Maternal & Child Nutrition

DOI: 10.1111/mcn.12245

Original Article

Constraints and opportunities for implementing nutrition-specific, agricultural and market-based approaches to improve nutrient intake adequacy among infants and young children in two regions of rural Kenya

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Abstract

Several types of interventions can be used to improve nutrient intake adequacy in infant and young child (IYC) diets, including fortified foods, home fortification, nutrition education and behaviour change communication (BCC) in addition to agricultural and market-based strategies. However, the appropriate selection of interventions depends on the social, cultural, physical and economic context of the population. Derived from two rural Kenyan populations, this analysis combined information from: (1) a quantitative analysis to derive a set of food-based recommendations (FBRs) to fill nutrient intake gaps in IYC diets and identify 'problem nutrients' for which intake gaps require solutions beyond currently available foods and dietary patterns, and (2) an ethnographic qualitative analysis to identify contextual factors posing opportunities or constraints to implementing the FBRs, including perceptions of cost, convenience, accessibility and appropriateness of the recommended foods for IYC diets and other social or physical factors that determine accessibility of those foods. Opportunities identified included BCC to increase the acceptability and utilisation of green leafy vegetables (GLV) and small fish and agronomic interventions to increase the productivity of GLV and millet. Value chains for millet, beans, GLV, milk and small fish should be studied for opportunities to increase their accessibility in local markets. Processor-level interventions, such as partially cooked fortified dry porridge mixes or unfortified cereal mixes incorporating millet and beans, may increase the accessibility of foods that provide increased amounts of the problem nutrients. Multisectoral actors and community stakeholders should be engaged to assess the feasibility of implementing these locally appropriate strategies.

Keywords: behaviour change communication, food-based recommendations, food value chains, fortification, infant and child nutrition, Kenya.

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Introduction

Adequate nutrition during the first 2 years of life is of critical importance to support the optimal health of individuals and the economic development of populations (Victora *et al.* 2008; Black *et al.* 2013). Several types of nutrition-specific intervention strategies have been used to address the poor nutritional quality of infant and young child (IYC) diets in developing countries (Bhutta *et al.* 2008), while agricultural and food value chain or market-based approaches are currently in development (FAO 2013a). All approaches require an understanding of the current feeding practices, belief systems, social and physical context and specific nutritional inadequacies in target populations (WHO & UNICEF 2003; Paul *et al.* 2011).

Fortification of staple foods and blended products, such as dry porridge mixes targeted for IYC feeding, can contribute to nutrient intake adequacy if the strategy is well designed, implemented and monitored,

and the product is accessible (i.e. available, affordable and acceptable) in the target population (WHO & FAO 2006). With regard to home fortification options, studies suggest that micronutrient powders (MNP) provide a benefit in improving iron deficiency anaemia and retinol deficiency and are increasingly in use at scale (De-Regil *et al.* 2013; Salam *et al.* 2013). While lipid-based nutrient supplements have been shown to promote healthy growth and prevent undernutrition among infants and young children (Adu-Afarwuah *et al.* 2007; Phuka *et al.* 2008; Isanaka *et al.* 2010), this has not always been the case (Maleta *et al.* 2015). Further development and experience with this intervention modality will provide insights about its potential role as a population-based public health intervention (Dewey & Arimond 2012).

Nutrition education and behaviour change communication (BCC) about nutritious foods focus on increasing their use and acceptability. These strategies alone can have some impact on IYC nutritional status (Imdad *et al.* 2011). However, unless access to nutritious food sources is also improved, the impact of education alone may be limited (Imdad *et al.* 2011; Paul *et al.* 2011).

Selected agricultural-based interventions have addressed specific micronutrient deficiencies. These include home-based or community-based gardening for increased pro-vitamin A intakes from fruits or vegetables and livestock production targeted mainly to increased intake of bioavailable iron (Masset *et al.* 2011; Ruel 2001; Leroy & Frongillo 2007). The biofortification of staple food crops with select micronutrients (i.e. iron, zinc and pro-vitamin A) has been under development (Bouis *et al.* 2011) and is beginning to show promise for impact related to the specific nutrients addressed (Low *et al.* 2007; Hotz *et al.* 2012; Cercamondi *et al.* 2013; Kodkany *et al.* 2013).

Strengthening food value chains for nutrition is an approach under development that aims to increase the accessible supply of nutritious foods (Hawkes & Ruel 2012). This might be achieved by strengthening various points in the food value chain, including use of inputs for increased agricultural productivity (e.g. planting material for improved varieties, fertiliser and irrigation), improving access by producers to markets and pricing information, improving transportation and storage methods to expand market access and minimise food and nutrient losses (especially for nutrient-dense fruits, vegetables and animal-source foods) and incorporating qualities in nutritious food products that consumers demand and are willing to pay for and, hence, may increase their use of (Hawkes & Ruel 2012; FAO 2013b).

In view of the complex determinants of nutrition, the development of effective interventions to improve the nutrition of vulnerable people requires a holistic approach to identifying nutritional deficits, their relationship to prevailing social, environmental and cultural factors, and, hence, multiple points of intervention (FAO 2013a). A combination of strategies may ultimately be required to reach the largest number of individuals in a sustainable manner.

The Global Alliance for Improved Nutrition and the U.S. Agency for International Development initiated a collaborative project in Kenya to improve the nutritional adequacy of foods consumed by infants and young children (q.v. Tumilowicz *et al.* 2015). The project began with a study to determine current food and nutrient intakes, estimate nutrient intake gaps and identify a set of food-based recommendations (FBRs)

Key messages

- Quantitative and qualitative data on infant and young child (IYC) feeding practices can be usefully combined to identify locally specific, nutritionally appropriate food-based recommendations and appropriate intervention strategies to support them.
- While behaviour change communication alone may contribute to the increased feeding frequency of recommended foods in the IYC diet, improvements to agricultural production and value chains for those nutritious foods are also required to increase their accessibility in rural communities.
- Multi-sectoral actors and community stakeholders need to be engaged to assess the feasibility of implementing these strategies.

to fill those nutrient gaps among breastfed infants and young children in two distinct agro-ecological zones of rural Kenya (q.v. Ferguson *et al.* 2015). Using a focused ethnographic study (FES), the cultural-ecological determinants of IYC feeding were documented (Pelto & Armar-Klemesu 2013a; Pelto & Armar-Klemesu 2013b). The main objective of this paper is to interpret the combined results of the Optifood analysis and the FES to identify constraints and opportunities to facilitate the implementation and adoption of a set of evidence-based, locally appropriate FBRs in the study areas.

Materials and methods

This paper uses two sources of data to identify potential constraints and opportunities to facilitate adoption of FBRs for improved nutrient intake adequacy among IYC in two counties in Kenya: (1) sets of FBRs (Table 1) and identified 'problem nutrients' derived from linear programming analysis using dietary intake survey data and analysed using Optifood software (q.v. Ferguson *et al.* 2015, pp. 6–20) and (2) ethnographic data from the FES surveys for IYC feeding in the same counties. A conceptual framework was developed to guide the derivation of the recommendations for nutrition-specific and nutrition-sensitive, food-based intervention strategies in these populations (Fig. 1).

The research was carried out in two counties representing different agro-ecological zones in Kenya but both characterised by high rates of child malnutrition and poverty: Kitui County represents a low-rainfall, semi-arid area in eastern Kenya, and Vihiga County represents a high-rainfall area with high population density in western Kenya. The methods and main findings for the dietary assessment survey and derivation of FBRs using Optifood software, and the FES surveys, are described in detail elsewhere (q.v. Ferguson *et al.* 2015, pp. 6–20; q.v. Pelto *et al.*, pp. 21–38) and are briefly summarised here. Demographic characteristics for the participating children, caregiver respondents and their households are summarised in Table 2.

To derive the FBRs, 24-h dietary recall surveys were conducted in samples of breastfed infants and young children 6–23 months of age (q.v. Ferguson *et al.* 2015, pp. 6–20). Data derived from this survey (food items consumed by individual children, imputed minimum

Table 1. Recommended foods and number of servings per week derived from the Optifood linear programming analysis and the median servings per week derived from the 24-h dietary recall survey

	6–11 months			12–23 months	
Recommended food or food subgroup	Recommended servings	Median servings	Recommended food or food subgroup	Recommended servings	Median servings
Kitui					
Milk	≥3 per day	2 per day	Milk	≥3 per day	<1 per day
Fortified cereal	≥1 per day	<1 per day	Fortified cereal	≥1 per day	<1 per day
GLV	1 per day	<1 per day	GLV	1 per day	<1 per day
Millet flour	1 per day	<1 per day	Millet flour	≥1 per day	<1 per day
Either legumes or MFE	1 per day	<1 per day (legumes) <1 per day (MFE)	Legumes MFE	2 per day ≥3 per day	<1 per day <1 per day
Vihiga					
Milk (9–11 months)*	1 per day	1 per day	Milk	≥3 per day	1.5 per day
GLV	1 per day	<1 per day (6–8 months) 1 per day (9–11 months)	GLV	2 per day	1 per day
Legumes/bean flour	1 per day	<1 per day	Legumes/bean flour	1 per day	<1 per day
Small whole fish	≥5 per week	<1 per day	Small whole fish	≥5 per week	<1 per day
Fortified cereal	≥3 per week	<1 per day	Fortified cereal	≥3 per week	<1 per day

GLV, green leafy vegetables; MFE, meat, fish, egg.

*The median frequency of milk intake among breastfed children 6–8 months of age was twice per day; the recommendation for increased frequency of milk applies only to children 9–11 months of age.

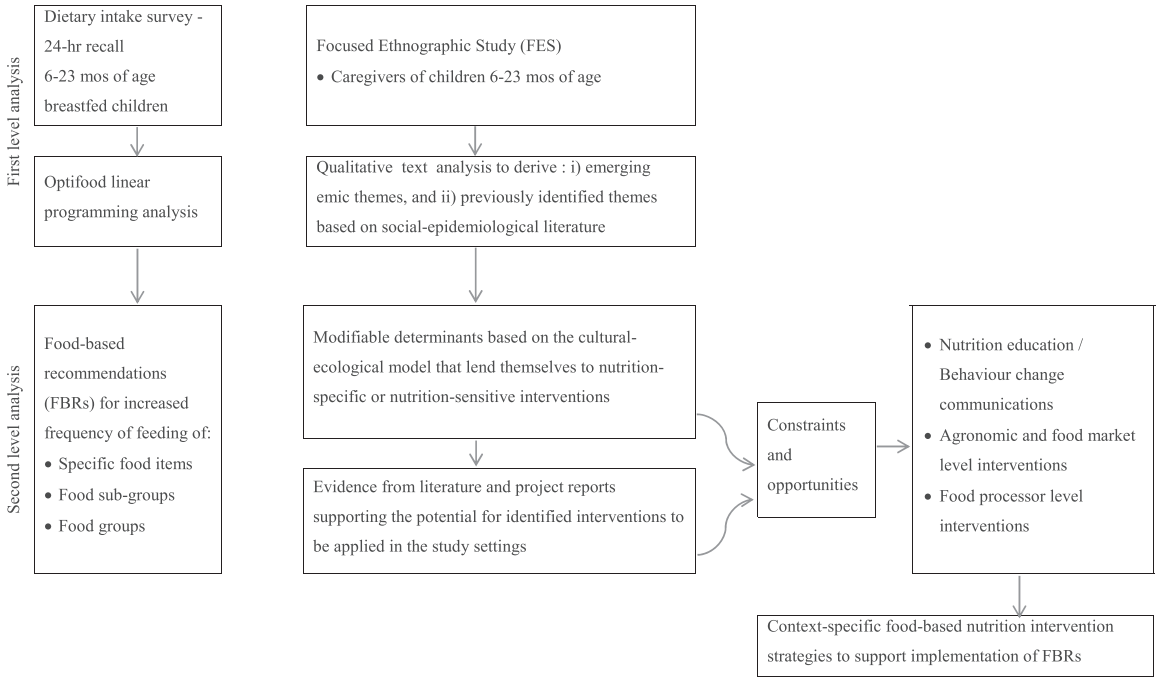

Fig. 1. Conceptual framework for the identification of constraints and opportunities to implement food-based recommendations through nutrition-sensitive and nutrition-specific interventions based on dietary assessment and linear programming analysis and focused ethnographic studies examining infant and young child feeding practices, behaviours and beliefs among caregivers.

and maximum frequency per week and portion size per serving) were used as inputs to the linear programming analysis using Optifood software (Ferguson *et al.* 2006; Daelmans *et al.* 2013). The Optifood analysis determines intake gaps for 11 nutrients and identifies an optimal mix of modifications to current diets to fill those gaps within a set of modelling constraints based on the current dietary patterns [i.e. foods selected only from among those being consumed, within the minimum and maximum (e.g. 10th to 90th percentile) number of servings of those food items per week, the median portion size per serving], and where total energy content of the diet does not exceed the estimated dietary energy requirement. The analysis results in a set of FBRs, expressed as the recommended frequency of consumption of individual food items or food groups/sub-groups on a weekly basis.

The Optifood analysis identified iron and zinc as the most common problem nutrients in both counties, and calcium was also identified as a problem nutrient in Vihiga (q.v. Ferguson *et al.*, pp. 6–20). The analysis showed that if the dietary requirements of these nutrients were to be met for most individuals, either additional novel food sources of these nutrients would need to be introduced or the accessibility and intake of existing food sources would need to increase substantially above current levels to achieve a higher frequency of use. Therefore, in addition to considering the food types included in the FBRs, the introduction of novel food products, particularly fortified foods, as well as home-fortification options, was examined as a potential strategy to address the problem nutrients.

The *Focused Ethnographic Study of Infant and Young Child Feeding 6–23 Months: Behaviors, Beliefs, Contexts and Environments* (Pelto & Armar-Klemesu 2014) is a formative research tool based on a cultural–ecological framework that encompasses the social and cultural elements that affect nutritional status of individuals. This framework provides a means of ensuring that data are collected on all of the domains that have been shown to influence IYC feeding. The five components of this framework include factors that reside in the following: (1) 'social environment' (e.g. welfare

Table 2. Characteristics of participating breastfed children 6–23 months of age, caregivers and households in Kitui and Vihiga districts, Kenya in a dietary assessment survey and FES survey

	Kitui	Vihiga
Dietary survey	*n*, 179	*n*, 156
	%	%
Low income (≤8000 KSh/month)	78.0	77.1
Self-owned land	93.5	96.5
Land size ≤ 1 acre	46.0	86.0
Maternal education		
None	3.5	4.0
Standard	86.0	86.6
Secondary or tertiary	10.5	9.5
Household sources of income[a]		
Casual labour	45.0	48.8
Business	16.5	37.3
Formal employment	10.5	10.0
Agricultural produce	3.5	22.4
Other	4.5	8.0
Weight-for-age *z*-score < −2 (months)		
6–8	12.2	4.4
9–11	18.8	12.1
12–23	8.2	6.4
FES survey	*n*, 32	*n*, 32
	%	%
Age of participating child (months)		
6–8	25	19
9–11	22	19
12–23	53	62
Age of respondent (years)		
<20	3	3
20–29	50	59
30–39	44	28
≥40	3	9

FES, focused ethnographic study.

programmes, work opportunities, markets and informal sector for acquiring food); (2) 'physical environment' (e.g. land, water and fuel resources related to food production and seasonal challenges); (3) 'available technology' (e.g. tools related to the production, preparation and consumption of food including for storage, clean water and sanitation and cooking fuel); (4) 'social organisation', including factors that involve household-level resources and constraints (e.g. economic resources, time allocation, family organisation and child care resources); and (5) 'culture' or the ideational component (e.g. knowledge, values and attitudes related to acquisition, preparation and consumption of food, and to child health and development) (Pelto & Armar-Klemesu 2013a; Pelto & Armar-Klemesu 2013b).

The tool includes sets of modules that are administered through in-depth interviews that employ open-ended and guided questions, followed by extensive probing. A first phase of data collection was carried out among key informants ($n = 8$ per county), results of which were used to adapt the subsequent modules for a second phase of data collection conducted among caregivers of children 6–23 months of age ($n = 32$ per county) (Pelto & Armar-Klemesu 2013a; Pelto & Armar-Klemesu 2013b). The modules were designed to explore issues including foods used for infant and young child feeding, food preparation and feeding practices, sources of income used to acquire food and the sources from which it is acquired, types of problems faced by parents and the food and nutrition problems among their infants and young children, perceptions around health and nutrition, and perceptions about micronutrient supplements and fortified foods for infants and young children.

Following the collection and transcription of data, standard ethnographic qualitative data analysis methods were used, including identification and codification of multiple themes (Strauss 1987; Bernard 2011). Although the resulting themes can be organised in various ways depending on the purpose of the study, in this analytic exercise, we organised the themes according to the cultural–ecological framework. For presentation in the Results section, summaries of findings relevant to the objective of this analysis were condensed into two categories: (1) culture and social organisation and (2) social environment, physical environment, and technology.

With the combined results from the Optifood and FES analyses, potential intervention strategies were identified. Published literature and unpublished project reports were reviewed to identify appropriate intervention strategies and supporting evidence for their applicability in these settings. The proposed potential strategies are summarised and addressed in the Discussion section according to the types of intervention strategies identified (Fig. 1).

Results

General context for barriers to adequate IYC feeding and opportunities for improvement

The two study populations, which were selected based on their vulnerability with regard to food security,

nutrition and health, present inherently challenging situations where there are multiple inter-related barriers that affect the nutritional adequacy of IYC feeding. In Vihiga, despite the availability of some fertile land, land holdings are small, while in Kitui, the difficulties associated with small land holdings are exacerbated by poor soil fertility and unreliable rains, which pose direct challenges to increased local production and diversity. None of the FES-sampled households were able to self-produce the annual household food requirements. The resultant reliance on markets coupled with the high prevalence of poverty due to limited availability of cash and earning opportunities was considered by caregivers as the primary limiting factor to purchasing food, in general, and to acquiring adequately nutritious food for IYC feeding, in particular. This situation highlights the importance of placing a greater focus on improving local access to nutritious foods at a low cost.

Despite these challenges, there are several favourable aspects that present opportunities for interventions for improved quality of IYC diets. Caregivers have very well-developed concepts about IYC feeding, and the links between food, nutrition and health, and have cultural norms and preferences that support good dietary practices. They place great importance on feeding their children well, which indicates that core values for good nutrition are established and suggests that BCC components of interventions to improve nutritional adequacy of IYC diets could focus on more refined aspects of the nutritional value of specific foods rather than having to first build a foundation for the basic concepts of nutrition and health.

The use of multiple channels for sourcing food, be it from self-production, purchase from or trade with other community members or purchase from markets, provides multiple entry points in food value chains at which interventions could be deployed, thus increasing the potential for high coverage. Several IYC foods are accessed through markets year round, and other foods are available at markets for at least part of the year, which provides opportunities to improve local or regional food value chains for whole food products and to introduce additional nutritious, centrally processed fortified foods. The near universal use of commercial vegetable fats or oils, many of which are vitamin A fortified, is a specific example of how fortifiable, centrally processed foods are accessible to poor rural households.

Food-based recommendations: constraints and opportunities

Green leafy vegetables

Culture and social organisation

Several types of green leafy vegetables were consumed by infants and young children in the study areas, including kale, jute mallow, cowpea leaves, pumpkin leaves and spinach. GLV are core foods for IYC feeding (i.e. foods that are considered by most caregivers as important constituents of the IYC diet) (Pelto & Armar-Klemesu 2013a; Pelto & Armar-Klemesu 2013b) and are usually served as an accompaniment to the main maize flour-based staple dish, *ugali*. The median frequency of GLV servings was lower in Kitui than in Vihiga (Table 1), which may be a function of differences between the two counties in both agro-ecology and seasonality. In both cases, the median frequency would have to increase by approximately one serving per day to improve the nutrient adequacy of IYC diets. In both sites, the percentage of children consuming different types of GLV was lower among the younger groups; for example, kale leaves, the most commonly consumed GLV, was consumed by 0%, 9% and 8% (Kitui) and 20%, 30% and 40% (Vihiga) of children 6–8, 9–11 and 12–23 months of age, respectively. It is also noteworthy that in both areas, children sometimes received only the low-nutrient-density broth from GLV dishes but not the leaves themselves, and caregivers may not fully distinguish their relative nutritional value. In terms of caregiver perception, GLV were considered to be suitable for IYC feeding due to their soft texture and favourable in terms of cost, but they were ranked only low in Vihiga and moderate in Kitui for perceived health attributes.

Social and physical environment and technology

In the growing season, GLV are commonly cultivated at the household level, particularly in Vihiga, while in the dry season, production is constrained by lack of irrigation, and GLV must be purchased in the market (q.v. Table 2 in Pelto & Armar-Klemesu, *Identifying interventions to help rural Kenyan mothers cope with food insecurity: results of a focused ethnographic study*,

pp. xxx–yyy). For those with no or little capacity to produce GLV, caregivers may purchase from neighbours who sell at lower prices than in markets. In Kitui, caregivers noted that the price of GLV varies from one market to another.

Small fish

Culture and social organisation

One of the few differences in dietary culture between the study sites concerned the utilisation of fish for IYC and household diets. In Kitui, fish was culturally not considered an IYC core food. However, in Vihiga, fish was considered part of the IYC and household core foods, and, in the dietary survey, its consumption was reported for nearly 10% of children 6–11 months of age and nearly 20% of breastfed children 12–23 months of age. A minority of Vihiga caregivers suggested that small whole fish (and other meats) were less appropriate for IYC feeding as they are not easily chewed, and this may be reflected in part in the lower frequency of fish consumption among children 6–11 months of age. Caregivers ranked small whole fish with *ugali* more favourably than chicken with kale and *ugali* in terms of cost, convenience and ease of acquisition but less favourably in terms of health attributes and child acceptance. The Optifood analysis indicated that small whole fish was an important source of the problem nutrients in Vihiga – calcium, iron and zinc – and would also help achieve adequacy for vitamins B6 and B12.

Social and physical environment and technology

In both locations, small fish were reported to be obtained only from markets. While the geographical source of this fish in Vihiga was not determined, the study area is located near Lake Victoria and in the vicinity of four major rivers. In the drought-prone area of Kitui, fish was not mentioned as part of the IYC core foods. Therefore, information on the impact of the social and physical environment on fish intake did not emerge during the interviews.

Milk

Culture and social organisation

There is a strong cultural support for animal milk as a core food in IYC diets. Milk is given as a beverage on its own or added to porridges or tea; adding it to tea was the predominant use of milk in Kitui. In Vihiga, fresh cow's milk was predominantly used, while in Kitui, either goat or cow milk was used. Milk is viewed very positively, and it was noted as a food that children are likely to enjoy, that helps increase appetite in poor eaters and that was ranked high for health attributes. In Kitui, caregivers ranked porridges with milk higher than plain porridges in terms of health attributes and child acceptance. Among all age groups in Kitui and among children 12–23 months of age in Vihiga, the majority (i.e. 72%–89% across groups) fell short of the target group-specific recommended frequency for milk intake (Table 1), while only 11% and 21% of children 6–8 and 9–11 months of age, respectively, in Vihiga did not meet the recommended frequency. The use of animal milk in IYC diets is not perceived by caregivers as a substitution for breast milk.

Social and physical environment and technology

Animal milk was obtained from household production as well as from the market. In Vihiga, only about half of all households owned cattle, while in Kitui, one-third owned cattle and two-thirds owned goats as potential sources of milk. Availability of milk from household production is seasonally determined, with production declining during the dry season. Among producing households, milk was largely kept for household use; excess production was sold. Among non-producer households and in times of low production, caregivers rely on markets to access milk; it was noted that milk was not always attainable, as low production times also coincide with times of low cash availability.

Beans

Culture and social organisation

Beans are considered a core food for IYC feeding and are typically served with *ugali*. They are also sometimes milled and blended with cereal flours for use in making porridge, a practice that is considered traditional. Beans served with *ugali* were ranked by caregivers as being moderate in terms of health attributes, cost, ease of acquisition and acceptance by children. Some respondents expressed concern that beans were problematic for IYC feeding, and they were considered inconvenient, likely due to the long cooking time and, hence, greater need for cooking fuel. The dietary survey indicated that the

percentage of infants and young children consuming beans was low: <10% among all age groups except for children 12–23 months of age in Kitui. As the majority of children across age groups in Kitui (i.e. 72%–90%) and Vihiga (i.e. 91%–98%) consumed less than seven servings of beans per week, a large gap exists between the current and recommended consumption frequency (Table 1).

Social and physical environment and technology

Beans are produced at the household level, but they are also obtained from markets and thus require cash to access. Although beans may store well, self-production may be limited by small land holdings for production and space for adequate pest-free storage. The ambivalence towards beans was also expressed with respect to ease of acquisition, cost and seasonal availability. Seasonal availability affects the capacity of households to grow or purchase beans: less than one-third of caregivers associated beans with the 'best months' and none associated beans with the 'worst months', with respect to food availability.

Millet (Kitui)

Culture and social organisation

Although maize is the dominant staple for preparing both the stiff porridge *ugali* and the soft porridge *uji*, millet-flour porridges were also considered part of the IYC core foods, and caregivers in Kitui expressed a preference for traditional millet flour for porridges. Millet porridge was ranked moderately when prepared plain and high when milk was added for health attributes; millet-based porridge ranked higher than maize-based porridge for both health and child acceptance, whether these porridges had milk added or not. In practice, however, only 31%–38% of children in Kitui reportedly consumed millet flour on the day of recall, indicating that most children would not be meeting the minimum recommendation for one serving per day (Table 1).

Social and physical environment and technology

In terms of accessibility, millet is not produced at the household level and is thus always purchased in markets. It is also more expensive than maize flour and is perceived by caregivers as being less easily acquired. The ethnographic studies revealed that women in both counties have experienced difficulties in successfully cultivating millet (Pelto & Armar-Klemesu 2013a; Pelto & Armar-Klemesu 2013b).

Processed foods: constraints and opportunities for external solutions

All households access basic commercially processed foods from the market, including sugar, tea, vegetable fats and oils and, in some cases, refined maize flour and cereal-based flour mixes for porridge. Despite the high rates of poverty, this habitual use of commercially processed foods provides an opportunity to employ external means to increase the accessibility of foods rich in the problem nutrients (i.e. iron, zinc and, in Vihiga, calcium). The ongoing fortification of several brands of vegetable fat, oil and margarine with vitamin A already contributes to the adequacy of vitamin A intakes in this population, as determined by our studies (q.v. Ferguson *et al.*, pp. 6–20), and refined maize flour, which some producers are now fortifying, will also contribute additional micronutrients to those who rely on commercial sources.

Fortified complementary foods

Two different types of commercial cereal-based porridge mixes with additional nutrients were reported to be consumed in the 24-h recall survey but only by 5% of breastfed infants and young children in Vihiga and 4% in Kitui. Based on the infrequent use of these products, the FBR was limited to just two servings per week; although these products were more expensive than maize flour on a per weight basis, suggesting two servings per week still made this the lowest cost FBR. However, the nutrient content of these products was still somewhat limited, especially given the small portion sizes reportedly consumed, and they may not have been specifically formulated for IYC feeding.

Rice is considered a favourable food for IYC feeding and forms part of the core IYC diet, with some rice dishes being prepared exclusively for infants and young children. As rice is not produced in the study areas, it is obtained only from markets, often as a foreign imported product. It could be considered a potentially useful vehicle for delivering additional nutrients to infants and young children, in addition to maize-based and millet-based cereal mixes.

Locally produced, nutritious dry porridge mixes

Some caregivers made use of mixed flours for porridges in IYC feeding, either producing their own blends or purchasing mixed flours in the market from local sellers. Increasing the frequency of this practice – incorporating millet flour, bean flour and small whole dried fish, foods that were mentioned as being used in these mixes and that are particularly rich in the identified problem nutrients – could help address several individual recommendations.

Discussion

We have identified a set of potential, context-appropriate opportunities to increase the accessibility and utilisation of foods that will help fill the identified IYC nutrient intake gaps. These opportunities have been categorised into four main strategic approaches: (1) BCC to increase the acceptability and utilisation of these foods; (2) agronomic interventions to increase their productivity; (3) market-level interventions to increase their local trade capacity and accessibility; and (4) processor-level interventions to increase the availability of fortified or unfortified nutritious processed foods.

Behaviour change communication

This strategic approach aims first to increase the utilisation of the selected nutritious foods that are already being accessed and used in IYC feeding. While most caregivers in Vihiga and Kitui already had an impressive knowledge base on the links between food, nutrition and health, BCC would be focused on specific messages to increase the feeding frequency of specific foods. Special efforts are needed to identify and reach caregivers who are less knowledgeable. Also, if novel food products are introduced, BCC would be required to support their trial and acceptance.

With regard to GLV, the results suggest that BCC may be effective in increasing their use by focusing on increasing caregivers' perceptions of the health attributes of GLV, which are currently of low rank, and by encouraging feeding them to infants and young children more frequently, particularly among those 6–11 months of age. Messages should emphasise that the leaves themselves contain the most nutritional value compared with GLV broth alone. One further focus that could be explored for acceptability is the use of GLV to enrich other dishes favoured for IYC feeding, such as rice-based and potato-based meals that currently do not incorporate GLV.

Overall in Vihiga, small fish ranked moderately with regard to perceptions of cost, convenience and health attributes. In terms of health, meals with small fish ranked lower than those with chicken but higher with regard to cost, convenience and ease of acquisition. This suggests that there is room for improving perceptions of small fish as a nutritionally important food for IYC feeding, taking advantage of the positive views on cost, convenience and acquisition. This may be aided by suggesting ways to improve the palatability of small fish, such as by mashing them before feeding or by further encouraging the use of small dried fish flour in porridge mixes, as was reported by some caregivers in Vihiga. Considering the nutrient density and median portion sizes, five weekly servings of small fish had a cost equivalent to that of seven weekly servings of GLV, making it an economical option, at least in relative terms.

In contrast to BCC about GLV and small fish, isolated BCC focused on increased utilisation of milk and millet is unlikely to have a large impact without concurrent efforts to increase their accessibility. This is due to the strong, positive cultural perceptions that already exist around milk, millet and health, and it is unlikely that nutrition knowledge is the main limiting factor for high feeding frequency.

Beans present a somewhat different case; perceptions of beans were moderate with respect to several characteristics, but compared with other ingredients, meals that included beans were ranked low for convenience. Although cost is always a limiting factor for foods that are obtained from markets, it is possible that lack of convenience due to long cooking times is a primary limitation for increased frequency of beans in IYC diets. This challenge may not be overcome unless the broader constraints regarding the availability of caregivers' time and quality

cooking fuel are addressed. Alternatively, the cultural practice of including beans in blended porridge flours and the important nutritional value of beans could be promoted through BCC as a way to minimise the burden of long cooking times for whole beans. Further, developing and marketing pre-processed bean flour blends, such as is done in Uganda by the Makerere University Food Technology and Business Incubation Centre and a local food company, or breeding faster cooking bean varieties (Dry Grain Pulses Collaborative Research Support Program (CRSP) 2012) provides additional options to improve utilisation of beans.

Agronomic and market-level interventions

These strategic approaches aim to improve the accessibility of selected nutritious foods, taking into account that affordability in the market is a primary limiting factor to utilising them more frequently in the IYC diet. Increased access to low-cost inputs and farmer education for improved cultivation or resource management aim to increase productivity, either for household production and consumption or for sale into formal or informal markets, while coordination of farmers groups and improved market linkages for those foods aim to improve market access (Ngigi *et al.* 2001; Dangour *et al.* 2012; Iannotti *et al.* 2013). Both approaches may increase opportunities for local income generation and improved livelihoods, thus providing a direct link between the achievement of inclusive economic growth and improved food and nutrition security (Dangour *et al.* 2012; Fowler & Irwin 2012).

The accessibility of GLV could be increased during the growing season by increasing yields, for instance, by distributing seeds of higher-yielding varieties, such as those recently made available for kale (IPS News 2010). This could be used to advantage among self-producers, or for small-scale producers that can make GLV available at lower cost in local or informal markets, or by regional, medium-scale producers to translate into greater productivity and profit at a lower stable cost to consumers. Off-season production could be increased locally through the use of kitchen gardens and water catchment systems or, for small-scale and medium-scale producers with some access to water, through the use of complementary technologies such as drip irrigation systems that have shown promise for vegetable production in arid and semi-arid areas (Ngigi *et al.* 2001; Ngigi *et al.* 2010). Variability in prices between markets, as noted by caregivers, suggests that the efficiency of the regional value chain for GLV could be further explored for strategies to support an adequate year-round supply at competitive prices.

The local and regional value chain for small fish should be further assessed for possible strengthening. While there have been some value chain analyses that included small dried fish in Kenya (Ardjosoediro & Neven 2008; Otieno 2011; Kamau & Ngigi 2013), these have not focused specifically on providing additional value for rural domestic consumers. In Kitui, where small fish were not considered part of the IYC or adult core foods and where they were very infrequently consumed, perceptions about their use as a nutritious food source may need to be further explored to determine if the reasons for their disuse are cultural or market based. In either case, this may require much more intensive intervention in Kitui than in Vihiga.

To increase the accessibility of milk, particularly in the off-season, targeted dairy value chain development would be needed. While this has already been a focus of research and programmes for improved rural livelihoods with some evidence that it leads to increased household incomes and reduced poverty, not all programmes have been designed to assess the nutritional benefit to children resulting from increased milk production (Iannotti *et al.* 2013). One programme to intensify dairy production among smallholders in coastal Kenya showed evidence of increased milk consumption and improved growth among children in participating households and among customer groups, and that increased incomes were more likely to be directed towards food expenditure and schooling when the project inputs were delivered by female extension workers, as summarised by Iannotti *et al.* (2013). Interventions for intensification of dairy goat production through improved management practices and better breeds have been successful in increasing incomes and children's milk intake in Ethiopia (Ayele & Peacock 2003) and may be particularly well suited for Kitui, where goat's milk is favoured and less costly inputs are required than is the case with cattle (Iannotti *et al.* 2013).

Experience from a value chain strengthening project for beans in neighbouring eastern Uganda suggests that there is an opportunity to improve markets for economic and nutritional gains by intervening at several points along the value chain (Hawkes & Ruel 2012). Intervention opportunities include improving the productivity of beans through breeding and participatory selection of improved varieties, introducing improved drying and storage practices to reduce post-harvest losses and coordinating community-based seed production to make quality seed locally available (Dry Grain Pulses Collaborative Research Support Program (CRSP) 2012).

There is a confluence of factors that justify the consideration of agricultural and market-based interventions to increase the local accessibility of millet in Kitui, in particular, but also in Vihiga. This emanates from the expressed cultural preference for millet over maize for porridges, millet's real and perceived nutritional value, particularly with regard to its higher content of the problem nutrients iron and zinc (ASARECA 2008) and its currently elevated price in comparison with maize. Increasing the productivity of millet by introducing improved, climate-appropriate varieties (i.e. those with disease and environmental stress resistance/tolerance) combined with improved crop management methods (e.g. inter-cropping and disease management) is an identified need (ASARECA 2008). Large-scale efforts to develop the millet value chain inclusive of smallholder farmers are under way in Kenya (ICRISAT 2012), including the evaluation of improved varieties by the Kenya Agricultural Research Institute (Esipisu 2013). This could be of particular utility in semi-arid areas like Kitui, as millet is well suited to these climates (ASARECA 2008). Iron and zinc bio-fortified varieties of millet with improved agronomic traits could also be considered for introduction and local adaptation. These have recently been demonstrated to provide meaningful amounts of additional bioavailable iron and zinc (Cercamondi *et al.* 2013; Kodkany *et al.* 2013), and introduction of such varieties could also help fill nutrient intake gaps for the problem nutrients. Taken together, these results suggest that an initial focus be put on increasing efforts to introduce locally adapted, improved millet varieties, improved cultivation techniques and links to market opportunities.

Agricultural development programmes to strengthen value chains for select foods have been successful in Kenya with respect to increased household incomes and poverty reduction among beneficiaries (Oehmke *et al.* 2010). However, these have more often focused on high-value products, and the direct or indirect impacts on nutritional outcomes have been documented only in one sub-study of the Kenya Dairy Development Program (Iannotti *et al.* 2013). Previous reviews of agricultural nutrition interventions suggested that impacts on child nutrition were more likely if nutrition education components were also included and if women were direct beneficiaries of project inputs and had control of additional resources (Berti *et al.* 2003; Leroy & Frongillo 2007; Masset *et al.* 2011). The analysis of our studies strongly supports the coordination of women-centred food value chain strengthening combined with the specific FBRs for IYC feeding.

Food processor-level interventions

The fourth strategic approach is to increase accessibility of a range of nutritious fortified or unfortified processed foods that are either currently not widely available in rural markets or are accessed only infrequently due to cost. This may be achieved centrally or regionally through marketplace support initiatives, such as those being fostered by public–private partnership programmes, including the recently launched the Global Alliance for Improved Nutrition Marketplace for Nutritious Foods programme and the Partners in Nutrition initiative, both currently operating in Kenya. The existing cultural and behavioural orientation to prepare some dishes especially for IYC feeding (Pelto & Armar-Klemesu 2013a; Pelto & Armar-Klemesu 2013b) combined with strong perceptions of the positive links between food, nutrition and health and the high value placed on health as a factor influencing food selection for IYC feeding suggest an elevated potential receptivity to nutritionally improved products formulated specifically for infants and young children.

Fortified complementary foods

Appropriately formulated porridge mixes designed specifically for children 6–23 months of age could

provide great nutritional benefit if a low cost could be maintained (Lutter 2003). Some public–private collaborations in industry have already been established in Kenya to produce pre-cooked, fortified porridge mixes from locally produced raw materials, but these processors are presently focused on sales to aid agencies for use in targeted programmes and are not yet operating on a large scale in retail markets. Nonetheless, the technology and raw material supply chains are in place, and the potential exists for adaptation and expansion to both urban and rural retail markets. These types of products should be market-tested for acceptability, affordability and safety. Recommendations for increased servings of legumes may also be facilitated if bean flour is included in these pre-cooked products.

The FES results also highlighted that availability of cooking fuel was a major constraint among households in both locations (Pelto & Armar-Klemesu 2013a; Pelto & Armar-Klemesu 2013b). Although instant cereal mixes may thus be attractive, they may not be appropriate in these settings, where water quality is often poor and caregivers may not comply with recommendations to boil water prior to reconstitution of the product to reduce bacterial contamination (Kung'u *et al.* 2009). However, partially cooked, fortified flour mixes could provide additional value to caregivers by reducing usual cooking times and fuel requirements, while still requiring them to be boiled for 5–10 min to ensure palatability and safety, as is done for a format already used in large-scale supplementary feeding programmes (de Pee & Bloem 2009).

Rice that is fortified by adding an extruded rice grain pre-mix has been developed and tested and is being promoted in rice-consuming populations (Muthayya *et al.* 2012). While fortified rice has generally been formulated for mass consumption, a recent study has demonstrated that iron-fortified rice specifically formulated for the once-weekly feeding of children 10–23 months of age was efficacious in reducing the prevalence of anaemia (Nogueira Arcanjo *et al.* 2013). Given the cultural importance of rice in IYC diet, the possibility of improving its relatively low content of the problem nutrients (e.g. iron and zinc) with a fortified rice product designed for IYC feeding could be explored as a new product, if additional cost could be minimised. Considerable market and product development research would be required to fully test the feasibility of this concept and to determine the most appropriate and cost-effective method of fortification (A2Z/AED 2008).

Locally produced, nutritious dry porridge mixes

The existing practice of using locally produced, blended porridge flour mixes containing multiple nutritious ingredients (i.e. millet, legumes and small whole dried fish) could be expanded to increase the availability of these products in the market and supported through BCC. Technical and investment support for the design, production and promotion of nutritionally improved porridge mixes would be required. Similar initiatives have been implemented in Kenya and elsewhere as a way of improving nutritional adequacy among infants and young children and supporting income generation among rural women (Maretzki 2007; Bruyeron *et al.* 2010). Experience has shown that affordable, nutritionally improved products can be locally produced (with or without fortificants) and marketed in impoverished populations, but the level of success and reach of these interventions varies depending on the local context and the strategies used for marketing (e.g. small package sizes to increase affordability) and distribution (Maretzki 2007; Bruyeron *et al.* 2010). Given the nutritional need and potentiating factors in the two rural areas studied here, the most context-appropriate strategies and market feasibility for such products warrant a comprehensive assessment.

Micronutrient powders

As MNP targeted for addition to IYC foods are not part of the food value chain *per se*, the ethnographic studies did not attempt to solicit caregiver perceptions about their prospective use. Nonetheless, the same evidence noted earlier to support the appropriateness of nutritious processed foods in these counties may be extended to MNP, both in terms of their potential benefit – increasing the intake adequacy of problem nutrients, in particular – and the potential receptivity of caregivers to using them. Evidence has shown that a community-based programme to market and distribute MNP in a western Kenya site resulted in an improvement in indicators of anaemia, iron deficiency and vitamin A

deficiency (Suchdev *et al.* 2012), even with an average use of just 0.9 sachets per child (6–35 months of age) per week. Formative research conducted with this programme concluded that acceptability was high and provided key lessons to apply in the extension of this programme in other parts of Kenya (Jefferds *et al.* 2010).

Several other observations are worth noting. While the nutrient intake gaps and resultant FBRs in these two counties are not identical, reflecting differences in agro-ecological conditions, the season at the time the studies were conducted and cultural aspects, such as social organisation and cultural expectations, there are also many similarities. Although context-specific aspects of intervention programmes may still be required for successful delivery, many of the core inputs could be similar, thus creating efficiencies for programme development and delivery. For example, strengthening nutritious food value chains on a regional level may benefit multiple districts and the formulation of food products is likely to be nutritionally appropriate across multiple populations. These studies examined only infants and young children as the focal point for this research and did not examine other vulnerable groups, such as reproductive-age women. Nonetheless, if appropriately supported with BCC, many of the food value chain interventions aimed at improving accessibility of nutritious foods for infants and young children also have equal potential to improve nutritional adequacy for other members of the household.

In conclusion, this combined analysis of the quantitative and qualitative studies has allowed us to define a strategic, evidence-based focus for food value chain interventions to increase the diversity of IYC diets and their nutritional adequacy, taking into account the local cultural and nutritional context. Sustainable improvements to IYC nutritional adequacy may be achievable by addressing both improved accessibility and utilisation of relevant nutritious foods across the food value chain; some of these approaches may also serve the dual purpose of improving both nutrition and rural livelihoods. As a next step, it is recommended that research and development plans be prepared to test BCC messages; to introduce agronomic, horticulture and livestock interventions for improved productivity of GLV, millet and milk; to conduct in-depth market chain analysis studies for GLV, millet, milk and small whole fish; and to undertake a market feasibility analysis for local and centrally produced processed nutritious food products.

Acknowledgements

The authors wish to thank Bonnie McClafferty (GAIN) for conceptualising and managing this research programme and Alison Tumilowicz (GAIN) for valuable comments on the manuscript.

Source of funding

This work was made possible by the generous support of the American people through the support of the Office of Health, Infectious Diseases, and Nutrition, Bureau for Global Health, U.S. Agency for International Development (USAID), under the terms of grant number GHA-G-00-06-00002 to the Global Alliance for Improved Nutrition (GAIN). The contents are the responsibility of GAIN and do not necessarily reflect the views of USAID or the United States Government.

Conflicts of interest

The authors declare that they have no conflicts of interest.

Contributions

CH, GP and EM conceptualised the manuscript. GP and MA-K conceptualised, led data collection and analysed the data. EF and PC analysed the dietary intake data and derived the food-based recommendations, and all authors contributed to the interpretation of results. CH drafted the manuscript, and all authors reviewed, contributed to and approved the manuscript.

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