleptic changes include alterations in taste (n=7), color (n=5), smell (n=5), and/or texture (n=3). One study reported MNP was perceived as a medicine due to its flavorless nature and powder form, which discouraged its use in the absence of illness (43).

Child acceptance can also be a consequence of the child’s appetite or the strategies that caregivers employ to encourage children to eat food mixed with MNP. In Peru, a caregiver stated, “I do better with banana because he eats more; with potato he hardly eats any, it must be because it has a taste” (31). Similarly, in India, a caregiver stated, “When I mix it [MNP] with rice and curry, nobody identifies that something is added to food. [The child] eats without any complaint” (50). Other strategies included giving MNP “when the child is most hungry” at the first meal of the day (31), not giving snacks before the meal with MNP (39), adding it without the child’s knowledge (42), and splitting one sachet of MNP over several meals during the day (42, 53, 60).

Caregiver forgetfulness. Caregivers forgetting to give their children MNP is the most influential limiting factor for continued intake of MNP (n=11 of 41 documents). Two studies statistically examined the association of factors related to caregiver forgetfulness and adherence. In a randomized clinical trial of adherence with ferrous fumarate Sprinkles (MNP) versus ferrous sulfate drops, caregivers in either group who reported difficulty integrating the supplement into their daily routine were more likely to have low
adherence (33). In Nepal, children of caregivers who received a reminder card had double the odds of meeting criteria for high intake adherence compared with children whose mothers who did not receive a reminder card (49).

Administration regimen, which may be related to caregivers’ capacity to remember to give MNP, also seems to be a critical program design feature affecting adherence (n=10 of 41 documents coded for “regimen”). A fixed schedule is defined as giving MNP according to a prescribed frequency (e.g., daily or every other day), whereas, using a flexible schedule, caregivers are given the option of choosing their own intake frequency, as long as a fixed number of sachets are consumed within a given time period. Ip et al. (2009) tested different MNP regimens in Bangladesh and found a flexible schedule (consuming 60 MNP sachets over a period of 4 months) was associated with higher adherence and improved anemia status compared to a fixed daily schedule (40). Caregivers in the flexible schedule group reported preferring more time to give all prescribed MNP sachets, more autonomy to decide on which day to give MNP, and less anxiety associated with missing a daily dose. In another study in Bangladesh, caregivers reported different administration regimen preferences: approximately three-quarters preferred the program’s recommended daily schedule, whereas a quarter of caregivers preferred to feed MNP every other day (27). Further, flexibility in terms of the number of times per day that MNP is added to foods may affect adherence. A self-initiated strategy that some caregivers adopt to ensure that their children consume the full daily dosage is to split the MNP sachet contents over several meals during the day. In Guatemala, formative research on the feasibility of feeding MNP twice per day revealed that some caregivers would be willing to give their children the MNP twice per day, but a few caregivers reported that they would not be able to because either they were “strong vitamins” or they did not have time. Other mothers reported that they would give MNP three times a day, because this is the number of times that they feed their children and because it will help them grow bigger and stronger faster (52).
Influence of relatives or neighbors. Across many cultural contexts, the influence of relatives and neighbors plays a role, in either facilitating or limiting caregivers’ decisions related to use of MNP (n=10 of 41 documents). For example, in Bangladesh, the influence of family and household members commonly determines what and how a baby is fed (60, 61). In Peru, the majority of caregivers who were suspicious of MNP eventually tried giving it to their child after receiving reassurance from a relative or neighbor supporting the idea that they are vitamins (31).

Careful targeting of BCC activities to influential audiences is reported as an important program design feature (n=7 of 41 documents). Target audiences include relatives and neighbors, as well as other members of the community and health system. For example, in Kyrgyzstan, investigators found that a few months after the start of the program, medical workers at the hospital level who were unaware of the MNP program were discouraging caregivers from using MNP when these caregivers brought their children to the hospital for diarrhea or other health issues (64). Training sessions for medical workers at hospitals were necessary to resolve misconceptions that diarrhea or other problems were caused by MNP.

In Bangladesh, the program implementer, BRAC, included awareness raising activities for the sales of MNP targeting government and non-government officers, political and religious leaders, health officials, alternative health care providers, teachers, adolescents and fathers (61).

Caregiver existing IYC feeding practices that favor appropriate utilization of MNP. Several IYC feeding practices were found to positively influence how MNP is integrated in the process of complementary feeding. The IYC practices coded in the database of publications (N=41) under the factor, “caregiver existing IYC feeding practices that favor MNP,” include: caregiver prepares semisolid foods (n=6), caregiver prepares special foods for infants and young children (n=1), and caregiver introduces foods at 6 months of age (n=1). Successful introduction of MNP into the IYC diet depends on having or adopting the custom to feed semisolid foods. For example, in Peru, there was greater acceptance of the MNP by caregivers who were accustomed to feeding semisolid or solid foods, whereas caregivers who customarily
served diluted or liquid foods and added the MNP to these preparations showed less acceptance and often discontinued giving it to their children (31). In China, introducing MNP was hampered by the custom of feeding powdered soy milk with water. Many caregivers fed MNP to their children in this fashion, in spite of recommendations to mix it with semisolid foods (58). In Timor-Leste, a few caregivers reported that feeding MNP had affected the way that they prepared the child’s porridge, in that they had to make it thicker so that the MNP could mix well (53); one mother said, “Now I cook the porridge thicker than usual because I am afraid that if it is cooked too thin [too much water], it won’t mix well with MNP.”

Shifting to the results of the analysis using the cultural-ecological framework, Table 1 shows how the factors that emerged from our content analysis as determinants of adherence can be classified in relation to the domains of the modified and expanded cultural-ecological framework (72, 73). The domains of the framework consist of: The Physical Environment, Technology, Social Organization, the Ideational System (“culture”) and the Social Environment, all of which affect the food system and diet. The majority of the factors (n=22 of 24 factors) identified by investigators can be characterized as pertaining to the “cultural” or “ideational systems” (72, 73). The term “ideational system” has been proposed by anthropologists to distinguish those aspects of culture that pertain to knowledge, beliefs, values, and perceptions, as contrasted with other domains. As shown in Table 1, in addition to the 22 factors that pertain to the “ideational system,” the other factors that investigators reported to affect adherence can be classified as follows: habit (n=3 of 24 factors: involves automated behaviors that can be triggered by cues); child biological needs (n=3 of 24 factors: includes individual biological requirements conditioned by developmental stage, activity level, health, and nutritional status); social organization (n=3 of 24 factors: includes household income and expenditures, socio-demographic features, health status, educational attainment, allocation of time to child care, and food acquisition); physical environment (n=2 of 24 factors: especially in this context, water supply and sanitation); and social environment (n=1 of 24 factors: especially in this context, markets, programs, and health services).
Discussion

On the face of it, adding a sachet of powdered nutrients to complementary foods and feeding it to a child once a day does not seem to be a difficult action for caregivers to take. In fact, compared to other potential complementary feeding interventions, the apparent simplicity of MNP is a central feature of its attractiveness as an intervention. However, what we found leads to a different conclusion, namely, that preparing food with MNP correctly and succeeding in getting a child to eat it depends on a complementary feeding process that requires a complex set of caregiver behaviors and caregiver-child interactions. From the caregiver side, effective behaviors depend on knowledge about preparation, on foods and feeding patterns that provide appropriate foods for fortification, including semisolid foods; and on creative strategies to encourage a child to eat the full portion. The centrality of interactions between children and their caregivers for adherence to MNP intake presents challenges and opportunities that call attention to the importance of equipping caregivers with knowledge, skills, and environments that are conducive to successfully feeding foods with MNP. It is likely that communications designed to support better use of MNP will have positive spin-off effects on complementary feeding behaviors in general, including encouraging timely initiation of complementary foods, appropriate consistency of complementary foods and active or responsive feeding.

Adherence is widely recognized as a critical intermediate step for achieving impact in long-term therapies in the treatment of disease (19) and micronutrient supplements (33, 77-80). In this review of existing evidence, we found that all of the factors affecting MNP adherence are common to other interventions that include new products or medications. The most influential factor facilitating adherence, measured by number of documents reporting the factor as having an effect, was the positive changes that caregivers observed in their children as a result of giving MNP. This is an example of “perceived benefit,” a construct that has been extensively studied. It is as a key construct in the Health Belief Model and has...
been shown to influence behavior across a variety of contexts and interventions (81), including other
forms of micronutrient supplements for children (33, 79). Further study of caregivers’ perceptions is
likely to provide more in-depth knowledge to inform the development of behavior change messages to
encourage MNP use. Measuring and quantifying caregivers’ perceptions about their children’s health,
appetite, and activity levels that are biologically plausible consequences of MNP consumption may also
serve to provide evidence to advocate successfully for programs to scale-up of MNP interventions. Policy
and program decision makers often want evidence that adherence to MNP improves health and nutrition
outcomes in their locality. Unfortunately, measuring biological impact often presents difficult practical
and economic challenges. New studies to address the relationship between factors that have been
identified with caregiver adherence and biological outcomes will be helpful to determine the adequacy of
caregiver MNP perceptions as substitutes for difficult-to-measure biological outcomes in the context of
program evaluations.

Turning to the implications of the findings for theory development, we begin by noting that the database
created through our content analysis broadly reflects the focus of issues of concern for investigators or
program implementers, as well as their relative frequency in publications and reports. It is probable that
the preponderance of knowledge and perception factors in the MNP studies reflect an underlying
assumption by investigators that caregiver behavior is primarily driven by the domain of
cultural/ideational systems. In other words, the results may reflect an underlying theoretical bias among
researchers as to what they measure. Taking a more cultural-ecological perspective leads us to recognize
determinants have been understudied. For example, results of a focused ethnographic study in Bangladesh
found that cultural prohibitions on women travelling unaccompanied outside the home meant that women
faced critical barriers to accessing products from the market (60). The highly gendered nature of public
space constrains caregivers’ actions in many diverse contexts (82), but this is not generally considered in
evaluations of nutrition programs, including in evaluations of MNP adherence. Another aspect of culture
that was not examined in the MNP studies is how conflicts and complementarities in caregivers’
knowledge systems (i.e., between biomedical ideas and traditional knowledge) affect adherence, although studies in nutritional anthropology have revealed their significance for responses to intervention efforts (83, 84).

In the sample we analyzed, the studies that identified infrequently reported factors used an ethnographic approach, which allowed investigators to reveal realities from an emic or insider’s perspective. Thus, the application of ethnographic data collection techniques, coupled with a theoretical framework that encourages examination of a wider range of potential determinants, provides opportunities to discover conditions, values, and behaviors that were not foreseen by the investigators (85). To achieve greater impact we need to adopt a more cultural-ecological perspective and draw on theories to inform the design of programs that take into account a broader set of determinants. For example, new, innovative approaches—adherence partners (86) and strategic use of social networks (87)—demonstrate the value of interventions that capitalize on aspects of the social organization of household and communities.

There are several methodological issues concerning our database of studies that need to be noted (88):

- Authors of the documents included in our analysis may have “misinterpreted” their data or used a labelling convention that obscured factors that should have been identified.
- There is a possibility that we did not find all of the available studies and that, within the studies we analyzed, we missed specific factors. Double coding a subsample of studies helps limit the potential for the latter but not the former.
- Within a document, the number of times a factor is mentioned and how thoroughly it was investigated is also likely to affect whether or not it is coded.
- The likelihood that the frequency with which factors are reported may also be influenced by what authors choose to present, as contrasted with what they examined.

Generalizations based on our database are further constrained because it includes a small number of exploratory studies and many of those were focused on the initiation of MNP and its appropriate use, not
its continued use. It is likely that a wider range of factors affecting adherence would have been identified if there were more publications using ethnographic approaches and of longer duration.

A primary motivation for the research reported here was to identify questions to include in GAIN’s process evaluations for the MNP intervention studies in Ethiopia and Mozambique. In this study we found that the approach we used to structure the analysis—creating a PIP, coupled with examining the results in relation to the cultural-ecological framework—facilitated the identification of hypotheses, as well as potentially significant gaps. Our analysis provides a theoretically sound basis on which to specify a priori expectations about MNP intervention outcomes. It permits an increased level of plausibility in planning quantitative studies for hypothesizing a causal role for individual factors in facilitating or limiting adherence (89). It also directs attention to the importance of using more exploratory approaches that will broaden the scope of our understanding about determinants of adherence.
Acknowledgments

We are grateful to Jean-Pierre Habicht and Marieke Vossenaar for valuable comments on the manuscript, to Mduduzi Mbuya for helpful suggestions on presentation of the figures, and to Jeff Feldmesser for his editorial assistance.

Statement of authors’ contributions to manuscript

A. T. designed research; A. T. and C. H. S. analyzed data with support of G. H. P.; A. T. wrote the first draft of the manuscript and had primary responsibility for the final content; C. H. S., L. M. N., and G. H. P. provided important intellectual content. All authors read and approved the final manuscript.
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http://dx.doi.org/10.1016/0277-9536(94)90135-X.


Table 1. Expanded PIP depicting household utilization of MNP, factors identified in analysis, and their domains based on cultural-ecological framework. Caregiver behaviors based on key messages communicated as part of Ethiopia program.

<table>
<thead>
<tr>
<th>Sequence of Caregiver Behaviors to Adhere to Recommendations Regarding MNP</th>
<th>Facilitating and Limiting Factors Identified in Analysis</th>
<th>Domain(s) of Identified Factor</th>
</tr>
</thead>
</table>
| Caregiver initiates feeding MNP to child:  
  • Caregiver feeds MNP to child who is between 6 and 23 months of age | CG knows MNP purpose  
  [Influence of relatives and neighbors]  
  CG trusts MNP product safety  
  CG familiarity with similar products  
  CG knowledgeable about nutrition prior to MNP intervention  
  [CG traditional beliefs] | Culture/idea system  
  Culture/idea system  
  Culture/idea system  
  Culture/idea system  
  Culture/idea system |
| Caregiver prepares food with MNP correctly:  
  • Caregiver washes hands before cooking and feeding  
  • Caregiver adds entire MNP sachet to a small portion of semisolid food that is not too hot and that the child can finish during one feeding session | CG knows recommendations regarding use  
  CG IYF feeding practices that favor MNP  
  (Household food insecurity) | Culture/idea system  
  Culture/idea system  
  Social organization, physical environment |
| Caregiver feeds food with MNP to child:  
  • Caregiver feeds the food mixed with MNP to the child with a spoon within half an hour of preparing it  
  • Caregiver feeds entire portion of food mixed with full dose of MNP to child | CG perceives child acceptance  
  CG knows recommendations regarding use  
  CG IYF feeding practices that favor MNP  
  (CG shares food with MNP)  
  (CG perceives organoleptic changes) | Culture/idea system  
  Culture/idea system  
  Culture/idea system  
  Culture/idea system  
  Culture/idea system |
| Caregiver continues feeding MNP:  
  • Caregiver feeds MNP 2 to 3 times per week, but not more than 1 sachet a day, to child between 6 and 23 months of age  
  • Caregiver acquires more MNP sachets when supply runs out  
  • Caregiver continues to use MNP even if child has darker stools, softer stools, mild diarrhea, or mild constipation | CG perceives positives changes in child  
  CG knows MNP purpose  
  CG perceives child acceptance  
  (CG forgetfulness)  
  CG knows recommendations regarding use  
  (CG perceives negative side effects)  
  (CG shares food with MNP)  
  CG informed of side effects  
  (Child illness or poor appetite)  
  [CG traditional beliefs]  
  (Gendered nature of public space) | Culture/idea system  
  Culture/idea system  
  Culture/idea system  
  Social organization, habit  
  Culture/idea system  
  Culture/idea system  
  Culture/idea system  
  Culture/idea system  
  Culture/idea system  
  Culture/idea system  
  Culture/idea system  
  Culture/idea system |

Factors not specific to a particular behavior but could affect adherence: child age (child biological needs, culture/idea system); child sex (child biological needs, culture/idea system); household SES (social organization); CG education (culture/idea system, social organization); CG age (culture/idea system, social organization).
Figure legends

Figure 1. PIP depicting household utilization of MNP. Caregiver behaviors based on key messages communicated as part of Ethiopia program.

Figure 2. Number of documents (N=41) reporting factors affecting adherence to MNP recommendations. CG = caregiver. SES = socioeconomic status. Factors in not in parentheses or brackets are facilitating factors. Factors in parentheses are limiting factors. Factors in brackets are factors that could be facilitating or limiting depending on other conditions.

Figure 3. Number of documents (N=41) reporting program design features affecting factors that influence adherence to MNP recommendations. CG = caregiver. BCC = behavior change communication. FW = frontline worker.

Figure 4. Number of documents (N=41) reporting positive changes or negative side effects in children associated with MNP intake and reported effect on adherence to MNP recommendations. CG = caregiver. Factors not in parentheses are facilitating factors. Factors in parentheses are limiting factors. “Black or dark stool” is in the figure twice because some mothers thought that it was a positive sign that the MNP was working, and so facilitated its use (facilitating factor), while other mothers were alarmed because they were not forewarned that it was a side effect (limiting factor). “Increased appetite” is also in the figure twice because it was reported as both a facilitating and limiting factor.
## Sequence of Caregiver Behaviors to Adhere to Recommendations Regarding MNP

<table>
<thead>
<tr>
<th>Initiation</th>
<th>Appropriate Use</th>
<th>Continued Use</th>
</tr>
</thead>
</table>
| Caregiver initiates feeding MNP to child:  
- Caregiver feeds MNP to child who is between 6 to 23 months of age | Caregiver prepares food with MNP correctly:  
- Caregiver washes hands before cooking and feeding  
- Caregiver adds entire MNP sachet to a small portion of semi-solid food that is not too hot and the child can finish during one feeding session | Caregiver continues feeding MNP:  
- Caregiver feeds MNP 2 to 3 times per week, but not more than 1 sachet a day, to child from 6 to 23 months of age  
- Caregiver acquires more MNP sachets when supply runs out  
- Caregiver continues to use MNP even if child has darker stools, softer stools, mild diarrhea or mild constipation |

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## Supplemental Table 1

<table>
<thead>
<tr>
<th>Source document</th>
<th>Setting</th>
<th>Study aim or purpose of publication</th>
<th>Study design or document type</th>
<th>Factors affecting adherence coded in document</th>
<th>Program design features coded in document</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. (Adu-Afarwuah et al., 2008)</td>
<td>Ghana</td>
<td>To compare the efficacy and acceptability of MNP, Nutritabs, and fat-based Nutributter among children age 6-12 mo.</td>
<td>Community-based randomized trial</td>
<td>CG perceives positive changes in child associated with MNP use; CG perceives child acceptance of food with MNP; CG perceives negative side effects</td>
<td></td>
</tr>
<tr>
<td>2. (Afsana et al., 2014)</td>
<td>Bangladesh</td>
<td>To describe process and outcomes of delivering MNP to children age 6-59 mo through BRAC’s (formerly known as Bangladesh Rural Advancement Committee) frontline health workers.</td>
<td>Program description</td>
<td>Influence of relatives or neighbors</td>
<td>BCC channels</td>
</tr>
<tr>
<td>3. (Angdembe et al., 2015)</td>
<td>Bangladesh</td>
<td>To assess adherence to MNP and associated factors among children age 6-59 mo among families who purchased MNP.</td>
<td>Cross sectional study</td>
<td>CG perceives positive changes in child associated with MNP use; CG knows MNP purpose; CG knows recommendations regarding use; CG perceives negative side effects; CG shares food with MNP; Child illness or poor appetite; CG perceives organoleptic changes associated with MNP; Child age, older; Household SES, poor; CG age</td>
<td>FW frequency of contacts with CG; FW knowledge and skills; Regimen; MNP cost</td>
</tr>
<tr>
<td>4. (Avula et al., 2010)</td>
<td>Rajasthan, India</td>
<td>To assess growth impacts among children age 6-72 mo resulting from enhancements to the existing Supplemental Nutrition Program which includes distribution of MNP.</td>
<td>Quasi-experimental longitudinal study</td>
<td>CG perceives negative side effects; CG informed of negative side effects</td>
<td>FW knowledge and skills</td>
</tr>
<tr>
<td>5. (Bilukha et al., 2011)</td>
<td>Butan</td>
<td>To evaluate the effectiveness of a large-scale MNP distribution program in reducing anemia prevalence and promoting growth in refugee children age 6-59 mo.</td>
<td>Pre-post design with no control group, included four representative cross-sectional surveys</td>
<td>CG perceives positive changes in child associated with MNP use; CG perceives negative side effects; CG perceives organoleptic changes associated with MNP</td>
<td></td>
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<td>6. (Christofides et al., 2005)</td>
<td>Canada</td>
<td>To determine the acceptability and safety of MNP for prevention of iron deficiency anemia among children age 4-18 mo.</td>
<td>Double-blind randomized controlled trial</td>
<td>CG forgetfulness; CG perceives organoleptic changes associated with MNP</td>
<td></td>
</tr>
<tr>
<td>7. (Creed-Kanashiro et al., 2015)</td>
<td>Peru</td>
<td>To explore acceptability of MNP by caregivers and the role of health personnel in piloting the MNP program.</td>
<td>Qualitative study</td>
<td>CG perceives positive changes in child associated with MNP use; CG knows MNP purpose; CG perceives child acceptance of food with MNP; CG forgetfulness; Influence of relatives or neighbors; CG knows recommendations regarding use; CG perceives negative side effects; CG IYC feeding practices that favor MNP: CG prepares semi-solid foods with MNP; CG uses strategies to encourage child to eat food with MNP; CG trusts MNP product safety; CG perceives organoleptic changes associated with MNP; CG prior nutrition knowledge</td>
<td>BCC channels; BCC messages; FW frequency of contacts with CG; FW knowledge and skills; Regimen; MNP supply; BCC target audiences; Demonstrations how to use MNP</td>
</tr>
<tr>
<td>8. (de Pee et al., 2007)</td>
<td>Indonesia</td>
<td>To describe the post-tsunami experience with distribution of Vitalita Sprinkles in Aceh and Nias and to analyze the monitoring data gathered for the emergency response.</td>
<td>Description of program experience and analysis of monitoring data</td>
<td>CG perceives child acceptance of food with MNP; CG knows recommendations regarding use; CG perceives organoleptic changes associated with MNP</td>
<td>BCC messages</td>
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<td>Source document</td>
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<td>9. (Fernandez- Rao et al., 2014)</td>
<td>India</td>
<td>To describe development, design, and implementation of an integrated randomized double-masked placebo-controlled trial that examines how home/preschool fortification with multiple micronutrient powder (MNP) combined with an early child-development intervention in rural India affects child development, growth, and micronutrient status.</td>
<td>Qualitative formative research</td>
<td>CG perceives organoleptic changes associated with MNP;</td>
<td>BCC channels; FW frequency of contacts with CG; Marketing strategies; MNP supply</td>
</tr>
<tr>
<td>10. (Geltman et al., 2009)</td>
<td>United States</td>
<td>To determine whether low-income infants’ adherence to MNP was better than to ferrous sulfate drops.</td>
<td>Randomized clinical trial</td>
<td>CG knows MNP purpose; CG forgetfulness; CG perceives negative side effects; CG trusts MNP product safety; CG perceives organoleptic changes associated with MNP</td>
<td>BCC channels; FW frequency of contacts with CG; Marketing strategies; MNP supply</td>
</tr>
<tr>
<td>11. (Halati et al., 2013)</td>
<td>Nepal</td>
<td>To describe experience of implementing MNP Program for Bhutanese Refugee Children in Jhapa and Morang Districts, Nepal.</td>
<td>Description of program experience</td>
<td>CG perceives positive changes in child associated with MNP use; CG perceives negative side effects; CG informed of negative side effects; BCC channels</td>
<td>BCC channels</td>
</tr>
<tr>
<td>12. (Harding et al., 2016)</td>
<td>Bangladesh</td>
<td>To evaluate components of program distributing child supplements; to determine adherence to lipid-based nutrient supplement (LNS) and MNP among children; and to compare the adherence indicators from the process evaluation and impact study follow-up.</td>
<td>Process evaluation consisting of cross-sectional survey</td>
<td>CG perceives child acceptance of food with MNP; CG forgetfulness; CG shares food with MNP; Child illness or poor appetite</td>
<td>BCC channels; FW frequency of contacts with CG; Marketing strategies; MNP supply</td>
</tr>
<tr>
<td>13. (Harris et al., 2012)</td>
<td>Kenya</td>
<td>To evaluate uptake of WaterGuard, insecticide-treated bednets, and MNP in Western Kenya.</td>
<td>Longitudinal study</td>
<td>Household SES</td>
<td>BCC channels; FW frequency of contacts with CG; Marketing strategies; MNP supply</td>
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<td>Source document</td>
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<td>Study aim or purpose of publication</td>
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<tr>
<td>14 (Hirve et al., 2013)</td>
<td>India</td>
<td>To assess the effectiveness of MNP supplementation in reducing anemia levels in children aged 6 mo to 6 y in India</td>
<td>Pre-post design with no control group, included baseline and endline cross-sectional surveys</td>
<td>CG knows recommendations regarding use</td>
<td></td>
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<tr>
<td>15 (Huo et al., 2015)</td>
<td>China</td>
<td>To assess the effect of MNP program on hemoglobin levels and the prevalence of anemia among children 6-23 mo</td>
<td>Pre-post design with no control group, included four representative cross-sectional surveys</td>
<td>CG knows recommendations regarding use; CG IYC feeding practices that favor MNP: CG prepares semi-solid foods with MNP</td>
<td></td>
</tr>
<tr>
<td>16 (Hyder et al., 2007)</td>
<td>Bangladesh</td>
<td>To determine whether iron provided in Sprinkles daily or in a higher dose once weekly affected hemoglobin, serum ferritin levels, and serum transferrin receptor levels, and to determine whether there were differences in the effects of the two regimens</td>
<td>Cluster-randomized, community-based trial</td>
<td>CG perceives positive changes in child associated with MNP use; CG perceives negative side effects; CG shares food with MNP; CG perceives organoleptic changes associated with MNP;</td>
<td></td>
</tr>
<tr>
<td>17 (Inayati et al., 2012)</td>
<td>Nias Island, Indonesia</td>
<td>To assess the impact of intensive nutrition education with or without the provision of MNP on the nutritional status of mildly wasted children.</td>
<td>Cluster-randomized trial</td>
<td>CG perceives child acceptance of food with MNP; CG forgetfulness; CG uses strategies to encourage child to eat food with MNP; CG shares food with MNP; CG perceives organoleptic changes associated with MNP;</td>
<td>BCC messages; FW frequency of contacts with CG</td>
</tr>
<tr>
<td>18 (Ip et al., 2009)</td>
<td>Bangladesh</td>
<td>To compare the effects of daily versus flexible administration of MNP on adherence, acceptability, and hematological status among young children in rural Bangladesh.</td>
<td>Cluster-randomized trial</td>
<td>CG perceives positive changes in child associated with MNP use; CG forgetfulness; CG shares food with MNP; Child illness or poor appetite; CG perceives organoleptic changes associated with MNP;</td>
<td>Regimen</td>
</tr>
<tr>
<td>Source document</td>
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<td>Study aim or purpose of publication</td>
<td>Study design or document type</td>
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<td>19 (Jefferds et al., 2010)</td>
<td>Kenya</td>
<td>To describe community members’ reactions to and experiences using MNP, with an emphasis on acceptability, utilization, and promotion.</td>
<td>Qualitative study</td>
<td>CG perceives positive changes in child associated with MNP use; CG knows MNP purpose; CG perceives child acceptance of food with MNP; CG forgetfulness; Influence of relatives or neighbors; CG knows recommendations regarding use; CG perceives organoleptic changes associated with MNP; CG perceives negative side effects; CG uses strategies to encourage child to eat food with MNP; CG shares food with MNP; CG informed of negative side effects; CG has familiarity with similar products; CG prior nutrition knowledge; Household food insecurity</td>
<td>BCC channels; BCC messages; FW knowledge and skills; MNP cost; MNP supply; Distribution location close to household; Type of distribution location</td>
</tr>
<tr>
<td>20 (Jefferds et al., 2015)</td>
<td>Nepal</td>
<td>To describe coverage of batches of MNP and factors influencing coverage for two MNP delivery models piloted in an integrated IYC feeding and MNP project among children 6–23 months of age.</td>
<td>Cross-sectional household surveys representative of children 6–23 mo in four pilot districts</td>
<td>CG perceives positive changes in child associated with MNP use; CG knows MNP purpose; CG perceives child acceptance of food with MNP; CG perceives negative side effects; Child age, older; Child sex, male; CG education</td>
<td>BCC channels; FW frequency of contacts with CG; MNP supply; Distribution location close to household; Frequency of distribution; Reminder tools</td>
</tr>
<tr>
<td>21 (Kodish et al., 2011)</td>
<td>Kenya</td>
<td>To identify factors at the distal and proximal levels leading to the low uptake of micronutrient powder through a qualitative inquiry.</td>
<td>Qualitative research including direct observations, in-depth interviews, and focus group discussions</td>
<td>CG knows MNP purpose; CG knows recommendations regarding use; CG perceives negative side effects; CG perceives organoleptic changes associated with MNP; CG trusts MNP product safety; Household food insecurity</td>
<td>BCC channels; BCC messages; FW knowledge and skills; MNP packaging</td>
</tr>
<tr>
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<td>Study design or document type</td>
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<tr>
<td>(Korenromp et al., 2015)</td>
<td>Nigeria</td>
<td>To determine the feasibility of distributing MNP during biannual Maternal, Neonatal and Child Health Week events.</td>
<td>Process evaluation including pre-post cross-sectional surveys among caregivers, longitudinal cohort of mother-child pairs, and cross-sectional survey of health workers</td>
<td>CG perceives positive changes in child associated with MNP use; CG perceives negative side effects</td>
<td>FW knowledge and skills; MNP supply; MNP packaging</td>
</tr>
<tr>
<td>(Kounnavong et al., 2011)</td>
<td>Lao People’s Democratic Republic</td>
<td>To compare the effect of twice weekly versus daily supplementation with MNP on anemia prevalence, hemoglobin concentration, and growth in infants and young children.</td>
<td>Randomized trial</td>
<td>CG perceives positive changes in child associated with MNP use; CG forgetfulness; CG perceives negative side effects; Child illness or poor appetite; CG perceives organoleptic changes associated with MNP</td>
<td>Regimen</td>
</tr>
<tr>
<td>(Loechl et al., 2009)</td>
<td>Haiti</td>
<td>To assess, in the context of an effectiveness evaluation, the feasibility and acceptability of distributing MNP through a food-assisted maternal and child health and nutrition program.</td>
<td>Program theory guided assessment including structured observations, checks of beneficiary ration cards, exit interviews, focus group discussions, individual interviews and survey data from the related effectiveness evaluation</td>
<td>CG perceives positive changes in child associated with MNP use; CG knows MNP purpose; CG perceives child acceptance of food with MNP; CG knows recommendations regarding use; CG perceives negative side effects; CG shares food with MNP; Child illness or poor appetite</td>
<td>BCC channels; BCC messages; FW knowledge and skills;</td>
</tr>
<tr>
<td>(Lundeen et al., 2010)</td>
<td>Kyrgyzstan</td>
<td>To test the effectiveness of a 2-month intervention with daily home fortification of complementary food using MNP in reducing anemia among children 6 to 36 months of age.</td>
<td>Cluster-randomized trial</td>
<td>CG perceives positive changes in child associated with MNP use; CG perceives negative side effects; CG shares food with MNP</td>
<td>Regimen</td>
</tr>
<tr>
<td>(Lundeen et al., 2013)</td>
<td>Kyrgyzstan</td>
<td>To describe experience of integrating MNP delivery into a broader child health and nutrition program.</td>
<td>Description of program experience</td>
<td>Influence of relatives or neighbors; CG perceives negative side effects; CG informed of negative side effects; CG trusts MNP product safety</td>
<td>BCC channels; BCC messages; BCC target audiences; Seasonal timing of initial MNP distribution</td>
</tr>
<tr>
<td>Source document</td>
<td>Setting</td>
<td>Study aim or purpose of publication</td>
<td>Study design or document type</td>
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<td>Program design features coded in document</td>
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<tr>
<td>27 (MacLean et al., 2013)</td>
<td>Bolivia</td>
<td>To describe experience of delivering MNP through government health system.</td>
<td>Description of program experience</td>
<td>CG knows MNP purpose; CG knows recommendations regarding use; CG shares food with MNP; FW knowledge and skills; MNP packaging</td>
<td></td>
</tr>
<tr>
<td>28 (Michaux et al., 2014)</td>
<td>Cameroon, Lao PDR, Rwanda, Sierra Leone, Uganda, Zambia</td>
<td>To describe lessons learned from formative research across six countries.</td>
<td>Formative research including key informant interviews, focus group discussions, and quantitative surveys</td>
<td>CG perceives positive changes in child associated with MNP use; CG has familiarity with similar products; CG IYC feeding practices that favor MNP: CG introduces complementary foods at 6 mo of age, CG prepares semi-solid foods with MNP; CG trusts MNP product safety</td>
<td>BCC messages; MNP packaging</td>
</tr>
<tr>
<td>29 (Mirkovic et al., 2015)</td>
<td>Nepal</td>
<td>To identify modifiable predictors of intake adherence to inform the design and implementation of MNP projects.</td>
<td>Cross-sectional household surveys representative of children 6–23 mo in four pilot districts</td>
<td>CG perceives positive changes in child associated with MNP use; CG knows MNP purpose; CG perceives child acceptance of food with MNP; CG forgetfulness; Influence of relatives or neighbors; CG knows recommendations regarding use; CG perceives negative side effects; CG uses strategies to encourage child to eat food with MNP; CG shares food with MNP; CG informed of negative side effects; CG perceives organoleptic changes associated with MNP; CG education</td>
<td>BCC messages; FW frequency of contacts with CG; Regimen; Frequency of distribution; Reminder tools</td>
</tr>
<tr>
<td>30 (Mridha et al., 2012)</td>
<td>Bangladesh</td>
<td>To assess the acceptability of LNS among pregnant and lactating women and IYC, and MNP among IYC, as well as to understand perceptions about malnutrition and nutrient supplements prior to implementing an effectiveness study.</td>
<td>Test feeding, home use study, and focus group discussion</td>
<td>CG perceives positive changes in child associated with MNP use; CG perceives child acceptance of food with MNP; CG perceives negative side effects; CG uses strategies to encourage child to eat food with MNP; CG perceives organoleptic changes associated with MNP;</td>
<td>BCC channels; FW frequency of contacts with CG</td>
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<tr>
<td>Source document</td>
<td>Setting</td>
<td>Study aim or purpose of publication</td>
<td>Study design or document type</td>
<td>Factors affecting adherence coded in document</td>
<td>Program design features coded in document</td>
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<td>(Nguyen et al., 2016) Vietnam</td>
<td>To assess MNP coverage and compliance, five months after the start of distribution.</td>
<td>Cross-sectional survey</td>
<td>CG perceives positive changes in child associated with MNP use; CG knows MNP purpose; CG perceives child acceptance of food with MNP; CG perceives negative side effects; CG iYC feeding practices that favor MNP: CG prepares semi-solid foods with MNP</td>
<td>MNP cost; MNP supply</td>
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<td>(Olney et al., 2012) Guatemala</td>
<td>To assess the quality and use of preventive health services; test the acceptability of two types of MNP and LNS; assess current practices and beliefs related to maternal and child care, health, and nutrition; and develop recipes based on currently fed foods.</td>
<td>Formative research including surveys, semi-structured interviews, focus group discussions, health facility assessments, key informant interviews, recipe trials</td>
<td>CG perceives positive changes in child associated with MNP use; CG knows MNP purpose; CG perceives child acceptance of food with MNP; Influence of relatives or neighbors; CG knows recommendations regarding use; CG perceives negative side effects; CG shares food with MNP; CG informed of negative side effects; CG trusts MNP product safety; CG perceives organoleptic changes associated with MNP;</td>
<td>Regimen; BCC target audiences</td>
<td></td>
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<td>(Osei et al., 2014)</td>
<td>Timor-Leste</td>
<td>To explore contextual factors that could influence acceptance, delivery, and use of MNP in Aileu District, Timor-Leste.</td>
<td>Focus group discussions, in-depth interviews, 14-day usability trial during which mothers fed their children MNP daily and were interviewed about their experience</td>
<td>CG perceives positive changes in child associated with MNP use; CG knows MNP purpose; CG perceives child acceptance of food with MNP; CG forgetfulness; Influence of relatives or neighbors; CG knows recommendations regarding use; CG perceives negative side effects; CG IYC feeding practices that favor MNP; CG prepares semi-solid foods with MNP; CG uses strategies to encourage child to eat food with MNP; CG shares food with MNP; CG informed of negative side effects; Child illness or poor appetite; CG perceives organoleptic changes associated with MNP; CG has familiarity with similar products</td>
<td>BCC channels; BCC messages; FW frequency of contacts with CG; FW knowledge and skills; MNP cost; BCC target audiences; MNP packaging</td>
</tr>
<tr>
<td>(Pelto et al., 2015)</td>
<td>Bangladesh</td>
<td>To enhance the understanding of cultural norms and beliefs related to IYC feeding practices and home fortification.</td>
<td>Focused ethnographic study</td>
<td>CG knows MNP purpose; Influence of relatives or neighbors; CG IYC feeding practices that favor MNP: Prepares special IYC foods; CG uses strategies to encourage child to eat food with MNP; CG has familiarity with similar products; CG prior nutrition knowledge; Traditional beliefs; Gendered nature of public space</td>
<td>BCC messages; Regimen; BCC target audiences; Distribution location close to household</td>
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<tr>
<td>(Rah et al., 2011)</td>
<td>Bangladesh</td>
<td>To document the experience and findings of a cross-sectional assessment of the micronutrient powder program implemented as part of the emergency response to Cyclone Sidr.</td>
<td>Cross-sectional assessment at the end of the MNP program was carried out in two distinct areas, one that was provided with MNP and another that received general food rations but not the MNP.</td>
<td>CG perceives negative side effects; CG perceives organoleptic changes associated with MNP;</td>
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<td>36 (Sazawal et al., 2014)</td>
<td>India</td>
<td>To evaluate compliance with two home-based food fortification strategies (fortified complementary food or MNP) for providing iron and zinc among children aged 6-24 months.</td>
<td>Cluster-randomized trial.</td>
<td>CG forgetfulness; CG perceives organoleptic changes associated with MNP</td>
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<tr>
<td>37 (Suchdev et al., 2010)</td>
<td>Kenya</td>
<td>To describe monitoring of wholesale sales, household demand, promotional strategies, and perceived factors influencing Sprinkles sales among vendors.</td>
<td>Baseline and follow-up cross-sectional surveys; office records of Sprinkles sales to vendors; biweekly household monitoring of Sprinkles use; and qualitative data collection, including vendor focus groups and key informant interviews.</td>
<td>Household SES, poor; CG education</td>
<td>Marketing strategies; MNP cost</td>
</tr>
<tr>
<td>38 (Suchdev et al., 2013)</td>
<td>Kenya</td>
<td>To evaluate the sustainability of market-based community distribution of MNP.</td>
<td>Cross-sectional survey.</td>
<td>Child age, older; Child sex, male; Household SES, poor; CG education</td>
<td>Marketing strategies; MNP cost; MNP supply</td>
</tr>
<tr>
<td>39 (Sun et al., 2011)</td>
<td>China</td>
<td>To test the concept of public-private partnership (PPP) to deliver MNP and to evaluate the effectiveness of marketing MNP through PPP.</td>
<td>Baseline and endline surveys.</td>
<td>CG knows MNP purpose; Influence of relatives or neighbors; CG IYC feeding practices that favor MNP: CG prepares semi-solid foods with MNP</td>
<td>BCC channels; Marketing strategies; MNP cost; BCC target audiences</td>
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<tr>
<td>40 (Tripp et al., 2011)</td>
<td>Niger</td>
<td>To assess the acceptability of an MNP and a lipid-based nutrient supplement (Nutributter), and to explore people’s willingness to pay for these products.</td>
<td>Qualitative study.</td>
<td>CG perceives positive changes in child associated with MNP use; CG forgetfulness; Influence of relatives or neighbors; CG perceives negative side effects; CG shares food with MNP; CG informed of negative side effects; CG perceives organoleptic changes associated with MNP; CG has familiarity with similar products; Household food insecurity</td>
<td>BCC channels; BCC messages; Regimen; BCC target audiences; Distribution location close to household; Type of distribution location</td>
</tr>
<tr>
<td>41 (Vanchinkhuu et al., 2013)</td>
<td>Mongolia</td>
<td>To describe experience of implementing MNP Program in Mongolia.</td>
<td>Description of program experience.</td>
<td>CG perceives positive changes in child associated with MNP use</td>
<td>FW frequency of contacts with CG</td>
</tr>
</tbody>
</table>

MNP = micronutrient powder. IYC = infant and young child. CG = caregiver. SES = socioeconomic status. BCC = behavior change communication. FW = frontline worker.


