

# Simulating Potential of Nutrition-Sensitive Investments

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The findings, interpretations, and conclusions expressed in this work do not necessarily reflect the views of SUN Movement or the governments they represent. The SUN does not guarantee the accuracy of the data included in this work.

# Executive Summary

## Purpose

The overall purpose of this study is to help decision-makers in SUN countries prioritizing key nutrition-sensitive investments across different sectors as part of their wider efforts to improve nutritional outcomes.

The study combines an extensive search of the literature with quantitative and qualitative methods to analyze the relationship between actions of different sectors and nutrition-relevant outcomes.

The focus is on modeling relationships between contextual factors, sectoral interventions and outcomes that are associated with child stunting, or chronic undernutrition among children under five years. Contextual factors are characteristics of the surrounding setting that are related to the effectiveness of an association.

By further understanding these relationships, it is hoped that the findings in this study can be used as a foundation to:

- Demonstrate new ways to look at the associations of nutrition sensitive approaches on the well established, core nutrition specific interventions;
- Assess and estimate the impact of different sectoral interventions on nutrition;
- Provide some basis for estimating the cost-effectiveness of nutrition-sensitive investments;
- Advocate for scaling up nutrition and particularly for integrated approaches to financing and planning nutrition strategies.

## Key Findings from the Modeling

### Public health sector

The study used meta regressions to **estimate the interventions' effect** on selected measurement outcomes after controlling for confounding variables (contextual factors)

#### **Exclusive breastfeeding for six months**

- Evidence suggests that breastfeeding has a direct impact on diarrhea incidence and, through that, an indirect link with child stunting prevalence (2013 Lancet, LiST tool).
- Our findings show that **peer counseling** increases the uptake of **exclusive breastfeeding closer to WHO recommendation of six months**. Facility based promotion and combined public health interventions are also found to be positively associated with the uptake of exclusive breastfeeding.
- **Peer counseling** is most effective in countries with high concentration of rural population (30% or higher), low prevalence of female formal labor participation (below 40%), female to male literacy rate lower than 80% and significantly high prevalence of adolescent birth rate (over 60%).

### **Complementary feeding of children between 6-23 months**

- Evidence suggests that promotion of complementary feeding and supplementation of complementary foods among poorest segments of the population (below US\$ 1.2 / day) have a direct impact on child stunting prevalence (2013 Lancet, LiST tool).
- **Minimum Acceptable Diet for a child between 6 and 23 months** is the indicator with the strongest association to child stunting. However, we found that existing trials do measure a wide range of outcome indicators that do not allow for a quantified synthesis yet.
- A significant association was found between the Minimum Acceptable Diet and the level of income (measured as GNI per capita), female to male adult literacy rate and rural setting. Together these **contextual factors** explained 59% of the variation across the analyzed countries.

### **Birth outcomes**

- Evidence suggests that maternal age, parity and spacing are all risk factors for poor birth outcomes including small-for-gestational age (SGA) and pre-term, which are both closely linked to child stunting prevalence (2013 Lancet, LiST tool)
- **Low-birth weight** is the most available proxy indicator for SGA and pre-term births. A significant association was found with female to male secondary enrolment, adolescent birth rate, female labor participation rate and urban setting. Together these **contextual factors** explain 54% of the variation across analyzed countries.
- Existing trials show that the uptake of **contraceptive use** is significantly higher among people (mostly adolescents) exposed to **school promotion, media campaigns and community-based education**. **Female secondary school enrolment** is the contextual factor with the strongest association.

### **Environment and Water sector**

- The impact of sanitation, water and hygiene promotion interventions on **diarrhea incidence of mothers** was measured.
- Diarrhea incidence amongst mothers was used as a **nutrition sensitive proxy** for childcare, child health and potentially, child diarrhea incidence.
- Impact of education, income and access to health services through the proxy indicators of adult literacy, percentage of the rural population and vaccination levels were controlled for in the model.
- It was found that in mothers who were exposed to **hand washing and water treatment interventions**, had a lower risk of incidence of diarrhea.

### **Agriculture sector**

The study looked at the indirect association with child stunting using **nutrition-related intermediary factors** and controlling for the income (using the GNI per capita). The analysis used a **contextual model** to identify associations (rather than causal relationships) between agricultural and nutrition variables using linear regressions. Four promising areas for nutrition sensitive investments include: diversification of agricultural production and supply, access to finance for farmers, agriculture research and development and fertilizer use. These investments mostly

interact with nutrition indicators as packages and are positively affected by economic development (Log GNI per capita) and negatively by exports.

### **Dietary patterns (proxy for maternal nutrition):**

- The analysis identified three **diet indicators** that together with log GNI per capita, explain 84% (= the adjusted R<sup>2</sup>) of the variability in stunting levels across countries:
  - The percentage of **energy from non-staple foods in the national food supply**, this is an indicator for *diet diversification*;
  - The amount of **calories available per capita**, this is an indicator for *food quantity*;
  - The amount of **iron availability from animal-based products**, which is an indicator for *micronutrient availability*.
- Each of the diet indicators was then modeled against agriculture indicators together with a set of contextual factors to explain the variability (the adjusted R<sup>2</sup>).
- Food supply diversity (energy from non-staples, i.e. crops and livestock products different from cereals and tubers) is a nutrition sensitive metric susceptible to economic transitions. In low-income countries, it depends on diversity of domestic production while in transitioning and high-income countries income and trade become significantly more important. Other two positive indicators are access to finance for farmers and improved road infrastructure, On the contrary, agriculture intensification (measured by number of tractors available per unit of agricultural land) is negatively associated with food supply diversity.
- Food supply quantity (calories available per capita) is strongly associated with fertilizer use per land unit and percentage of agriculture land. On the other hand, it is negatively correlated with domestic production diversity.
- For iron availability from animal-based products in supply there is a positive association with agriculture research and development and a negative one with agriculture import tariffs. No relation was found with number of animals available per capita in production.

### **Minimum Acceptable Diet among children 6-23 months (proxy for complementary feeding):**

- This diet indicator is strongly associated with diversity of domestic production (% energy from non-staples) and with iron availability from animal-based products.
- There is a negative association with percentage of agriculture land, which may indicate a trade-off between diversity and quantity in domestic production with implications on the child diet.

### **Formal education sector**

- The level of female education was found to be a significant contextual factor to explain the variation across countries on the minimum acceptable child diet scores and uptake of contraceptive.
- No significant relation was found with exclusive breastfeeding. However, peer counseling was found to be most effective in countries with low female to male adult literacy rate,
- The study did not analyze the sector as a potential delivery channel due to the lack of systematic reviews on interventions and trials.

## Key findings from literature reviews

### **Food safety of complementary foods**

- The review shows that the literature is very limited and the outcomes measured are mostly on the types of bacterial contaminants rather than on food safety implications for child health and nutrition status.
- This is an area expected to receive increased attention but will require a multi-disciplinary approach involving experts on food systems, clean water supply, public health, sociology and nutrition.

### **Mass media campaigns on the uptake of exclusive breastfeeding**

- The evaluation of large-scale mass media campaigns implemented by Alive & Thrive shows promising results.
- In Vietnam, mass media campaigns were very effective in reaching large proportion of mothers and influencing their behaviors. In Bangladesh, mass media campaigns were most effective when accompanied with counseling provided by trained frontline workers.
- It should be noted that Vietnam and Bangladesh are different when comparing contextual factors that significantly increase the effectiveness of peer counseling and facility-based promotion including high concentration of rural population, low prevalence of female formal labor participation, low female to male literacy rate and very high prevalence of adolescent birth rate.

### **Climate Change and nutrition outcomes**

- Climate agro-ecological change, variability and shocks can impact nutrition through several pathways including food security, maternal and childcare and infectious and vector-borne disease pathways.
- The impact of climate variability and change on food quality, including food safety and micro-nutrients contents, is still poorly understood and impact on dietary diversity, child feeding practices, and the interlinks between climate, diseases (particularly water-related diseases) and undernutrition, is largely overlooked with limited models.
- There is a need for new research to better model and understand the importance and potential of climate sensitive and climate change programs for nutritional outcomes.

### **Social protection: conditional cash transfers (CCT)**

- The review shows that the literature is still limited and the variety of outcomes used to measure existing trials does not allow a comparable quantified synthesis.
- The experimental evidence of effectiveness comes mostly from Latin America but there is a growing body of literature under development.
- Several of the CCT studies provide evidence of positive impacts on the uptake of preventive health services and access to formal school. As noted by Lagarde et al (2009) the success of CCT is possibly dependent on the magnitude of barriers to service access.

- It should be noted that, in the agriculture contextual model, access to finance for farmers is positively associated to food supply diversity (energy from non-staple crops), which is a nutrition sensitive metric susceptible to economic transitions.

## Conclusion

This study represents a first step in attempting to fill the gaps of providing evidence based recommendations on decisions that can be made across key sectors to effect the risk factors or to increase the uptake of nutrition-specific interventions that have a direct impact on stunting among children under five years of age. It should be clear that the conclusions should not be seen as standalone answers or direct recommendations for the optimization of investments in nutrition. They should be used as part of a suite of tools and wider resources that policy makers consult with in the decision-making process being cognizant of the trade-offs and the “do no harm approach”.

Evidence published in the literature remains scant and varied for nutrition-sensitive interventions, and more implementation science should be published. Using a quantitative statistical simulation model can only go so far as the current literature and data allows. This has resulted in some interesting insights but not in a complete tool that is sufficiently practical for countries looking to scale up nutrition. Planning and costing tools could provide an entry point for additional learning and decision making in which this quantitative modeling could be used as a first step resource.

## Purpose of the study

The overall purpose of this study is to help decision-makers in SUN countries prioritizing key nutrition-sensitive investments across different sectors as part of their wider efforts to improve nutritional outcomes.

The study combines an extensive search of the literature with quantitative and qualitative methods to analyze the relationship between actions of different sectors and nutrition-relevant outcomes. The focus is on modeling relationships between contextual factors, sectoral interventions and outcomes that are associated with child stunting, or chronic undernutrition among children under five years. Contextual factors are characteristics of the surrounding setting that are related to the effectiveness of an association.

By further understanding these relationships, it is hoped that the findings in this study can be used as a foundation to:

- Demonstrate new ways to look at the associations of nutrition sensitive approaches on the well established, core nutrition specific interventions;
- Assess and estimate the impact of different sectoral interventions on nutrition;
- Provide some basis for estimating the cost-effectiveness of nutrition-sensitive investments;
- Advocate for scaling up nutrition and particularly for integrated approaches to financing and planning nutrition strategies.

The analytical framework draws on the [Lives Saved \(LiST\) tool](#) developed at Johns Hopkins University, the recently released 2013 Lancet series on child and maternal nutrition and the [Action Against Hunger report](#) on maximizing the impact of nutrition-sensitive investments.

The findings are based on a review of available literature and national-level secondary datasets.

We collated and organized data from trials and studies that met the following selection criteria:

- The studies were Randomized controlled trials (RCT) or cluster-randomised controlled trials (C-RCT). Controlled before and after studies or longitudinal studies were included as long as they included baseline, pre-intervention data.
- The studies assessed impact on one of our 5 outcome areas. Studies that looked at the direct impact of intervention on stunting/weight or wasting were only included if they also measured impact on an intermediary factor such as a dietary indicator.
- There was not restriction on the geographic location of the studies but studies used had to identify the location of the trial, as well as the sample size used<sup>1</sup>. This data was required for the contextual factors/externalities component of our model.

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<sup>1</sup> Studies could be from high-, middle- or low-income countries. We originally wanted to focus only on middle- and low-income countries to be of most relevance to SUN however we found that such a criteria would discount too many studies and further reduce our sample sizes.

Simulation modeling is conducted when enough data are available to obtain a quantified synthesis. Meta-analysis is used to evaluate the impact of identified interventions in public health, environment and water sectors. Given the limitations of the literature on nutrition-sensitive agriculture interventions, the contribution of this sector is analyzed and treated separately. National level data are collated and organized to develop a contextual model that allows, through linear regressions, to identify associations rather than causal relationships between agricultural and nutrition variables.

The report also presents key evidence-based findings that are not included in the modeling but are relevant for the current knowledge gap. These include the impact and process evaluation on exclusive breastfeeding uptake of the mass media campaigns, the review of publications on food safety of complementary foods and the review of evaluation studies on the impact of conditional cash transfers on nutrition and health related outcomes.

# Introduction

## ***Multi-causes nature of malnutrition***

Coordinated effort of multiple sectors and disciplines is required to address both the short and long-term determinants and drivers of undernutrition. The original causal framework of undernutrition called for different sectors to work together (UNICEF 1990). The recent global momentum around hunger and undernutrition has highlighted the importance of integrating specific nutrition interventions with broader approaches to address the underlying causes of maternal and child undernutrition – incorporating perspectives from agriculture, public health, water and sanitation, women’s empowerment and education, social protection, and infrastructure (World Bank 2006; World Bank 2012; UN HTF 2004; Andersen 2009; Horton 2008; UNMDG 2005). Such an approach would inherently build on the knowledge and capacities of local communities to transform and improve the quality of their diets and feeding practices with attention to mothers and children.

## ***Nutrition-specific interventions***

Both the 2008 and 2013 Lancet Maternal and Child Nutrition series and the Lives Saved Tool (LiST) tool developed by Johns Hopkins University with other partners have modeled the impacts of key *nutrition-specific* interventions on certain disease risk and nutritional status (Lancet 2008; Lancet 2013; LiST 2013). The LiST tool, using computer analytics, estimates the impact of scaled-up, proven maternal, neonatal and child health interventions on mortality, morbidity, stunting and wasting. The LiST tool acts as a cohort model, where risk factors and interventions impact the probability of an outcome at the cohort ages. The user can then build scenarios of different packages of interventions and of expanded health coverage. For each of these packages, the model produces estimates of both the number of deaths averted and intervention cost with the larger purpose to assist in planning and decision making of prioritized investments.

Nutrition-specific interventions that have been assessed and modeled in the 2013 Lancet series and LiST tool include: micronutrient supplementation (including iron and folic acid, vitamin A and multiple micronutrients), infant and young child feeding (exclusive breastfeeding and complementary feeding), diarrhea prevention, improved water, sanitation and hygiene (WASH), and therapeutic and supplementary feeding. Nutrition-relevant outcomes include birth outcomes, diarrhea incidence, stunting and wasting. Birth risks are defined by maternal age, parity and spacing.

The LiST tool effectively identifies nutrition-specific interventions that have been shown to impact stunting and wasting (as well as other health outcomes) utilizing the extensive evidence base of published trials and available experiments. It also quantifies the estimated reductions that can be expected when these interventions are scaled. The LiST tool can help policy makers to prioritize which interventions are most important to invest in for directly improving nutritional outcomes.

## ***Nutrition-Sensitive Approaches***

Nutrition-sensitive approaches are those that draw upon relevant sectors such as agriculture, public health, social protection, early child development, education, environment and water and women’s affairs to affect underlying causes of undernutrition including poverty, food insecurity,

poor access to adequate care resources, and health, water and sanitation services. These approaches should be designed to address the critical underlying determinants of nutrition, they should be implemented at a large-scale and must be effective at reaching all sections of society who are at risk of or already suffering from undernutrition. They must also be focused on prevention, be complementary to curative approaches needed to address undernutrition and be leveraged to serve as delivery platforms for nutrition-specific interventions (Ruel et al, 2013).

Although it is well understood that drawing on these relevant sectors is critical to addressing the underlying determinants of nutrition, more evidence and understanding of *how* to carry out nutrition-sensitive approaches is still needed.

*Linkages between contextual factors, interventions and nutritional outcomes*

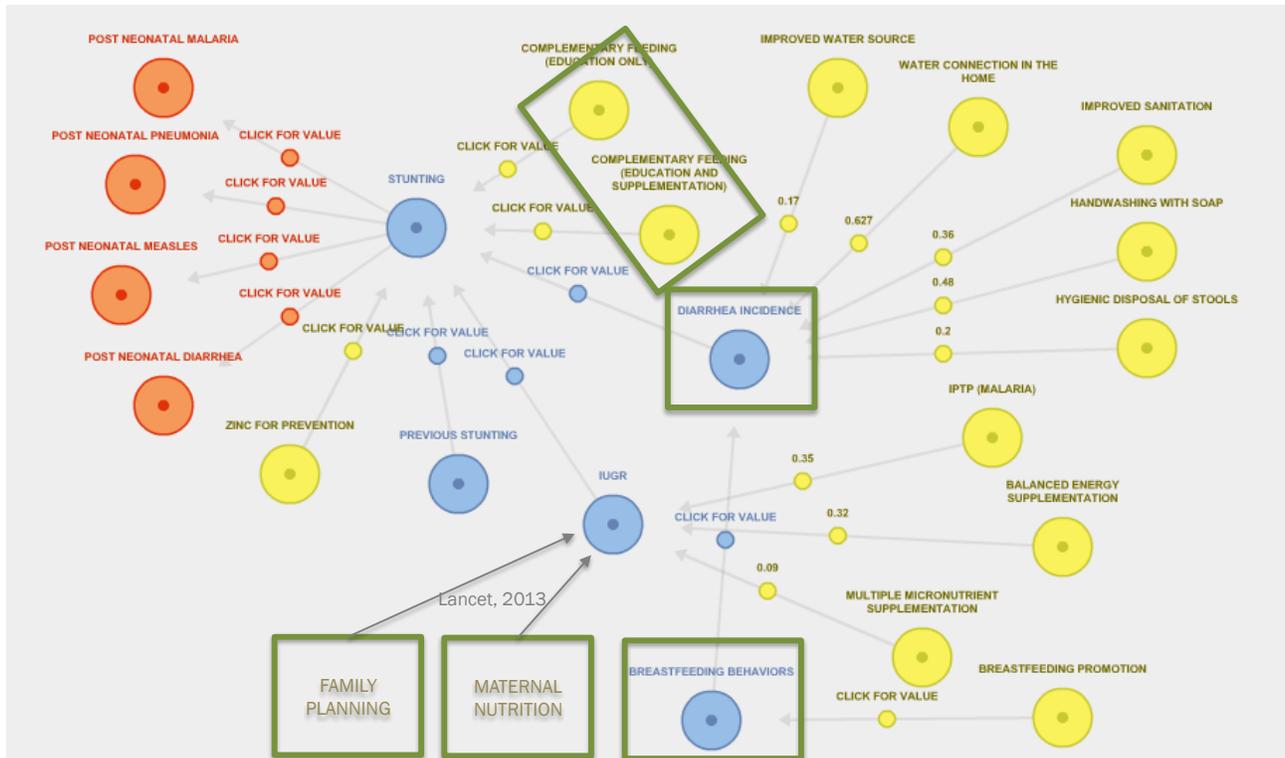
Unlike the LiST tool, we are not looking at the direct impacts of interventions on anthropometric measures, such as stunting or wasting. This study goes one step back from the important work done by LiST and explores interventions that can be made across key sectors to effect or influence the risk factors as well as the respective uptake of the nutrition-specific interventions that have a direct impact on anthropometric measures.

**Identifying and quantifying the options that lie behind the evidence-based nutrition-specific interventions is the crux of our study.** Our approach is grounded in evidence from the scientific literature with an eye to be as practical as possible and to develop an end product that is useful from the standpoint of a policy maker.

# Our Approach and Framework

Our analytical framework draws on the Lives Saved (LiST) tool developed at Johns Hopkins University, the recently released 2013 Lancet series on child and maternal nutrition and the Action Against Hunger report on maximizing the impact of nutrition-sensitive investments.

**Figure 1** below shows key interventions (in yellow circles) and outcomes (in blue and orange circles) considered in LiST. Interventions relevant to nutrition include: multiple-micronutrient supplementation, infant and young child feeding (exclusive breastfeeding and complementary feeding) and WASH activities to prevent diarrhea. The overall key outcome of this study is stunting among children under five years, which in turn is linked to intra-uterine growth retardation (IUGR), previous stunting, diarrhea incidence and breastfeeding behavior.



**Figure 1: LiST modeling of intermediary outcomes and interventions on stunting. The five intermediary outcome areas that served as starting point for our study are indicated.**

The **first aspect** of our approach is to use *nutrition-specific* interventions already modeled by the LiST tool as our “starting point” and to explore and quantify how their uptake and success can be increased by actions across relevant sectors, through *nutrition-sensitive* approaches. Five intermediary outcome areas are identified for the purpose of our study: exclusive breastfeeding; complementary feeding; maternal nutrition; family planning and diarrhea incidence. Family planning uptake, as well as maternal nutrition are included in our analysis since maternal age,

parity and spacing are highlighted in the recent Lancet 2013 series as being risk factors linked directly to IUGR and indirectly to stunting (Black et al 2013).

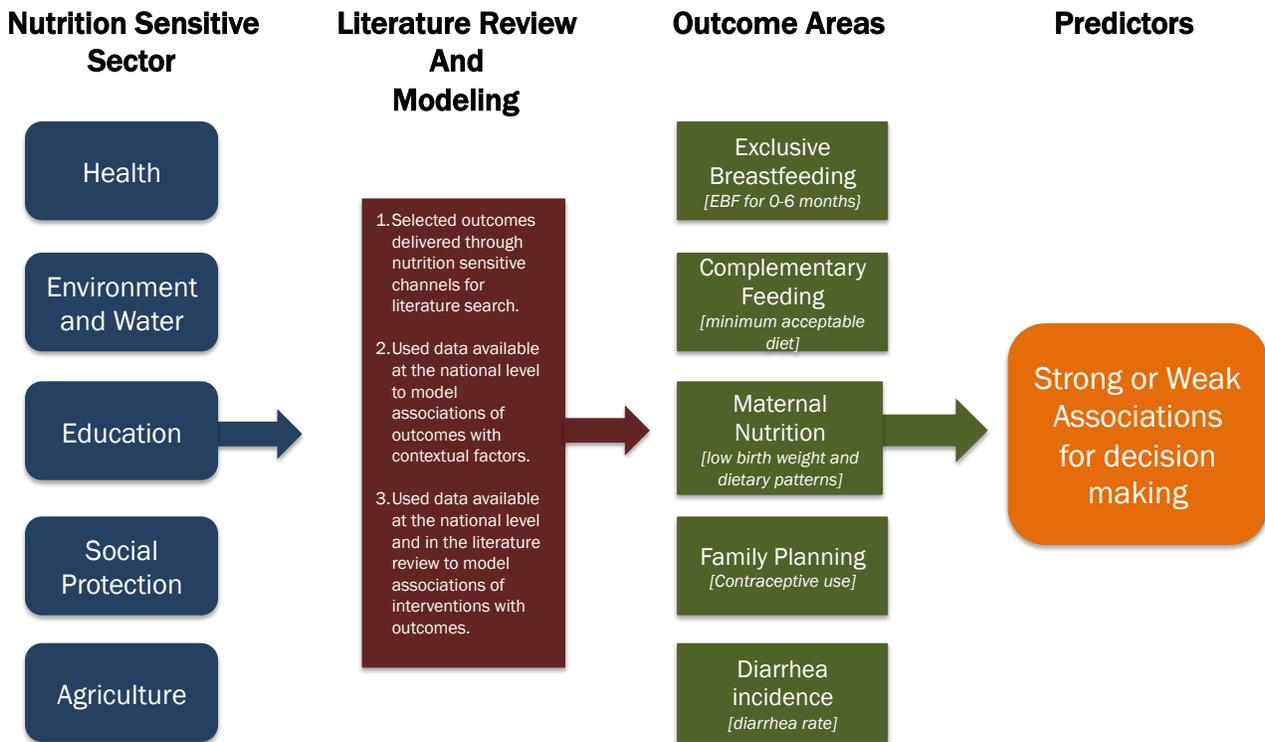
The **second aspect** of our approach is to select the most relevant sectors to model against the five intermediary outcome areas. Five sectors are identified for the purpose of our study: agriculture, public health, environment and water, education, and social protection. These sectors are chosen because of their potential link to improving nutrition (Ruel and Alderman, 2013, Fanzo et al. Technical report 1). Furthermore these sectors broadly reflect the division of the key line ministries that any country level investments would fall under and be channeled through. Interventions promoted in these sectors are included in our study when they affect any of the five identified intermediary outcome areas directly as delivery channels or indirectly by addressing underlying factors. Two different modeling techniques were used to analyze: 1) public health, environment and water and, 2) agriculture sectors. Social protection interventions were analyzed separately in a qualitative review due to the lack of comparable quantitative data from available trials. The formal education sector was not analyzed as a potential delivery channel but the level of education was modeled as a contextual factor.

The **third aspect** of our approach is to identify and describe contextual factors that can influence the impact of selected interventions on the five intermediary outcome areas. There is great diversity within the SUN countries when it comes to, for example, the characteristics of their economies, labor forces and demographics, which all may influence the uptake and impact of the interventions under investigation. As a result we determined that it was critically important to investigate and account for the role that these contextual factors can have on our intermediary outcomes.

The **fourth aspect** of our approach is that it uses a mix of quantitative and qualitative methodologies to examine the influence of contextual factors and interventions on the five identified intermediary outcomes. Quantitative modeling is limited by the lack of data for several reasons. Beyond the health sector, there is a dearth of randomized control trials (RCT) and impact trials. Interventions in agriculture, social protection or education may not have a direct impact on child stunting or other anthropometric measures. Their experimental design is more complex and nuanced as they address nutrition through a long and non-linear path that depends strongly on the local context. In many cases the data simply does not exist yet to quantitatively understand the impact. Furthermore, many of the available trials do not examine the impact on the same or comparable nutrition outcomes. Lastly, since many of the identified nutrition-sensitive interventions fit within a multi-sectoral approach, little has been done to unpack how effective each intervention contributes to a larger multi-sectoral approach, how these different interventions interact with each other and how they should be more systematically measured when considered as a “package.”

**Figure 2** shown below maps out the theoretical framework of our overall approach. Five nutrition-sensitive sectors were chosen to assess their effectiveness on five key intermediary outcomes to associated to stunting, being: exclusive breastfeeding, complementary feeding, maternal nutrition, family planning and diarrhea incidence. The dependent variable identified and measured is shown for each of these five outcomes. By thoroughly searching the published literature and modeling the contextual factors from national level data that may influence the outcomes, a model was used to

demonstrate strong or weak associations of nutrition-sensitive interventions stemming from the five sectors on the nutrition specific outcomes.



**Figure 2: Theoretical Framework of our Approach**

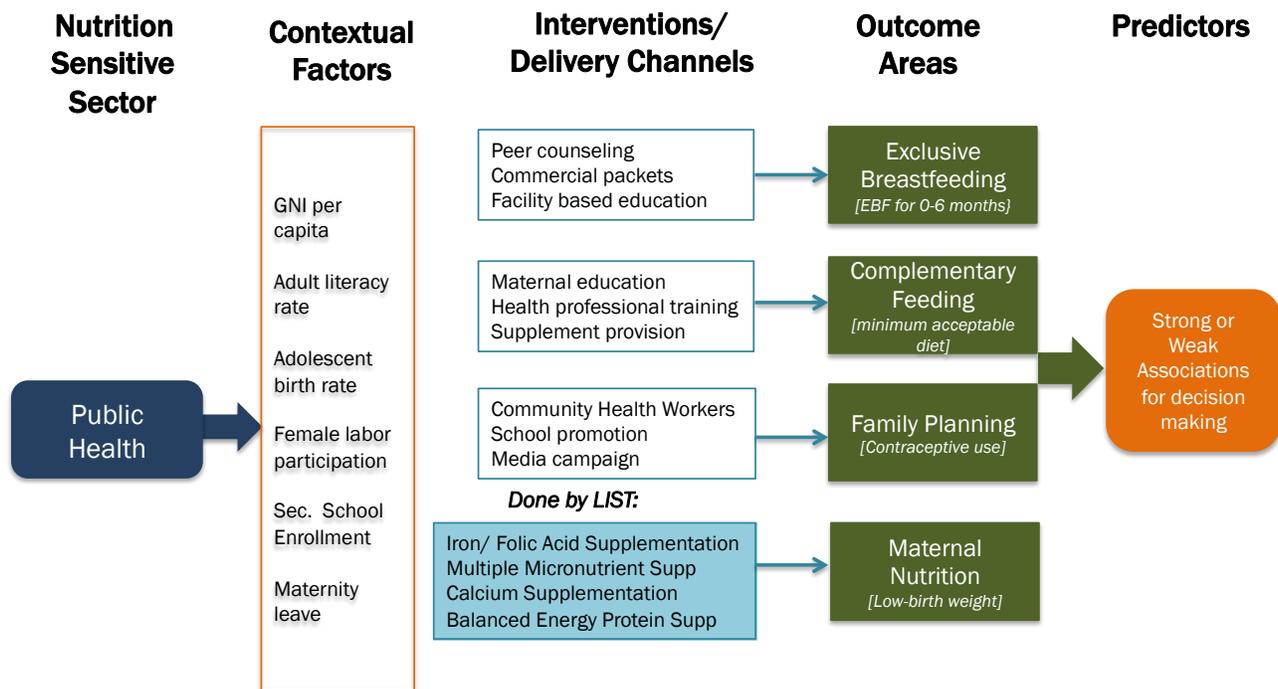
To give an example of how we adapted this theoretical framework to our study, we select complementary feeding as one of the five intermediary outcomes having an impact on stunting (**Figure 1** from the LiST tool). Our research focuses on what kind of contextual factors and interventions in relevant sectors can impact the uptake of complementary feeding using the indicator, minimum acceptable diet (WHO, UNICEF 2011) (**Figure 2**). Keeping our end-user of the policy maker in mind, we are trying to add greater guidance for wider investment decisions. In addition to understanding the impact that complementary feeding prevalence has on stunting, policy makers want to know *how* they can increase correct complementary feeding levels, through various investments for example facility based or community based initiatives or by tackling key contextual factors (e.g. maternal formal education level, access to income, etc.)

### The public health sector model

The 2008 and 2013 Lancet Maternal and Child Nutrition Series identified that the public health sector plays a critical role in the delivery of most of the high-impact nutrition-specific interventions, which rely heavily on functioning health facilities, services and personnel. In countries where government health services provide wide coverage and are easily accessible, health services are a logical and sustainable channel for nutrition interventions (Penny et al, 2005). In contexts where

access to primary health care facilities is difficult, community health workers (or frontline health workers) are also increasingly being used for the delivery of home-based health and nutrition interventions. Health-based investments and services are influenced by contextual factors such as maternal age, parity and spacing.

**Figure 3** shown below outlines the public health sector analysis, which examined some of the core interventions and delivery channels that impact exclusive breastfeeding, complementary feeding, family planning, and maternal nutrition. Contextual factors such as maternity leave, female education rates, vaccination rates and rural population percentages were factored into the model to address any confounding associations and externalities that might also impact the results.



**Figure 3: Contextual factors, interventions and delivery channels in the public health sector model (after selection of variables based on literature review and national level data availability)**

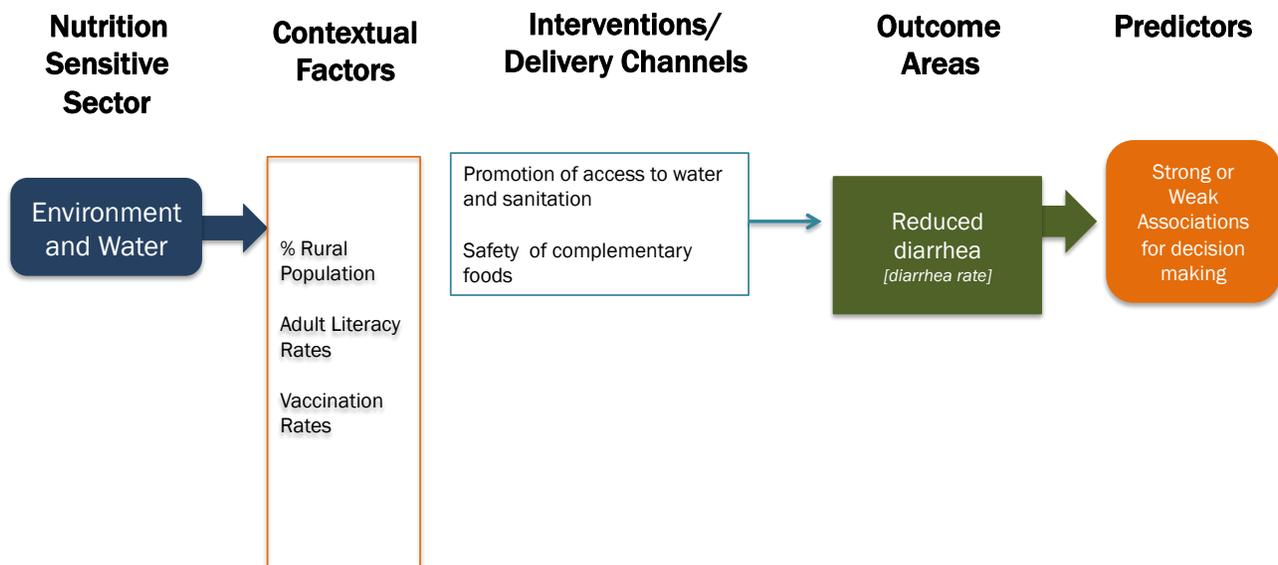
## The environment and water sector model

Fifty percent of malnutrition is associated with repeated diarrhea or intestinal worm infections as a result of unsafe water, inadequate sanitation or insufficient hygiene (WHO 2013). A recent Cochrane meta-analysis examined the impact of WASH interventions (which included solar disinfection of water, provision of soap, and improvement of water quality) on stunting reductions in children under five years of age. Although the studies investigated were of short duration and the methodological quality of many of the trials was low, the review identified that WASH interventions can have an impact (albeit quite small) on stunting. The authors indicated that several trials in low-income countries are ongoing and that more needs to be done to examine intervention adherence,

attrition and costs to assess the impact of WASH investments on stunting and other anthropometric measures (Dangour et al 2013).

In our initial literature review, we identified clean environment and food safety pathways<sup>2</sup> as potential WASH interventions aimed at reducing communicable and parasitic disease progression and development. New research is beginning to show that increasing food consumption among children has not resulted in the expected growth rates indicating an alternative or multiple cause(s) may contribute (Humphrey, 2009). It is hypothesized that parasitic infection of the gut lining may be limiting the intestines ability to efficiently absorb nutrients necessary for adequate growth (Korpe, 2012; Prentice, 2013). This particular ailment known as environmental enteropathy implies that regardless of nutrient and caloric intake, child linear growth will remain blunted unless the underlying parasitic infection were treated (Humphrey 2009).

**Figure 4** shown below provides a schematic of how the analysis was done for the environment and water sector, which exclusively examined diarrhea incidence as the main outcome. Attempts were made to also incorporate interventions that could potentially stem from the environment sector such as improved food safety and the separation of humans from animals in living quarters,, however the literature is scant or disparate in outcome data.



**Figure 4: Contextual factors and interventions in the environment and water model (after selection of variables based on literature review and national level data availability)**

For details on the datasets and methodology of the public health, and environment and water sectors, please see:

**Annex I:** Methodology

**Annex II:** Trials included in the meta-analysis

**Annex III:** Moderator analysis

<sup>2</sup> Detailed in our first technical report to the SUN Secretariat, May 2013

## The agriculture sector model

Investment in agriculture sector is now widely recognized as critically important to improve nutrition (Herforth et al. 2012; Ruel and Alderman, 2013), but compared to other sectors described above, there is probably the least hard quantifiable evidence on *how agriculture impacts nutritional status* (Masset et al. 2011; Ruel and Alderman, 2013). Since 2001, there have been numerous significant reviews that incorporate literature going back to the 1980s, searching empirical evidence of 'what works' to leverage agriculture's potential to maximize impacts on nutritional status (Ruel 2001; Berti et al. 2004; LeRoy and Frongillo 2007; World Bank 2007; Haider and Bhutta 2008; Kawazurka 2010; Masset et al. 2011; Arimond et al. 2011; Girard et al. 2012; Ruel and Alderman 2013; Doward 2013; Webb 2013). All these reviews point out that despite the clear potential for agricultural transformation to effect anthropometric measures, the evidence base for this causal relationship is poor. This is mainly due to the type of research design and the complexity of how agriculture affects nutritional status, which depends very much on the context (Masset 2012, Girard 2012, Hawkes, 2012; Webb, 2013, Ruel and others). As Doward (2013) points out, the most effective pathways and interventions linking agriculture to improved nutrition change with the stage of economic growth and development.

The most consistent results are found in studies that include **dietary patterns as an outcome**, including maternal and children's diets (Masset et al. 2011, Girard et al. 2013). Most of these studies find a positive impact of the interventions on the consumption of specific foods promoted through a specific agricultural project but only few studies evaluated the effect on the overall maternal or children's diets, i.e. in terms of overall diet quality, diversity or nutrient intake. This makes it difficult to link the results of these studies to a potential effect on the nutritional status because it remains unclear how the consumption of specific foods changed the overall quality of maternal and children's diet (Masset et al. 2011).

Further, the agricultural interventions considered in combined agriculture and nutrition reviews are mostly all community-based approaches focused on home production and consumption. The effect of large-scale agricultural investments, e.g. national subsidy programs, agricultural extension programs, irrigation, agricultural trade policies etc. on nutrition-related outcomes is still largely unknown (Domenech et al. 2013; Webb 2013).

To analyze the agriculture sector, we took a different modeling approach from the one used for public health and environment and water sectors. This is due to limitations of the literature on causal impact pathways between agriculture and nutrition outcomes, the systematic reviews available (including the quantification of these relationships) and the importance of context-specificity.

We focused our analysis on two intermediary outcome areas including maternal nutrition and complementary feeding. We hypothesized that agricultural investments affected these outcomes through a variety of pathways (e.g. as a source of food and income while empowering woman).

Agricultural investments were categorized according to basic components of agricultural systems including inputs, infrastructure, institutions, markets and research. We also noted that agricultural

investments mostly engage a combination of delivery channels that can hardly be disentangled: community based approaches, national public programs, private sector and regulation/ legislation.

We further took into account a set of basic contextual factors that may influence the relationship between the agricultural factors and the outcome areas. The overall stage of economic development (described by Gross National Income (GNI) per capita) and the role of agriculture in society (described by the percentage of rural population, the employment rate in agriculture, and the value added to the national income by agriculture), determine how important agriculture is as an economic driver, and how transformations in agriculture will affect nutrition outcomes (Doward, 2013). The overall health and education level of a society influences a population's productivity, adoption of technologies and disease risk, and thereby also affects agriculture's potential impact on nutrition (Hawkes and Ruel, 2006). Since in most developing countries, particularly in Africa and Asia, women represent the largest workforce in agriculture and are responsible for a household's nutrition, gender relationships are also important to consider when studying agriculture-nutrition interactions.

Figure 5 shown below provides a schematic of how the model was constructed for the agriculture sector.

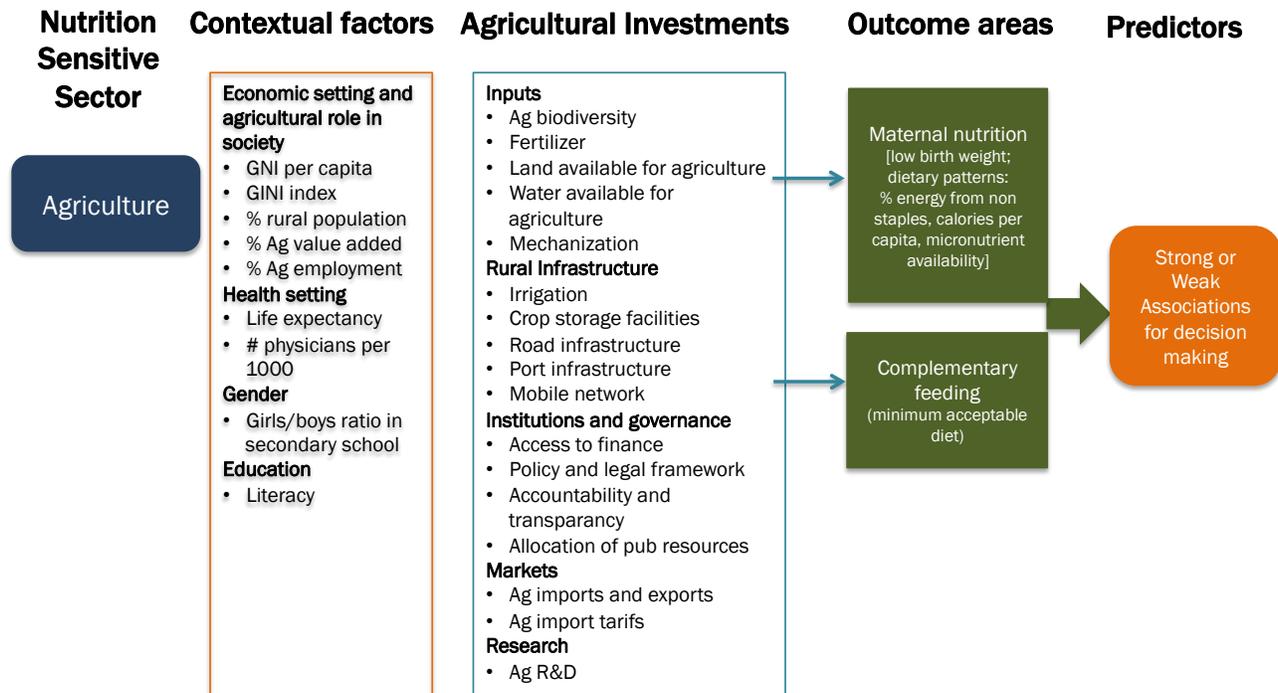


Figure 5: Contextual factors and investment areas in the agriculture model (prior selection of variables based on literature review and national data availability)

For these two intermediary outcomes, we first identified national-level indicators that are most strongly associated with stunting taking into account the context-specificity as determined by the stage of economic development (described by GNI per capita). We then developed a **contextual**

**model** that allows us to identify associations between these indicators and the most significant agricultural variables.

**Figure 6a** shown below identifies the indicators against which the agricultural factors were modeled taking into account the stage of economic development.

For **dietary patterns** (proxy for maternal nutrition), we identified **three indicators** that together with log GNI per capita, explain 84% (= the adjusted  $R^2$ ) of the variability in stunting levels across countries:

- The percentage of energy of the national food supply that is coming from non-staple food items (i.e. this is an indicator for diet diversification);
- The amount of calories available per capita, this is an indicator for food quantity;
- The amount of iron availability from animal-based products, which is an indicator for micronutrient availability.

It is important to note that these three complementary aspects of diets are each significantly related to stunting independent from the income level of a country and independent from each other. This means that for the national food supply, it is important to not only consider the amount of calories available, but also the food diversity and the micronutrient availability.

**The percentage of neonates with low-birth weight** (as another proxy for maternal nutrition) was also found as a significant predictor for stunting, in line with LiST findings (Lancet, 2013). Interestingly, the diet diversification indicator (percentage of energy from non-staples) is also related to low-birth weight prevalence (**Figure 6**) - the more energy from non-staples the lower the prevalence of low-birth weight. This suggests that part of the contribution of diet diversification to lower stunting rates, might be explained through improved birth outcomes.

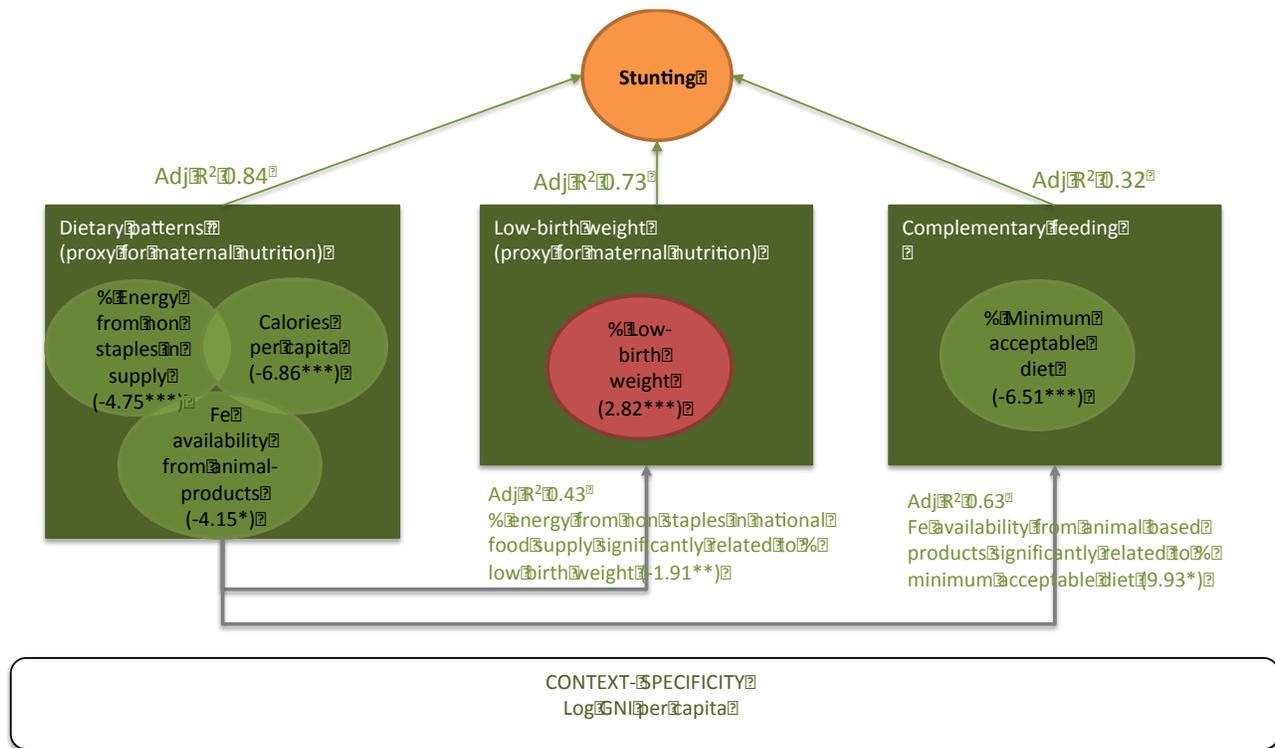
For the outcome, **complementary feeding**, the proportion of children between 6 and 23 months of age who receive a minimum acceptable diet (WHO, 2010), was significantly related to stunting and selected as the complementary feeding indicator for our model. The amount of iron availability from animal-based products is related to the minimum acceptable diet indicator (**Figure 6**). This suggests that part of the contribution of micronutrient availability to lower stunting rates might be explained through better infant and young child feeding practices.

Because agriculture can be a major driver for overall development, we also explored the relationship between agricultural investments and water and sanitation and family planning.

For details on the datasets and methodology of the agriculture sector, please see:

**Annex I:** Methodology

**Annex IV:** Indicator list and datasets



**Figure 6:** Model indicators directly related to stunting. The adjusted R<sup>2</sup> indicates how much of the variation in % stunting could be explained by the set of specific indicators of each module together with log GNI. In parentheses are the regression coefficients for standardized variables as related to % stunting (or % low birth weight or % minimum acceptable diet). The larger the coefficient, the steeper the relationship with % stunting. \* p<0.05; \*\* p<0.01; \*\*\* p<0.001

# Findings

This section outlines the key findings from our analyses stemming from the literature review and modeling. The results are presented in detail by sector and by intervention area. An accompanying, user-friendly, document will be developed on how to interpret these results for more practical planning purposes. Some interventions and approaches are assessed only qualitatively because we were unable to find enough studies or data to quantitatively evaluate their impact.

The complete data sets from the literature review are presented in the systematized and searchable tables in **Annex I**, which accompanies this report. All of the studies or trials that were used in the analyses were coded with a unique ID and were recorded with relevant searchable information, including intervention type, geographic location and population ethnicity. Archiving the studies in this way enables anyone using this analysis to search for the studies according to their specific area or region of interest.

## I. Public health sector

### Ia. Exclusive Breastfeeding

#### Literature Review Results

Given the well-documented importance of exclusive breastfeeding (EBF) for the first 6 months of life, there has been substantive interest in the effectiveness of various breastfeeding promotion and support interventions, most of which are channeled through the public health sector. In one of the most important meta-analysis reviews on the topic, Imdad et al. (2011) explored the impact of breastfeeding promotional strategies on EBF rates at 4 and 6 weeks and at 6 months (with the latter indicator being of most relevance to this study). On the whole they found that breastfeeding promotion interventions (which are disaggregated in the next section) led to an overall 137% increase, with a significant 6 times increase in EBF rates in low- and middle-income countries, compared to 1.3 fold increase in high-income countries (Imdad 2011). This meta-review is the study used by the LiST tool for quantifying the impact of breastfeeding promotion interventions.

In our first technical report, we identified a series of “plausible pathways” where investments in the public health sector could improve exclusive breastfeeding rates. These included, for example; counseling (group, individual and peer based counseling), mass media campaigns, facility based promotion of breastfeeding, the potentially detrimental effect of private sector infant formula promotion, the provision of maternity leave and the regulation for supportive work environments.

In the data collection phase of the research, we honed in on the specific trials that could be used for the quantitative analysis. Approximately 70 studies were retrieved in total, and from those, 46

were identified as meeting our initial selection criteria<sup>3</sup> (see **Annex III** methodology). A number of studies then had to be discounted because they tracked breastfeeding initiation or breastfeeding rates and not exclusive breastfeeding rates for the first six months of life.

The interventions reviewed in the trials and that met our selection criteria were broadly categorized under the following headings:

1. **Peer counseling**, a *community based approach*, which is explored heavily in the literature.
2. **Facility based promotion**, which includes *public health facility based* interventions such as education, counseling and support for mothers, the provision of lactation nurses, facilities meeting the Baby Friendly Hospital Initiative (BFHI) standards, and the provision of education materials.
3. **Private sector promotion of commercial packets**, assessing the impact of the practice of *private sector* formula companies providing “starter packets” of formula to young mothers in health facilities. There are a limited number of studies on this area and they have been exclusively been conducted in high-income countries.

It should be noted that many of the interventions included in our original plausible pathway are not listed above or interventions are grouped together under a broad heading such as “facility based promotion”. That was because we could not find sufficient data in our literature review to assess these areas quantitatively or as separate interventions. Some of these interventions are instead reviewed qualitatively in the following sections.

### **Potential Contextual Factors**

Contextual factors may influence the effect of the intervention on exclusive breastfeeding. We examined the effect of the public health interventions identified above taking into account the following contextual factors: female literacy rates, length of maternity leave, female labor participation, breastfeeding duration, geographic location, and per capita income (expressed as log GNI per capita).

Literature on formal maternal education levels and exclusive breastfeeding practices (EBF) is quite scarce. A study in Ghana found that mothers with less than a secondary education were half as likely to exclusive breastfeeding as compared to those with at least secondary education (Aidam, Perez-Escamilla et al. 2005). Likewise, others studies stressed that in Nigerian semi-urban setting, low maternal educational status was significantly associated with failure to breastfeed exclusively during the first 6 months (Ogunlesi 2010). However, in similar studies in Sri Lanka, Ethiopia, and Iran, maternal educational status did not show any significant association with EBF (Perera, Ranathunga et al. 2012; Setegn, Belachew et al. 2012; Olang, Heidarzadeh et al. 2012). For our analysis we used **female adult literacy rates** as our proxy measure for female education.

Adolescent mothers are at increased risk of early exclusive breastfeeding cessation according to the literature in the field. A Cochrane review notes that in high-income countries, adolescent

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mothers and those in low-income groups or those who ceased full-time education at an early age are least likely to either start breastfeeding or continue for a period of time sufficient to confer health gain (Hamlyn 2002). High-income societies, on the whole, do not provide women with the opportunity to observe other breastfeeding women before they attempt breastfeeding themselves (Enkin 2000). In such societies, women are at risk of lack of support to breastfeed their babies. Paradoxically, in low- and middle-income countries, more affluent groups may have lower breastfeeding rates (Chhabra 1998; Rogers 1997). Cordova do Espirito Santo et al (2007) found that the influence of maternal age on exclusive breastfeeding duration varies depending on culture, access to information, and characteristics of each study population. We ran our analysis with **adolescent mothers birth rate** and with the **percentage rural population** to control for these contextual factors.

Returning to work after maternity leave has been identified as a significant cause for stopping or never starting breastfeeding (Bick, MacArthur et al. 1998; Baker and Milligan 2008; Agunbiade and Ogunleye 2012, Perera, Ranathunga et al. 2012). In most low- and middle-income countries, maternity leave is limited to formal sector employment or is not always provided in practice (Koujianou Goldberg and Pavcnik 2003, Ogbuanu, Glover et al. 2011, Ruhm 2011). In Canada, a reform which extended maternity leave from 6 months to 1 year, showed that breastfeeding increased 10 days with every additional month not at work (elasticity<sup>4</sup> of 0.458) (Baker and Milligan 2008). The proportion of women attaining 6 months of exclusive breastfeeding increased about 8-9 percentage points over a pre-reform mean (Baker and Milligan 2008). To account for the potential effect of maternity leave and female employment in our analysis, we used the indicators of **maternity leave** and **female labor participation rate** and also assessed the interaction between the two. It should be noted that the analysis is inherently limited by the fact that only *formal* employment data is captured.

### **Simulation Model Findings for Contextual Variables**

Here we analyze the relationship between the suite of contextual factors and exclusive breastfeeding using secondary national level data. Our findings show that each \$1,000 increase in GNI per capita (US\$ PPP) is associated with 0.01% increase in EBF 95% confidence interval [0.0001, 1.84]. Each 1% increase in adolescent birth rate is associated with 0.10% decrease in EBF at the 95% confidence interval [-0.21, 0.03]. Maternity leave and female labor participation rate are not significant predictors when taken separately, yet were found to be significant in interaction: the importance of maternity leave as a predictor for EBF increases for countries with higher female to male ratio of labor participation at the 95% confidence interval [-10.79,-1.60]. **These contextual factors explain a total of 31% of the variation of exclusive breastfeeding.**

The detailed Moderator Analyses for these Results are listed comprehensively in **Annex IV**.

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<sup>4</sup> Elasticity is defined as the degree to which a dependent variable (in this case breastfeeding) changes in response to an associated independent variable (in this case months of maternity leave).

## Intervention Models Results

### 1. Peer counseling

Combining an extensive search of the literature and secondary national level databases, we simulate the effect of peer counseling on exclusive breastfeeding while taken into account a suite of contextual factors.

The results from 62 trials show the likelihood of exclusive breastfeeding for mothers that received peer counseling is **2.46 times** higher than for mothers who weren't counseled (95% CI: 1.99 to 3.04,  $p < 0.001$ ). The association is highly significant.

**Figure 7** below shows risk ratios (RR) and the 95% confidence intervals of the individual studies and the overall effect size of the association between peer counseling intervention and the rate of exclusive breastfeeding. Overall, the association between peer counseling and exclusive breastfeeding is positive.

In comparing the observed intervention effect of the studies and the pooled intervention effect estimate (2.46), the results show a high degree of variation between the studies (heterogeneity) that is not due to chance ( $I^2 = 97.7\%$ ;  $Q = 2141.38$ ,  $p < 0.0001$ )<sup>5</sup>. Part of this variation can be accounted for by contextual factors, therefore we added to our model the duration of exclusive breastfeeding and countries' maternity leave policy, female labor participation rate, female to male adult literacy rate, rural population and adolescent birth rate to the overall model. The total amount of heterogeneity accounted for by these 6 factors is 31%, which leaves a significant amount of variation. What this means is that with a meta-analysis, a method used to combine results of different trials to obtain a quantified synthesis, these studies are not always undertaken in the same way using the same experimental design, which leads to increased heterogeneity.

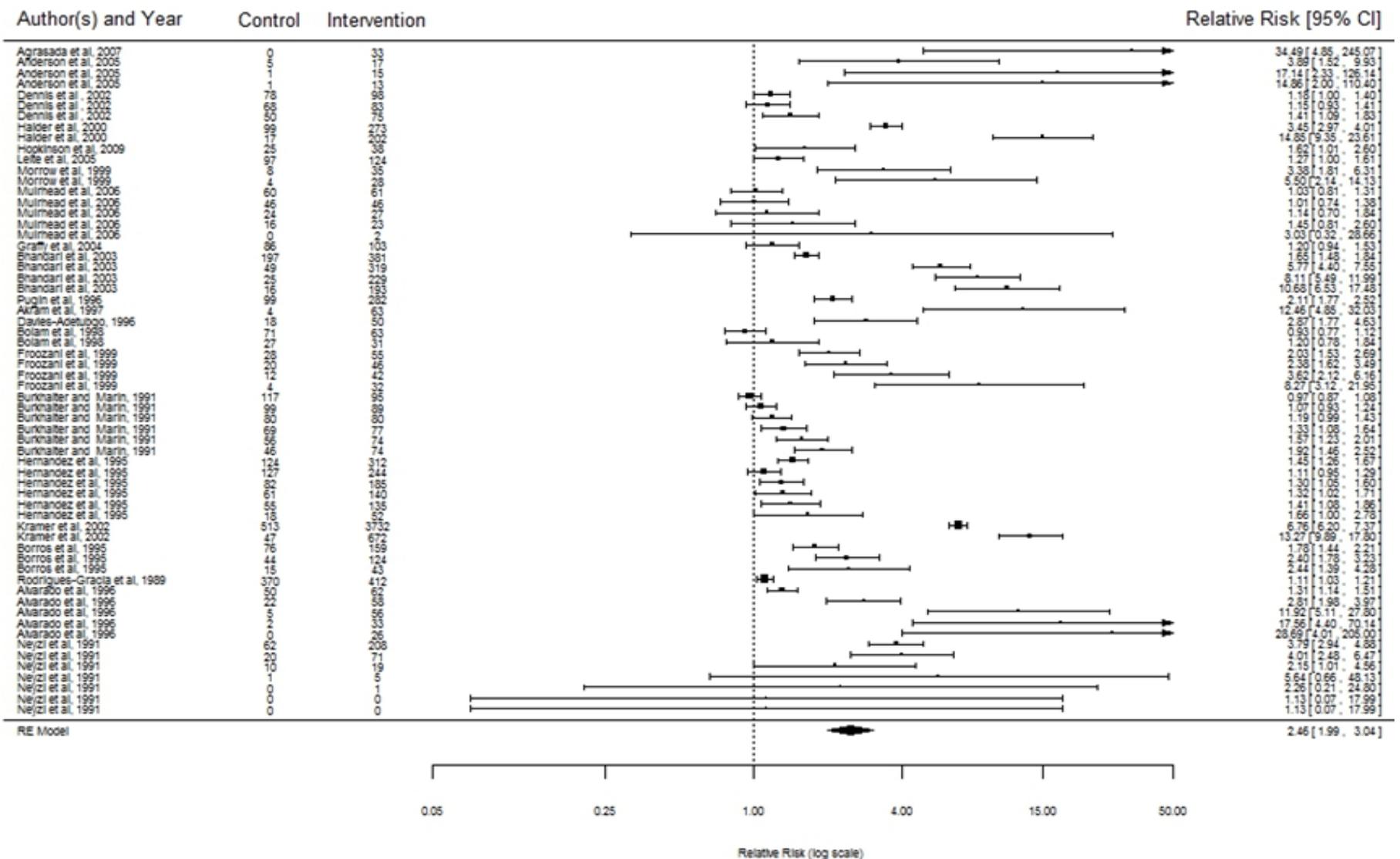


Figure 7: Association between peer counseling and exclusive breastfeeding in 62 trials

**Table 1** below shows the results of the analysis on contextual factors for peer counseling on exclusive breastfeeding. Further on, we separately tested whether the intervention effect is significantly different using categorical contextual factors. The cutoff values used for creating categories were chosen based on the distribution of contextual variables, i.e. observed changing points in the continuous distribution.

**Table 1. Results of meta regression for the effect of peer counseling on exclusive breastfeeding in randomized controlled trials and quasi-experimental studies**

Covariate	No. of observations*	RR (95% CI)	p-value
<b>Duration of breastfeeding (study)</b>			
3 months or less	36	1.84 (1.44 to 2.35)	<0.0001
4 to 6 months	26	3.82 (2.80 to 5.22)	<0.0001
<b>Adult literacy rate, female as % of male (country)</b>			
<80	13	3.09 (1.94 to 4.92)	<0.0001
>=80	36	2.61 (1.96 to 3.48)	<0.0001
<b>Rural population, % (country)</b>			
<=30	41	2.24 (1.72 to 2.92)	<0.0001
>30	21	2.89 (2.04 to 4.10)	<0.0001
<b>Maternity leave, # of weeks (country)</b>			
<=12	19	2.79 (1.93 to 4.02)	<0.0001
13 to 20	34	2.63 (2.00 to 3.47)	<0.0001
>20	9	1.38 (0.80 to 2.38)	0.2462
<b>Female labor participation rate, % (country)</b>			
<40	16	3.99 (2.63 to 6.03)	<0.0001
>=40	46	2.11 (1.69 to 2.64)	<0.0001
<b>Adolescent birth rate, % (country)</b>			
<=60	53	2.61 (2.07 to 3.29)	<0.0001
>60	9	1.81 (1.06 to 3.07)	0.0286

\*Number of observations can differ from the number of studies if the publications report multiple outcomes

The estimated intervention effect was double for mothers that exclusively breastfed for 4 months or more in comparison with the ones that exclusive breastfed for 3 months or less. This indicates that peer counseling increases exclusive breastfeeding duration closer to WHO recommendation of 6 months.

We analyzed which of the following maternity leave durations has a bigger impact on EBF: 12 weeks or less, between 13 and 20 weeks, and more than 20 weeks. We found that the effect for periods less than 20 weeks were similar, highly positive and significant, while the effect for maternity leave lasting more than 20 weeks was not significant. This indicates that peer counseling has a higher effect for countries where the maternity leave duration is less than 20 weeks.

A country's rural population percentage is not a significant predictor for EBF (which includes the intervention effect and the contextual factors). However, when we looked separately at the rural population below 30% versus those above 30% having rural populations, we found .65 higher effect of peer counseling on exclusive breastfeeding for countries with rural populations of 30% or higher. This indicates that peer counseling has a higher effect for countries where the rural population is 30% or higher.

We further found that the impact of peer counseling on exclusive breastfeeding is higher for countries with lower than 80% female to male literacy rate. For the countries with higher female to male literacy rate, the effect of the intervention is slightly lower and significant. This indicates that peer counseling has a higher effect for countries where the female to male literacy rate is lower than 80%.

When we tested the relationship for female labor participation rates, we found an almost double effect of peer counseling on exclusive breastfeeding when the female labor participation rate was below 40%. This indicates that with lower female (formal) labor participation rates, peer counseling as an intervention has a greater impact.

We found that a country's adolescent birth rate is not a significant predictor of EBF, however, when we looked separately for countries with birth rates of 60% or less versus higher, we found that peer counseling had more effect (.80) on exclusive breastfeeding in countries with high adolescent birth rates, i.e. higher than 60%.

## 2. Facility based promotion

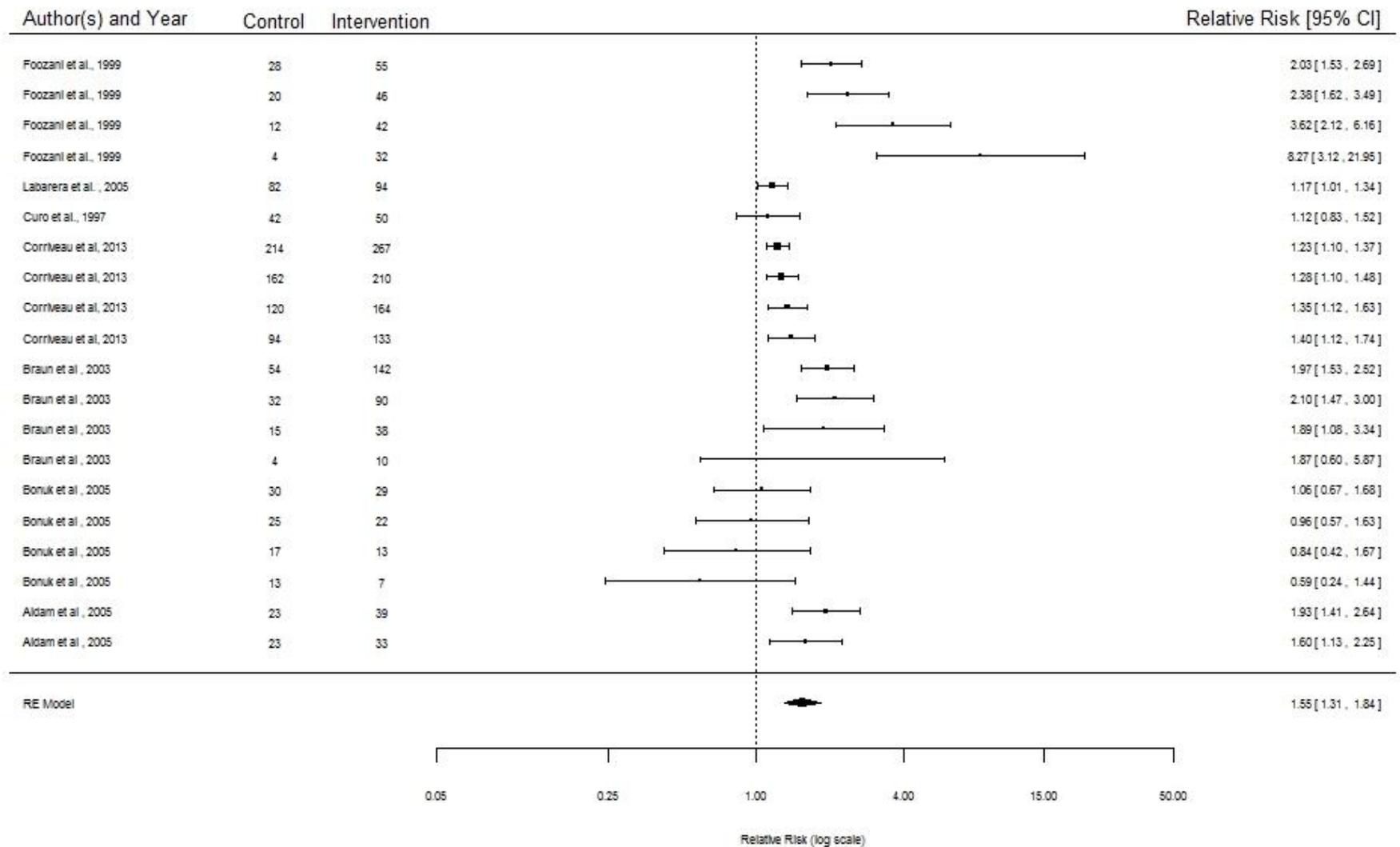
The results from 20 trials show the likelihood of exclusive breastfeeding for mothers that benefitted from facility based promotion is **1.55 times** higher than for mothers who didn't receive such benefits (95% CI: 1.31 to 1.84,  $p < 0.001$ ). The association is highly significant.

Health-facility based promotion includes strategies such as the Baby Friendly Hospital Initiative (BFHI), training on the Integrated Management of Childhood Illness (IMCI) program in facilities, and the provision of education and breastfeeding support at public health clinics and hospitals. We identified 20 trials that met our selection criteria, including 3 trials that measured the impact of BFHI (in Brazil and Belarus), while the other trials focused on the provision of education materials and support from clinic health staff.

We compared the observed facility based promotion effect of the studies and the pooled intervention effect estimate of 1.55, and the results show a high degree of variation between the studies (e.g. heterogeneity) that is not due to chance ( $I^2 = 85.14\%$ ;  $Q = 81.35$ ,  $p < 0.0001$ )<sup>6</sup>.

To account for the contextual factors, we added to our model the duration of exclusive breastfeeding and countries' maternity leave policy, female labor participation rate, female to male adult literacy rate, rural population and adolescent birth rate to the overall model. The total amount of heterogeneity accounted for by these six factors is 31% (as described above).

**Figure 8** shows risk ratios (RR) and the 95% confidence intervals of the individual studies and the overall effect size of the association between facility based promotion interventions and the rate of exclusive breastfeeding. Overall, the association between facility based promotion and exclusive breastfeeding is positive.



**Figure 8: Association between facility based promotion and exclusive breastfeeding in 20 trials.**

**Table 2** below shows the results of the analysis on contextual factors for facility based promotion on exclusive breastfeeding. We separately tested whether the intervention effect is significantly different using categorical contextual factors.

The estimated effect of facility based promotion is positive and significant for mothers who breastfed exclusively for shorter period (3 months or less) or longer duration (4 to 6 months). Facility based promotion has a very slight higher effect on the shorter period.

Facility based promotion has a larger effect on exclusive breastfeeding for countries with maternity leave durations between 13 and 20 weeks compared with a shorter maternity leave duration. The effect for maternity leave lasting more than 20 weeks is insignificant.

Similarly with peer counseling intervention, the effect of facility based is higher for countries with rural percentage of 30 or higher, below 40% female labor participation rate, and 60% or higher adolescent birth rate.

**Table 2: Results of meta-regression for the effect of facility based promotion on exclusive breastfeeding in randomized controlled trials and quasi-experimental studies**

Covariate	No. of observations*	RR (95% CI)	p-value
<b>Duration of breastfeeding (study)</b>			
3 months or less	10	1.60 (1.28 to 2.01)	<0.0001
4 to 6 months	9	1.56 (1.20 to 2.04)	0.0010
<b>Adult literacy rate, female as % of male (country)</b>			
<80	4	1.98 (1.33 to 2.95)	0.0008
>=80	7	2.09 (1.58 to 2.77)	<0.0001
<b>Rural population, % (country)</b>			
<=30	13	1.33 (1.11 to 1.59)	0.0016
>30	7	2.05 (1.60 to 2.63)	<0.0001
<b>Maternity leave, # of weeks (country)</b>			
<=12	10	1.27 (1.05 to 1.54)	0.0136
13 to 20	9	2.07 (1.66 to 2.58)	<0.0001
>20	1	1.12 (0.63 to 2.00)	0.6974
<b>Female labor participation rate (%) (country)</b>			
<40	5	2.24 (1.63 to 3.08)	<0.0001
>=40	15	1.39 (1.16 to 1.65)	0.0002
<b>Adolescent birth rate (%)</b>			
<=60	14	1.43 (1.19 to 1.71)	<0.0001
>60	6	1.89 (1.42 to 2.51)	<0.0001

### 3. Combined Public Health Interventions

The results from 88 trials show the likelihood of exclusive breastfeeding for mothers that received public health interventions such as peer counseling and facility-based promotion as described above is **2.02 higher** than mothers included in control group (95% CI: 1.74 to 2.34,  $p < 0.001$ ). The association is highly significant.

We find that the percent of variation between the studies is very high ( $I^2 = 96.98\%$ ;  $Q = 2489.08$ ,  $p < 0.0001$ )<sup>7</sup>, similar to what we found for peer counseling interventions (which account for the majority of studies included in meta-analysis).

To account for the contextual factors, we added to our model the duration of exclusive breastfeeding and countries' maternity leave policy, female labor participation rate, female to male adult literacy rate, rural population and adolescent birth rate to the overall model. The total amount of heterogeneity accounted for by these six factors explains 31% of the heterogeneity.

**Figure 9** shows risk ratios (RR) and the 95% confidence intervals of the individual studies and the overall effect size of the association between combined public health interventions and the rate of exclusive breastfeeding. Overall, the association is positive.

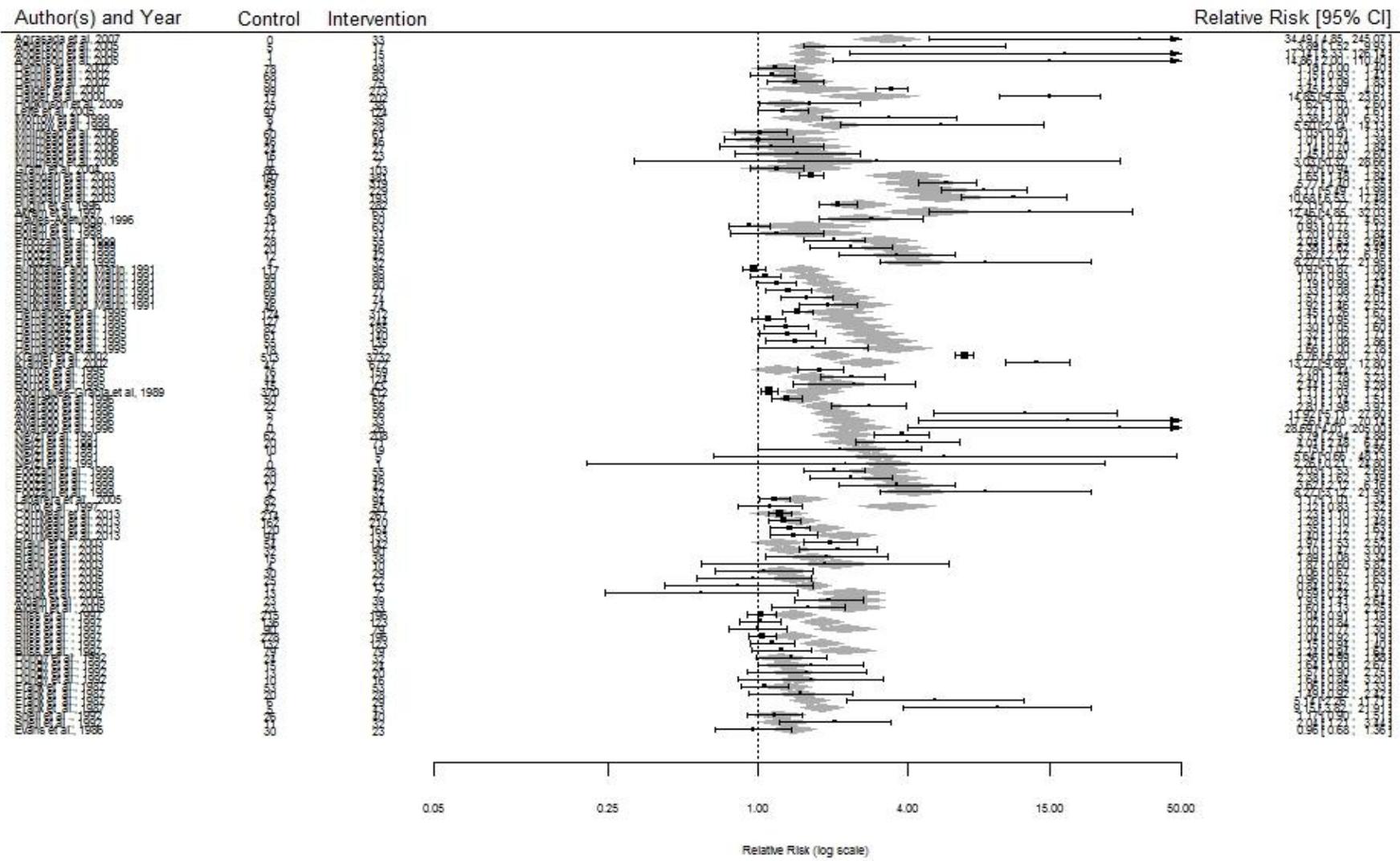


Figure 9: Association between public health interventions and exclusive breastfeeding in 88 trials

#### 4. Commercial Packets

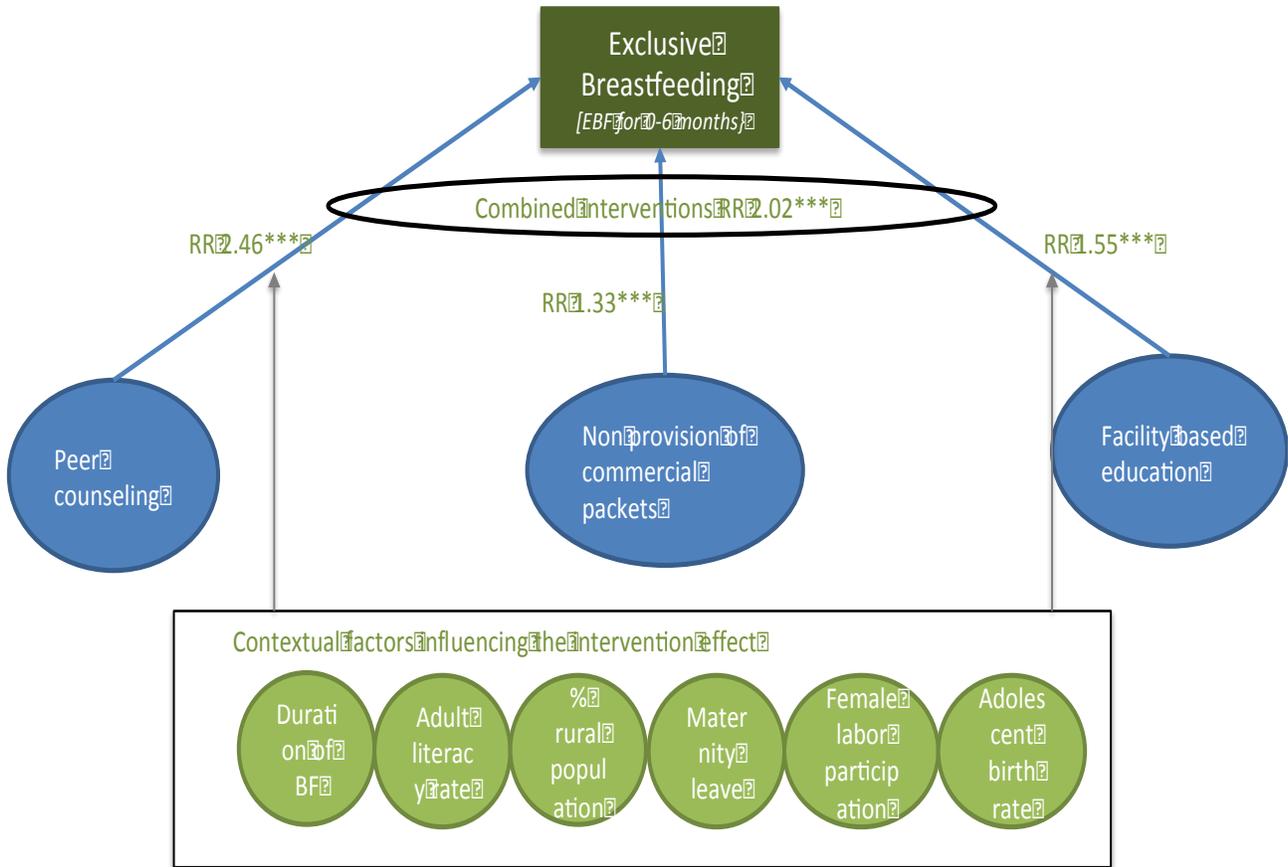
The results from 12 trials in the USA show the likelihood of exclusive breastfeeding for mothers that were not given commercial packets is 1.34 higher than for mothers who received the packets (95% CI: 1.12 to 1.59,  $p=0.0011$ ). The association is significant.

The extant literature on hospital discharge packages containing infant formula provides little guidance concerning the effect of these items on the duration of breastfeeding (Dungey et al, 1997). Some studies have reported that the distribution of free infant formula samples in hospital discharge packages contributes to the decline in the duration of breastfeeding, however, other studies have failed to demonstrate a negative effect of infant formula discharge packages on the duration of breastfeeding. In one of the most recent studies, Rosenberg et al (2008) noted that commercial hospital discharge packs are one of several factors that influence breastfeeding duration and exclusivity. They also commented that distribution of these packs to new mothers at hospitals is part of a longstanding marketing campaign by infant formula manufacturers and implies hospital and staff endorsement of infant formula (which is contrary to WHO recommendations).

Data sources that met our selection criteria were scant in the literature and the trials that found were all exclusively conducted in the same country (USA), which highly limits the broader applicability of any findings.

The degree of variation between the studies that is not due to chance is considerable ( $I^2 = 84.16\%$ ;  $Q = 53.88$ ,  $p<0.0001$ )<sup>8</sup>. The country level contextual factors cannot be included because all the studies included have been implemented in the same country. Our regression results show that the duration of exclusive breastfeeding does not influence the average effectiveness of the intervention, therefore we cannot account for heterogeneity using the contextual factors.

The results of the peer counseling, facility-based education and provision of commercial packets is summarized in **Figure 10**.



**Figure 10: Synthesis figure of the impact of public health interventions on exclusive breastfeeding rates.**

For interpretation: Relative Risk (RR) = 1 indicates that the outcome in intervention and control groups are equally likely to occur; RR<1 outcome in intervention is less likely to occur compared with control; RR>1 outcome in intervention is more likely to occur compared with RR>control. The RR <1 are usually interpreted in the following way (exp for RR=0.6). (1-0.6)\*100=40%, the outcome in intervention is 40% less likely to occur. If RR is 1.5, the outcome is 1.5 times more likely to occur in the intervention compared with control (or 50% increased risk). \*  $p<0.05$ ; \*\*  $p<0.01$ ; \*\*\*  $p<0.001$

## 5. Mass Media Campaigns – Analysis from the Literature

Mass media campaigns are widely used to expose high proportions of large populations to messages through routine uses of existing media, such as television, radio, and newspapers (Wakefield et al, 2013). They are often popular investment choices by governments and multilateral agencies to promote behavior change, whether it be encouraging a particular behavior such as exclusive breastfeeding, or discouraging an activity such as smoking. There are a wide range of EBF mass media campaigns that have been launched across the world by organizations like UNICEF, Ministries of Health and civil society. Examples include New York City's "Latch on NYC" campaign or the Philippines, "Breastfeeding TSEK!" program.

Evidence of the impact of these large-scale programs is harder to come by. Wakefield et al 2013 conducted a meta-review on the impact of mass media campaigns on health changing behavior, across the areas use of tobacco, alcohol, and other drugs, heart disease risk factors, sex-related behaviors, road safety and concluded that mass media campaigns can produce positive changes or prevent negative changes in health-related behaviors across large populations.

Although many mass media programmes to promote breastfeeding have been mounted, reviews from the 1990s onwards seem scarce or non-existent. As noted by Wakefield et al, two studies—one from Jordan in the late 1980s and one from Armenia - show positive effects.

Given the aforementioned data scarcity, we were not able to generate the quantitative analysis with our models for this area. However some very interesting relevant data and findings were obtained from Alive and Thrive who are conducting impact and process evaluations of their Bill & Melinda Gates Foundation-supported initiatives to improve infant and young child feeding and ultimately, child nutritional status in Bangladesh and Vietnam. In both countries media campaigns are a key component to their comprehensive behavior change strategies for improving infant and young child feeding. The evaluation results on both projects are awaiting publication (by IFPRI) but initial findings suggest that in Bangladesh (n=2188), EBF rates increased from 50% at baseline to 61% following exposure to the media campaign. Interestingly, when the media campaign was combined with EBF promotion by frontline workers, the EBF rates increased to 83%. In Vietnam the same indicators went from 18% at baseline to 40% after media exposure and to 62% with frontline support and media.

Further obtained by Alive and Thrive, were extracts from a paper being written on a separate Vietnam evaluation study that is being undertaken with several academic institutions. This is the first major evaluation of a national mass media breastfeeding campaign in about 20 years. Preliminary findings indicate:

- The mass media campaign has reached a large proportion of Vietnamese mothers. About 18 months after the launch of the campaign, 85% of mothers interviewed (in areas with and without trained frontline workers) reported exposure to a breastfeeding message through at least one of the following media: TV spots, Internet, village loudspeaker script, print media,

or out-of-home advertisement (e.g., billboards). The mass media campaign has reached an estimated 2.3 million Vietnamese mothers with children under two years.

- Exposure to the mass media campaign is associated with increased exclusive breastfeeding. Women who report exposure to the mass media campaign are more likely than their unexposed counterparts to breastfeed exclusively (48% exposed vs. 30% unexposed); both groups reported higher rates of exclusive breastfeeding than mothers who were interviewed in the same four provinces before the launch of the campaign (26%).
- Behavior change happens fast. Despite seemingly entrenched beliefs that were identified as impeding exclusive breastfeeding, significant shifts in behavior – and in those deeply held beliefs – have been detected as early as 9 months into the campaign.

Whilst too limited to draw major conclusions from, these studies do however provide some insight into the impact and the potential of mass media campaigns for promoting breastfeeding behavior.

## Ib. Complementary Feeding

### Literature Review Results

A wide variety of interventions exist that are designed to improve not only the quality and quantity of foods but also to improve child feeding behaviors in the transition from exclusive breastfeeding to family foods (Imdad et al, 2011). Health facilities, clinics, health outposts and community health workers can all serve as the delivery channels for complementary feeding interventions. These commonly involve educating and counseling caregivers on improved feeding practices but, in some cases, can also include the direct provision of foods and nutrition supplements. A key focus area for a lot of the trials in the literature is on community or facility based education of mothers on diets, and on improved feeding and care practices.

Dewey et al (2008) conducted one of the most comprehensive systematic reviews on the efficacy and effectiveness of complementary feeding interventions in low- and middle-income countries. The key findings included the fact that educational interventions that stress feeding nutrient-rich animal foods may be more effective in terms of child growth compared with general educational messages. In areas with higher levels of food insecurity, complementary feeding interventions that provide food in addition to education seem to be more effective for improving child growth outcomes. Furthermore the scaling up of nutrition training for health workers is seen as a potential entry point to improve complementary feeding (Sunguya 2013).

In our data collation we identified 13 trials that met our basic selection criteria (see Methodology in **Annex III**). The interventions broadly fell under the following categories:

- **Maternal counseling and education** (community based intervention via community health workers and/or facility based via health staff).
- **Health professional training** (interventions targeting the training of health professionals in nutrition counseling, in enhancing their communication skills and performance on improving feeding practices, and reducing growth faltering in children aged 6-24 months as well, as well as training on how to counsel locally developed feeding recommendations).
- **Supplement provisions** (direct provision of micronutrient-fortified food supplements which can also be supported by nutritional counseling).

As mentioned previously, a key challenge observed when collating the data was the diversity of indicators and outcome measures that were used to track the impact of the interventions. Whilst the evidence base on complementary feeding interventions is quite thin (Dewey et al 2008), the data is further reduced and limited when cross-comparisons between studies are not possible due to the differences in the categorization of outcome variables (Sunguya et 2012).

### Potential Contextual Factors

The association of correct initiation of complementary feeding with socio-economic status and maternal formal education levels (i.e. levels of primary and secondary schooling) has been found to be statistically significant in a number of studies (Rao 2011; Fawzi 1997, Semba et al 2007,

Chou et al 2011). Parental schooling has been consistently associated with child nutritional status, with maternal education often, having a larger explanatory power than paternal education (Ruel et al 2013). Schooling directly increases individual earnings and national income and, through these pathways, can affect nutritional outcomes in the long term.

For our analysis to control for the impact of formal education and income we chose the proxy variables of female literacy rates and GNI per capita.

**Simulation Models Findings for Contextual Factors**

**Minimum acceptable child diet** was chosen as the key outcome indicator for complementary feeding of children between 6-23 months because of the strongest statistical association with stunting. Apart from breast-milk, an acceptable diet is achieved when there is the minimum dietary diversity and meal frequency (as well as minimum milk feeds for non-breastfed children).

<b>For breastfed children:</b>	<b>For non-breastfed children:</b>
<ul style="list-style-type: none"> <li>• Feeding infants 6-8 months <math>\geq</math>two times and young children 9-23 months <math>\geq</math>three times with solid, semi-solid or soft foods</li> <li>• Feeding with foods from four or more out of 7 food groups</li> </ul>	<ul style="list-style-type: none"> <li>• <math>\geq</math> 2 milk feeds (infant formula, yoghurt or milk – fresh, tinned, canned, etc.)</li> <li>• Feeding <math>\geq</math>four times with solid, semi-solid or soft foods or milk feeds)</li> <li>• Feeding with foods from four or more out of 6 food groups</li> </ul>

Each \$0.01 increase in GNI per capita (US\$ PPP) is associated with 8.6% increase in the percentage of children ages 6 to 24 months receiving a minimum acceptable diet (95% CI: 0.022 to 0.3295). Also, each 1% increase in female to male adult literacy rate is associated with 0.24% increase in the percentage of children ages 6 to 24 months receiving a minimum acceptable diet (95% CI: 0.004 to 0.48). Our findings show that **income and education explain 59% of the variation in the minimum acceptable diet scores.**

We were not able to generate intervention model findings here. However the contextual findings are of interest, particularly when viewed with the findings of the agriculture model, which assesses impact of agriculture factors on the minimum acceptable child diet.

**Ic. Maternal nutrition**

**Literature Review Results**

Maternal malnutrition is a key contributor to poor fetal growth, low birth weight (LBW) as well as short-and long-term infant morbidity and mortality (Imdad and Bhutta 2012). Bhutta et al 2013, conducted a comprehensive review of interventions to address undernutrition and micronutrient deficiencies in women and children and assessed emerging new evidence for delivery platforms.

They found that interventions targeted to women exist to address intra-uterine growth restriction and prevent small-for-gestational age (SGA) and pre-term births in low- and middle-income countries. These interventions include balanced energy protein, calcium, and multiple micronutrient supplementation and preventive strategies for malaria in pregnancy. Their respective impacts are presented in the [LiST](#) tool.

A women's nutritional status both before and during pregnancy is also important for her own health. Women who are stunted are at higher risk for obstetric complications such as obstructed labour, and mortality. Environmental and psychosocial stress affecting the mother can increase risk to mothers themselves but also contribute to child undernutrition (Walker et al 2011). While the prevalence of low BMI in adult women has decreased in Africa and Asia since 1980, it remains higher than 10%. At the same time, maternal overweight and obesity has increased steadily since 1980; resulting in increased maternal morbidity and infant mortality (Black et al 2013).

Interventions aimed at improving maternal health and nutritional status are directly linked to birth outcomes and only indirectly to stunting among children under five years. In our study we looked at the contextual factors associated with both anthropometric measures.

### **Simulation Models Findings for Contextual Factors**

**Low birth weight** was chosen as the key outcome indicator for interventions addressing maternal health and nutritional status. Low birth weight is used as a proxy for small-for-gestational age and pre-term births, which are both strongly associated with child stunting in the 2013 Lancet series and in the LiST tool.

Our findings show that **urban population, female to male secondary school enrollment, adolescent birth rate and female labor participation rate explain 54% of the variation in the percentage of low birth weight**. Each 1% increase in the population that is urbanized is associated with .56% decrease in percentage of low birth weight (95% CI: -0.90 to -0.19). Each 1% increase in female to male secondary school enrollment is associated with 0.52% decrease in percentage of low birth weight (95% CI: -1.0 to -0.04). Each 1% increase in adolescent birth rate is associated with 0.26% increase in the percentage of low birth weight (95% CI: 0.07 to 0.71). Each 1 unit increase in female to male labor force participation ratio is associated with 64.3% decrease in the percentage of low birth weight babies (95% CI: -95.5 to -35.0).

We were not able to generate intervention model findings here. However the contextual factor findings are of interest, particularly when viewed with the findings of the agriculture model which assesses impact of agriculture factors on adult diet indicators chosen as proxies for adequate maternal diet.

## **Id. Family Planning**

### **Literature review results**

The provision of access to voluntary family planning, especially effective contraceptive methods, is not only crucial for directly improve reproductive health outcomes, but is also positively associated with improvements in health, schooling, and economic outcomes (Darroch, 2013), all of which are important determinants for improving nutritional outcomes. Given the importance of family planning, efforts are being made to link basic health services with a wider range of social support for women. The health sector can provide the appropriate, and in some contexts the only, delivery channels for family planning methods, either in the form of the direct provision of contraceptive products and/or through the counseling on family planning options and the associated benefits of birth spacing.

Our literature review identified 13 trials in low- and middle-income countries that met our selection criteria, with the key interventions falling under the following categories:

- **Promotion and provision of contraceptives by community health workers** (community based)
- Media and social **marketing campaigns** promoting contraceptive use
- **School based promotion** and education (facility based)

Many of the trials combined all three of the above strategies with over half of the studies specifically targeting adolescent girls. Our common outcome indicator for the analysis was contraceptive use. Fertility rate was another potential indicator of interest but it was not tracked as extensively in the published trials. Furthermore, many of the trials and studies examined the impact of interventions on reproductive health knowledge and attitudes, which whilst not examined in detail here may also be an area of interest for decision makers (see for example Speizer et al, 2003).

The available evidence does not point to a single intervention that is likely to be a “magic bullet” for promoting family planning and increasing contraceptive use. Rather the literature suggests that these needs can be provided for in a variety of ways, the most appropriate or effective of which might well depend on the context-specificity, particularly in view of the fact that adolescents are influenced by a myriad of factors operating at the individual, family, school, community, and societal levels, it might well be the case that multicomponent interventions that influence multiple risk and protective factors are needed in order for large, sustained behavioral impacts to be realized (Speizer et al, 2003).

### **Potential Contextual Factors**

**Contraceptive use uptake** can be impacted by women’s knowledge, awareness, empowerment and formal education. The positive impact of formal education has been widely noted in the literature. By closing the gender gap in education, women can enhance their access to reproductive health services (Westoff 1988; Al Riyami; Afifi et al. 2004; Ahmed, Creanga et al.

2010; Baird, Chirwa et al. 2010). In our analysis, to control for this we used **secondary school enrollment** as a proxy for female education levels.

### **Simulation Models Findings for Contextual Variables**

Countries with a higher percentage of female secondary school enrollment as compared to male enrollment have a higher percentage of contraceptive use (95% CI: 0.26 to 0.69). This contextual factor explained 59% of the variation in contraceptive use. None of the other previously analyzed contextual factors were found to have a significant effect on contraceptive use in cross-country simulations.

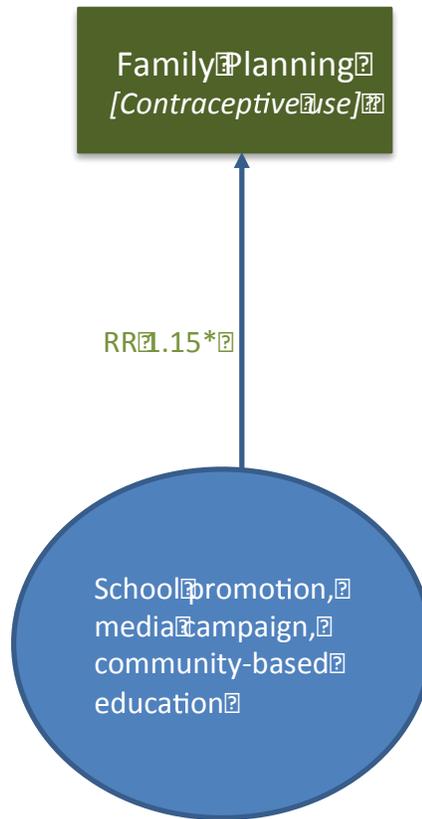
### **Intervention Model Results**

The results from 16 trials show that the contraceptive use for participants who were exposed to school promotions, media campaigns and community-based education is **1.16 higher** than control groups (95% CI: 1.01 to 1.35,  $p < 0.0425$ ). The association is significant.

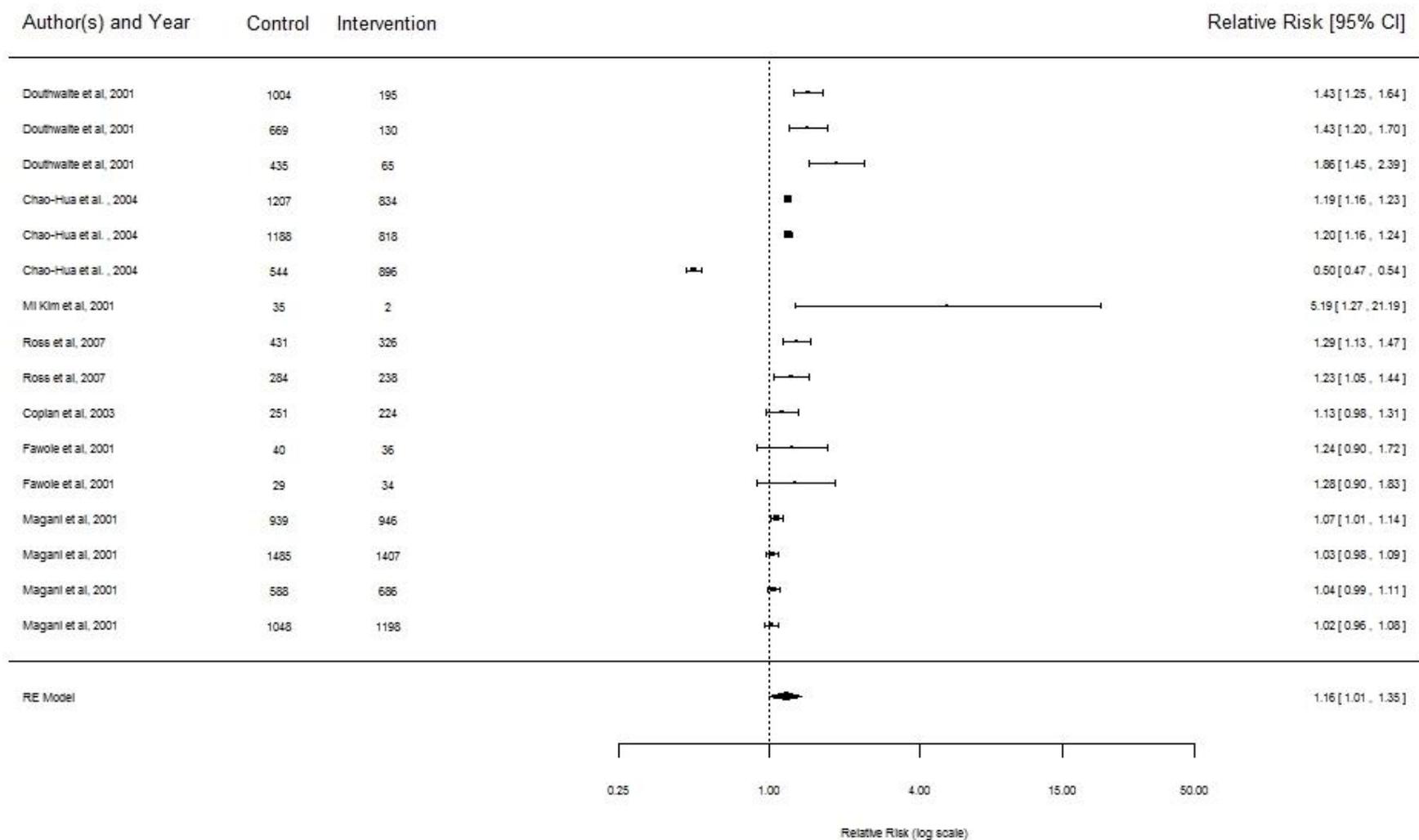
There is a high degree of variation between the studies (e.g. heterogeneity) that is not due to chance ( $I^2 = 98.47\%$ ;  $Q = 671.41$ ,  $p < 0.0001$ )<sup>9</sup>.

**Figure 12** shows risk ratios (RR) and the 95% confidence intervals of the individual studies and the overall effect size of the association between combined school promotion, media campaign and community based education interventions and contraceptive use. Overall, the association is positive, as shown in **Figure 11**.

Female secondary school enrollment as percentage of male enrollment was included in the model which showed that one unit increase in female enrollment corresponds to a change of 0.98 in the average rate of contraceptive use. This indicates that with more women in secondary school, contraceptive use increases.



**Figure 11: Synthesis figure of the impact of public health interventions on family planning.** \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$



**Figure 12: Association between school promotion, media campaign and community based education and contraceptive use in 16 trials.**

### III. Environment and water sector

#### Literature Review Results

The purpose of the literature review was to consider interventions that have successfully reduced or eliminated diarrhea rates under the presumption that such efforts ultimately result in increased nutritional absorption (and improved nutritional status).

In the broadest sense WASH or clean environment interventions encompass efforts to maintain an adequate water supply both in terms of quality and quantity, a sufficient means of sanitation, and proper hygienic practices. Poor sanitation and hygiene practices are essential determinants in the causal pathway and cycle of infectious disease burden and malnutrition. Some sanitation and hygiene interventions are included in the LiST tool as nutrition-specific interventions having a direct quantified impact on diarrhea incidence. Other pathways are less straightforward and are broadly linked to environmental enteropathy and food contamination. Although the work below does not provide much more evidence for decision making than what LiST has already provided, two elements that come need further exploration include the food safety of complementary foods and environmental enteropathy.

A recent Cochrane meta-analysis examined the impact of WASH interventions (which included solar disinfection of water, provision of soap, and improvement of water quality) on stunting reductions in children under five years of age. The available evidence from the meta-analysis of data from cluster-randomized controlled trials with an intervention period of 9-12 months is suggestive of a small benefit of WASH interventions (specifically solar disinfection of water, provision of soap, and improvement of water quality) on length growth in children under five years of age. Similarly Bhutta et al noted the significant effects of reduced risk of diarrhea with hand washing with soap (RR 0.52, 95% CI), with improved water quality, and with excreta disposal.

“Child diarrhea needs to be understood through the mother because a child’s world is predominantly controlled by and experienced through the mother.” The care a mother provides for her children is dictated by many factors including her own health status, but also familial, social, and cultural factors. The mother is intricately bonded to her child biologically and also takes care of her child’s basic needs (Caruso et al 2010). It could be hypothesized that a women’s own nutritional and health status can impact her children’s status as well, and often, hygienic practices in cooking and child care can influence not only the incidence of diarrhea in children, but also for mothers as well.

In our data collation we reviewed trials, which tracked the impact on diarrheal cases with the interventions of the promotion of hand washing and improved water quality. These two indicators were chosen because they were the most routinely collected in global and national databases and in the literature.

## **Potential contextual factors**

It is estimated that improvements in socio-economic conditions are drivers for improvements in diarrheal reductions (Walker et al 2013) and the socio-economic gradient of diarrhea occurrence is well established in literature (Aremu et al 2011), showing that as socioeconomic status increases, incident of diarrhea decreases.

For the purposes of our analysis, we wanted to isolate the impact that sanitation, water and hygiene promotion interventions have on diarrhea incidence as the outcome measure. For this reason, we controlled for the impact of education, income and access to health services through the proxy indicators of **adult literacy, percentage of the rural population and vaccination levels**.

Vaccination was included as a contextual factor as nearly a third of episodes of severe diarrhea are preventable by vaccination (ie, against rotavirus and cholera). Rotavirus is the most common cause of severe dehydrating diarrhea in infants worldwide (Walker et al 2013). In their review of six studies assessing the effectiveness of new rotavirus vaccines, Munos et al estimated that use of these vaccines was associated with a 74% reduction in very severe rotavirus infections (which cause 20% of diarrhea cases), a 61% reduction in severe infections (Walker et al 2013).

## **Intervention Model Results**

### **1. Hand washing**

The results from 10 trials show the likelihood of diarrhea for mothers that were exposed to hand washing intervention is 24% less likely than for mothers included in control group (RR= 0.76% CI: 0.62 to 0.93, p=0.0074). The association is significant.

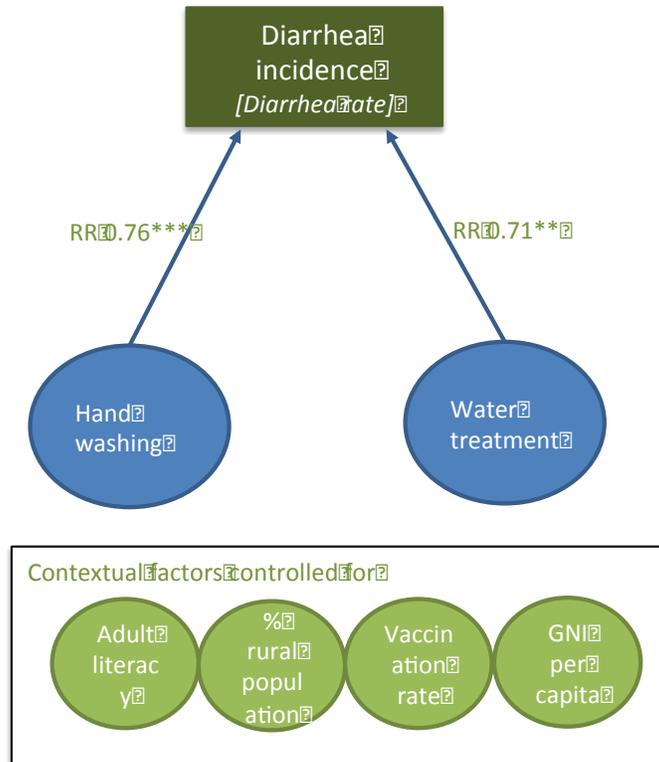
There is a high degree of variation between the studies that is not due to chance ( $I^2 = 92.56\%$ ;  $Q = 97.91$ ,  $p < 0.0001$ )<sup>10</sup>. None of the contextual factors that were found significant in the cross-country regression simulations had significant effects on diarrhea rates. We used a study level variable – absolute latitude of the area where the study was implemented – to account for 57.88 of the heterogeneity.

### **2. Water treatment**

The results from 12 trials show the likelihood of diarrhea for mothers that were exposed to water treatment intervention is 29% less likely than for mothers included in control group (RR= 0.7073% CI: 0.56 to 0.90, p=0.0043). The association is significant.

We were unable to evaluate the influence of contextual factors because of the small number of observations in the regression model.

These findings suggest that mothers who have poor hygienic practices are more likely to expose her children to pathogens, resulting in increased diarrhea. Although not a direct link, one that is important when we begin to think about care practices, infant feeding and food preparation. **Figure 13** summarizes the findings of the modeling.



**Figure 13: Synthesis figure of the impact of environment interventions on diarrhea rates.** \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$

### Emerging Area

It is thought that environmental enteropathy afflicts many children in the developing world (Humphrey 2009). Environmental enteropathy is a syndrome that causes changes in the small intestine of individuals who lack basic sanitary facilities and are chronically exposed to fecal contamination. This in turn, decreases the ability of the intestinal tract to absorb critical nutrients necessary for optimum growth and development, leading to serious consequences in nutritional status. Environmental enteropathy is often seen in young children when complementary foods are introduced along with breastfeeding. Not only are children eating more solid foods, but have increased exposure to the outside environment itself, leading to an increased risk of consuming contaminated foods. The provision of toilets and community led sanitation and hygiene programs and improved systems can reduce the incidence of enteropathy (Guerrant et al 2008, Motarjemi 2000).

## Food Safety of Complementary Foods for Infants - Analysis from the Literature

Contaminated food is a major cause of acute diarrhea, malnutrition and mortality in low- and middle-income settings, particularly among children who become vulnerable to diarrheal diseases when transitioning from breast milk to complementary foods (Montarjemi et al 1993, Montarjemi et al 2011). Solving problems of contaminated food requires a multidisciplinary approach involving experts in clean water resources, sanitation, public health, epidemiology, nutrition and of course, agriculture, as the major food source. However, the literature in addressing food safety is scant, and the outcomes measured are disparate. Although a critical important area of work, the models presented do not include the role of agriculture and public health sectors on improving food safety. This is because:

- (1) the outcomes measured in various papers focus on different outcomes
- (2) the outcomes focus on the safety of the food, and there is no available evidence on the link between contaminated food and diarrhea exposure or effect on anthropometric measures
- (3) very few if any studies had controls or comparison groups.

As shown in the **Table 3** below, the outcomes are food-focused and diverse amongst a cross sectional sampling of studies.

**Table 3: Studies examining safety of complementary foods**

Author	Country	Outcome Measure
Barrell et al	West Africa	complementary food samples for E coli
Black et al	Peru	complementary food samples for E coli
Chen et al	Taiwan	risk factors of salmonella of infant foods
Ehiiri et al	Nigeria	complementary food samples for E coli
Henry et al	Bangladesh	complementary foods for various bacterial contaminants
Hipgrave et al	Indonesia	feeding practices post earthquake
Imong et al	Thailand	complementary food samples for E coli
Islam et al	Bangladesh	complementary food samples for E coli
Kungu et al	Tanzania	complementary food samples for E coli
Mensah et al	Ghana	fermented vs non-fermented comp foods for contamination
Monte et al	Brazil	education for improving sanitation of food preparation
Olwufami et al	Nigeria	complementary foods for various bacterial contaminants
Rowland et al	Gambia	complementary foods for various bacterial contaminants
Toure et al	Mali	education campaign & testing complementary food contaminants
Zeinab et al	Egypt	complementary foods for various bacterial contaminants
Zhnang et al	China	education with food hygiene component, measured child growth

This area of work is critically important in the infant and young child feeding interventions, and both public health, education, and agriculture all play critical roles ensuring food safety and nutrient availability. Most of the studies have examined the contamination of foods with E. Coli. There are four major categories of diarrheagenic Escherichia coli: enterotoxigenic (a major cause of travelers'

diarrhea and infant diarrhea in low-income countries), enteroinvasive (a cause of dysentery), enteropathogenic (an important cause of infant diarrhea), and enterohemorrhagic (a cause of hemorrhagic colitis and hemolytic uremic syndrome). Besides manifesting distinct clinical patterns, these categories of *E. coli* differ in their epidemiology and pathogenesis (Levine 1987). However, succinct outcomes need to be agreed upon as well as studies are required to determine the effect of contaminated food directly on diarrhea incidence and indirectly on anthropometry measures.

#### **Emerging Area**

More research and published evidence is required on food toxins such as aflatoxins. Aflatoxins are fungal metabolites that contaminate staple food crops in many developing countries and have been loosely associated with growth impairments in children. Foodborne aflatoxin exposure in maize and groundnuts is common in Africa and Asia (Khalngwiset et al 2011). More evidence is needed on how post-harvest storage and handling can control for aflatoxin, which could indirectly have an impact on the nutritional status of households (Wild 2007; LeRoy et al 2013).

#### **Climate and nutrition outcomes - Analysis from the Literature**

In line with the UNICEF framework of determinants of nutrition (UNICEF, 1990), three major pathways can be described between climate, agro-ecological factors and nutrition-related indicators:

1. the food security pathway: This is the most recognized pathway. Climate and agro-ecology influence farm productivity, available food quantity as well as the nutritional composition of crops, food biodiversity, food safety, storage and price volatility.
2. the maternal and child caring pathway: Women's life style and time dedication often depends on the climatic and environmental setting, especially in low-resources settings. A simple example is the time needed to collect water and firewood, and how this alternates with climate variability. Infant and young child feeding practices, which are critical for good nutrition outcomes, are largely dependent on women's time availability. Women working a lot do not have time to breastfeed eight to twelve times a day. Also, the amount of breast milk produced is related to water intake, and can be challenging during large droughts.
3. the disease pathway: Particularly the prevalence of several infectious and vector-borne diseases (e.g. malaria, diarrhea) and food safety (e.g. aflatoxin contamination) are prone to climate and can have huge impact on nutritional outcomes.

In addition, climate and agro-ecological change, variability and shocks (disasters) affect further underlying determinants of nutrition that interact with each of the above pathways. Climate shocks and variability often forces changes in behavior and cultural practices as well as in demographics (rural - urban migration, household size), infrastructure, and political and social structures. Climate anomalies can directly affect a household income (e.g. by destroying a harvest, by adding

unexpected costs) and add to the struggle of a society to grow economically. These factors are key underlying determinants of nutrition (UNICEF, 1990) and their dependence on climate should be considered in efforts to improve nutritional status but the literature is currently very scarce for these pathways.

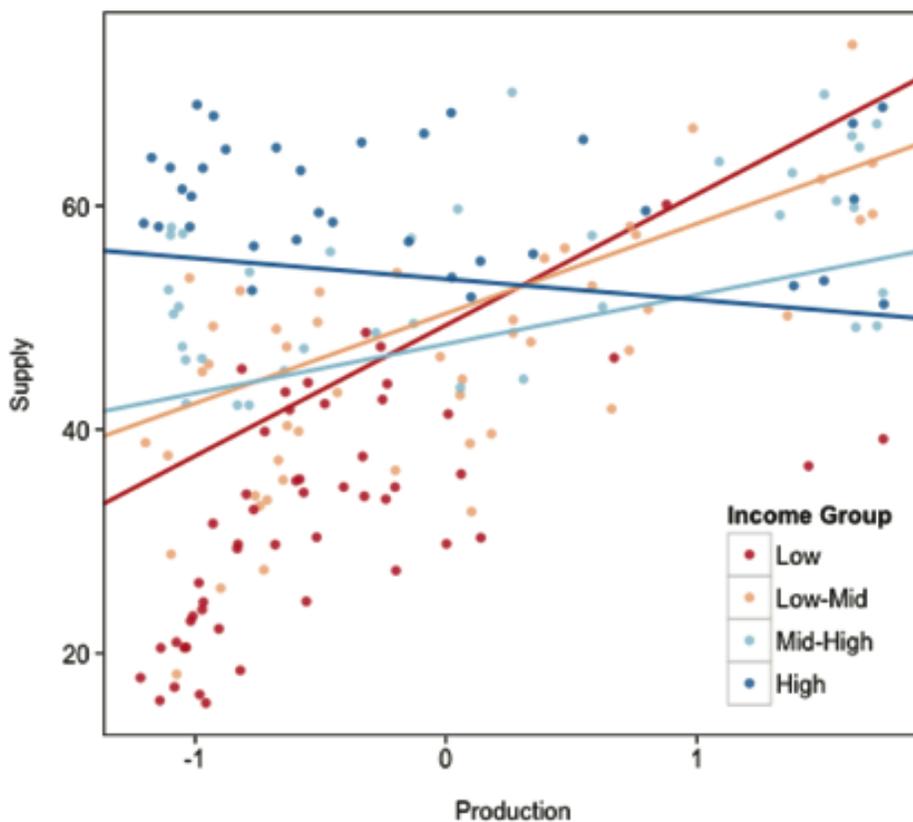
An increasing number of efforts and research focuses on the interaction between climate and staple crop productivity, but the other pathways impacting nutrition are often overlooked (Tirado et al. 2013). For example the impact of climate variability and change on food quality, including food safety and micro-nutrients contents, is still poorly understood. It has recently been described however that food composition changes under drought and higher CO<sub>2</sub> levels e.g. cyanogen levels in cassava flour triples in drought years compared to normal years (Burns et al. 2010). Similarly, the impact of climate change on dietary diversity, child feeding practices, and the interlinks between climate, diseases (particularly water-related diseases) and undernutrition, is largely overlooked. The few models that predict the impact of climate variability on undernutrition, only take into account caloric availability, per capita calorie consumption and child malnutrition numbers (Nelson et al. 2009; Lloyd et al. 2011). Early warning systems mostly focus on the risk for famines, emergencies and acute malnutrition (FEWSnet, VAM).

With a few exceptions, (Balk et al. 2005; SCN special newsletter on climate change and nutrition), multivariate regressions that analyze trends and determinants of nutrition outcomes do not take into account climate information (de Onis et al. 2011). This is despite the fact that development institutions have frequently stated that to improve food security and nutrition, it is important that programs pay attention to natural resource management including climate change adaptation (FAO 2013). This highlights an area where new research is needed to better understand and model the importance and potential of climate sensitive and climate change programs for nutritional outcomes.

### III. Agriculture sector

In the **contextual model** developed for the agriculture sector, we explored associations between agricultural and nutrition variables while taking into account a set of contextual factors.

For **diet diversification**, we found that in low- and middle-income countries, **diversity of the food supply depends on domestic production diversity** (Remans et al. unpublished). The more diverse the agricultural production of a country, the more diversity is found in the food supply available for consumption. This is however not true for high-income countries, where income and trade (imports & exports) are better predictors of diet diversification. **Figure 14** illustrates this relation.

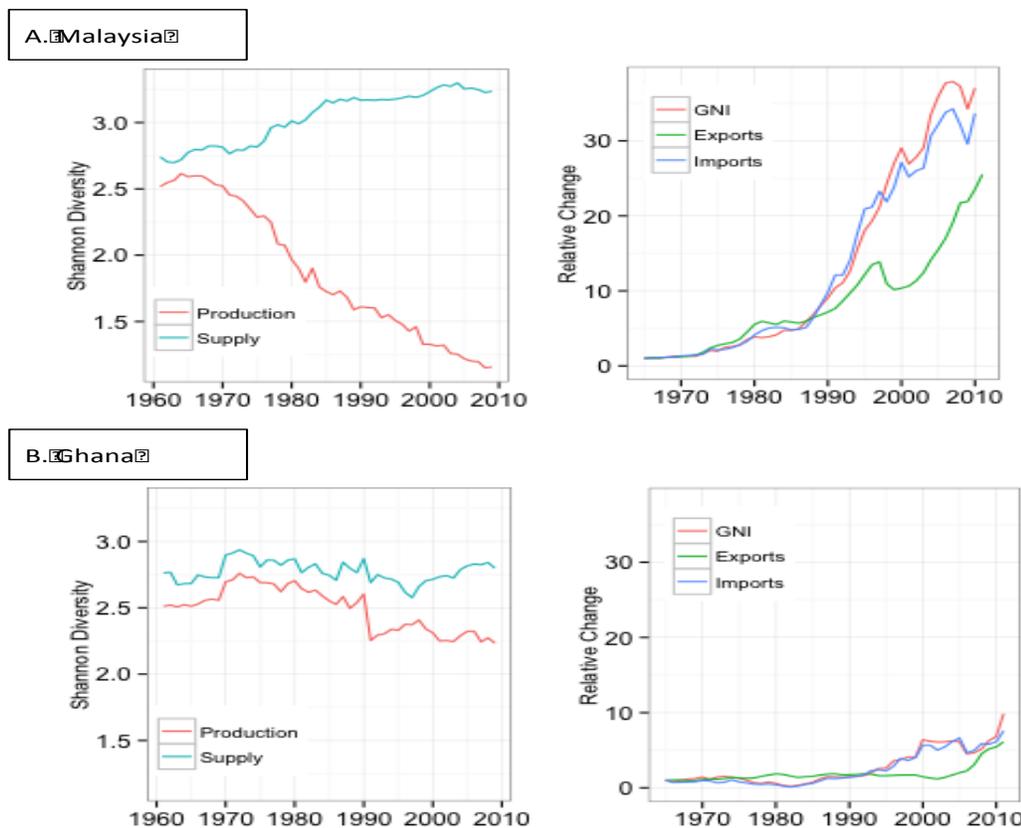


**Figure 14: Supply diversity as a function of production diversity per income category.** Production diversity is standardized. Low-income: GNI per capita  $\leq 1,025$  USD  $yr^{-1}$ ; low-middle-income: GNI per capita  $> 1,025$  USD  $yr^{-1}$  &  $\leq 4,035$  USD  $yr^{-1}$ ; high-middle-income: GNI per capita  $> 4,035$  USD  $yr^{-1}$  &  $\leq 12,475$  USD  $yr^{-1}$ ; high-income: GNI per capita  $\geq 12,475$  USD  $yr^{-1}$ .

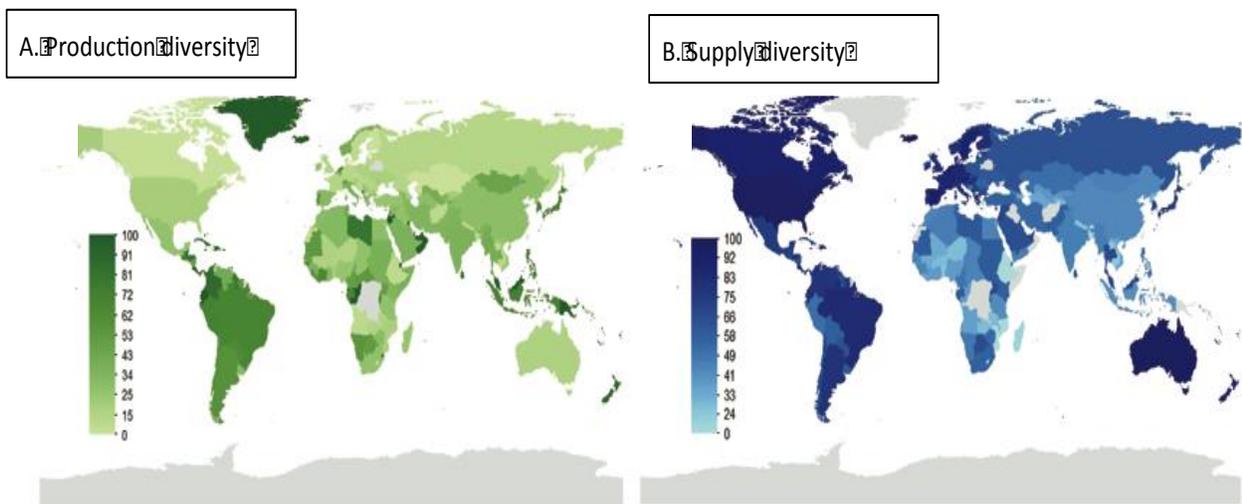
Seen this distinction between low and high-income countries, it is interesting to explore case studies of countries that underwent an economic transition. In the case of Malaysia (**Figure 15a**), for example, we observe an uncoupling between production and supply diversity over time, while the country transitions from low income to middle and high income. During this period, Malaysia

shifted to large palm oil plantations, resulting in decreasing domestic production diversity (Fitzerberth et al., 2008). This transition coincided with a period of sudden rise in export and import value as a percent of GDP (Figure 93a) suggesting that changes in macroeconomic policies drove the divergence between supply and production diversity. The maintenance of food supply diversity in Malaysia suggests that, although the country was producing less diversity, it compensated for that through trade. As low income countries transition to specialized production of fewer crops, it is important to ensure food supply diversity through the global market. The case of Ghana (Figure 15b) on the contrary shows a slight decrease in food supply diversity between 1970 and 1997, consistent with a decrease in domestic production diversity during a period of limited international trade. International trade starts to increase around 1997, followed by an increase in food supply diversity, and an uncoupling from domestic production diversity. Thus managing such transitions carefully can have important implications for diet diversification and related health outcomes (Webb et al. 2012). These results suggest that national agricultural and food system strategies should **consider food supply diversity as a nutrition sensitive metric.**

A global map of agricultural and food supply diversity (Figure 16) provides an insight in the status of this metric worldwide based on data from the last decade.



**Figure 15: Patterns of change over time for two country case studies including Malaysia (A) and Ghana (B) showing diversity of food production and supply (graphs in the left column) and relative changes in economic indicators compared to 1965 (graphs in the right column).**



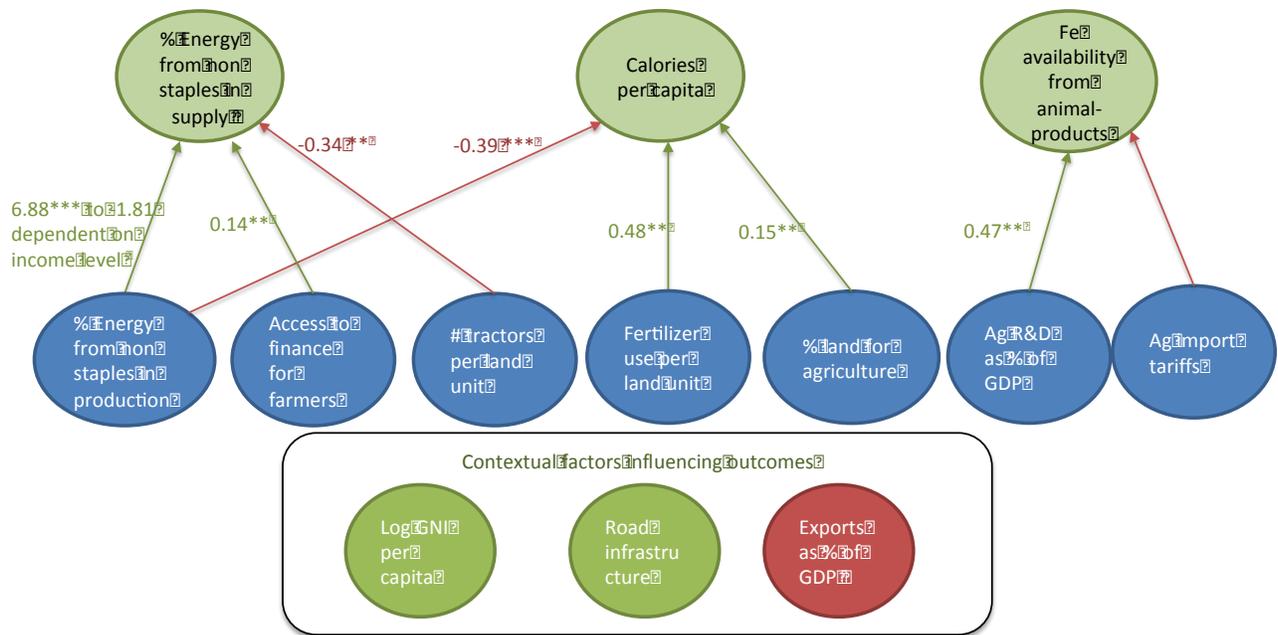
**Figure 16: Global map of food production and supply diversity** presented as the percentage of energy that is coming from non-staples on a scale from 0-100% based on data from the last decade.

In addition to production diversity, access to finance for farmers and improved road infrastructure were positively associated with food supply diversity. These two indicators characterize overall rural development. On the other hand, the amount of tractors available per unit of agricultural land, which is an indicator for agricultural intensification and mechanization, is negatively associated to the national food supply diversity. This might possibly be explained by large agricultural intensification projects that invest heavily on increasing grain productivity. It has hypothesized earlier that the change in agricultural production from diversified cropping systems towards ecologically more simple cereal based systems may contribute to poor diet diversification (Frison et al. 2006; Graham et al., 2007), but no hard evidence on this is available.

For food quantity, three agricultural indicators were identified. The amount of fertilizer used per unit of land and the percentage of land used for agriculture, both contribute positively to the amount of calories available per capita in food supply. On the other hand, domestic production diversity is negatively related to the amount of calories available per capita in food supply.

For iron availability from animal-based products, surprisingly we did not find a direct relation with the number of animals available per capita, but with market and research related indicators, i.e. a negative association with agricultural import tariffs and a positive association with public investment in agricultural research and development.

**Figure 17** below shows agricultural indicators that are strongly related to diet indicators. A green box indicates a positive effect while a red box indicates a negative effect on the diet indicators. The Adjusted R2 indicates how much of the variation in the diet indicator could be explained by the set of agricultural indicators together with the set of contextual indicators.



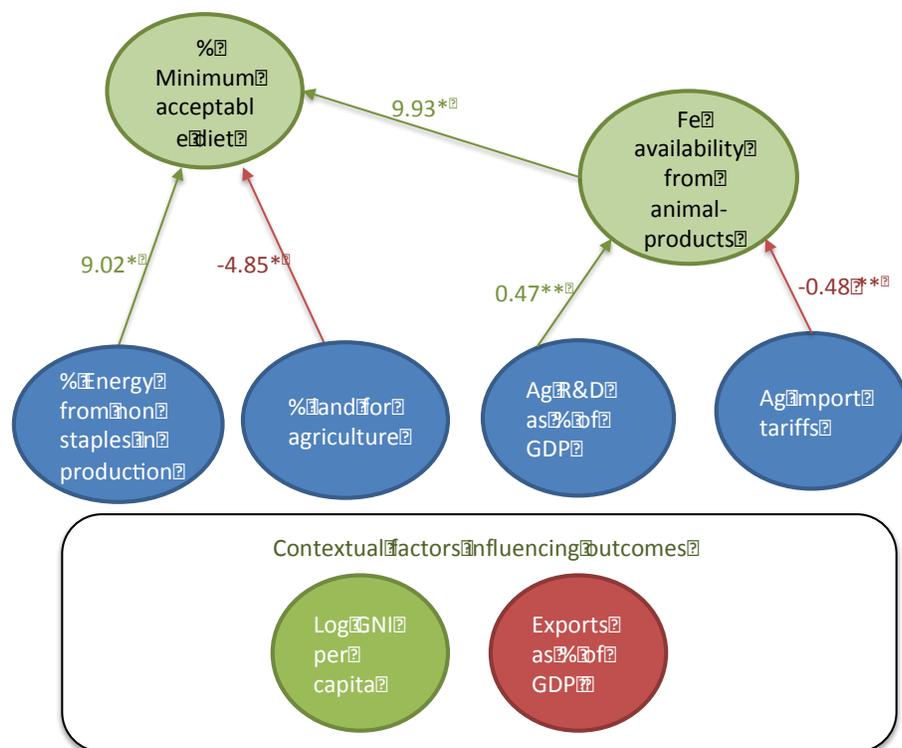
**Figure 17:** Agricultural investments related to dietary patterns (proxy for maternal nutrition). A green box indicates a positive effect while a red box indicates a negative effect. The Adjusted  $R^2$  indicates how much of the variation in the maternal diet indicator could be explained by the set of agricultural indicators together with the set of contextual indicators. \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$

For **low birth weight**, we did not find any direct significant associations between agricultural factors and low birth weight prevalence. However, as described above, a higher percentage of energy from non-staples in the national food supply was related to lower prevalence of low birth weight. This suggests that agricultural factors that contribute to diet diversification, might also effect birth weight.

As for maternal diets, we followed a similar approach to identify agricultural indicators related to **complementary feeding, using the minimum acceptable diet indicator (MAD) (Figure 18)**. For the IYCF model, it is important to note that the sample size for this model is small (32 countries) due to the limited number of countries for which these data are currently available. Therefore this analyses should be interpreted with extra care.

Two agricultural indicators were found as direct significant predictors for MAD, including food production diversity and the proportion of land devoted to agriculture. Higher diversity in food productivity is associated with improved MAD, while the contrary is true for the amount of land devoted to agriculture (independent from the level of income).

In addition, we modeled the MAD indicator against national food supply variables. Higher iron availability from animal based product in national food supply was found to be significantly associated to improved MAD. Previous studies have described that in low-resource settings access to animal-based products is often a key factor to improve complementary feeding (Murphy and Allen, 2003) and promotion of animal products has shown potential to improve dietary intake and nutritional status (Leroy and Frongillo, 2007).



**Figure 18: Agricultural investments related to infant and young child feeding practices.** A green box indicates a positive effect on nutrition, a red box indicates a negative effect on nutrition. The Adjusted R2 indicates how much of the variation in the IYCF indicator could be explained by the set of agricultural indicators together with the set of contextual indicators. \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$

Because agriculture can be a major driver for overall development, we also explored the relationship between agricultural investments and water and sanitation and family planning. For these purposes, two WASH indicators were used, i.e. the proportion of households with access to improved drinking water, and the proportion of household with access to improved sanitation, and fertility rate was used as family planning indicator. All three indicators are significantly related to stunting. It was found that increased use of fertilizer and access to finance were related to access to improved water and improved sanitation. In addition, improved access to finance was also significantly related to lower fertility rate. While the pathways between agriculture and water and sanitation and family planning are often long, it interesting to note that more general rural development indicators such as access to finance are found as important predictors for intermediary outcomes areas like family planning and WASH. This confirms that agriculture is not only important for nutrition through diet improvements, but also as an overall driver of development.

Taken together, the results of these quantitative agricultural models, identify **four promising areas for nutrition-sensitive agricultural investments: agricultural diversification in supply and production, access to finance for farmers, investment in agricultural research and development and fertilizer use.** These areas mostly interact with nutrition indicators as packages rather than standalone investments. In addition, there seems to be a trade-off with agricultural exports.

Some major limitations of our analyses need to be emphasized in order to correctly interpret these results. First, seen the nature of the model, we cannot claim causality for any of the associations between agriculture and nutrition-related indicators. Second, by limiting our analysis to the national level, we do not address important household-level barriers to food production, access and utilization or differences in distribution of income, agro-ecological setting and food security within countries. Third, our analysis is limited by data availability. Only indicators for which data are publicly available at the national level, were included in our model. For example we did not have access to any data that describe the level of agricultural extension services or the inclusion of nutrition aspects therein.

Starting from the results of the quantitative models, we revisited the literature to identify specific agricultural interventions and programs that can contribute to the four identified promising areas and for which nutrition impact has been previously described in specific contexts. The main results of this literature review are presented in **Table 4**.

For agricultural diversification (supply and production), six agricultural interventions/ programs were identified for which a positive association with nutrition outcomes has been described previously. One of the most studied nutrition-sensitive interventions includes diversified homestead gardens, for which positive effects on diet diversity and women income generation has been described in numerous studies. The promotion of animal production (including aquaculture, small scale fisheries, dairy development, poultry and animal husbandry) and specific vegetables and fruits (e.g. African green leafy vegetables) has proven to increased consumption of these specific products but the effect on the overall diet remains unclear. More recently, studies have shown a positive effect of agro-forestry and legume intercropping on diet diversity. These are examples of agro-ecological approaches that offer potential to provide multiple ecosystem services simultaneously - e.g. erosion control and improved nutrition. Finally, small-scale irrigation, using for example water-harvesting techniques to collect irrigation water, can facilitate many of the agricultural diversification activities mentioned above and thereby positively improve nutrition outcomes.

Regarding access to finance for farmers, we identified a few studies that describe a positive impact of social cash transfers combined with nutritional knowledge on nutrition outcomes and also of access to microcredits (see also under the social protection section).

For public investment in agricultural research and fertilizer use, the literature is less clear on the connection to nutrition. Biofortification of local staple crops is certainly a promising area of agricultural research and development and adoption of biofortified crops has shown to lead to increased micronutrient intake (Vitamin A, Fe, Zinc). But we don't have data that describe the connection between national public investment in agricultural R&D and the development or success of bio-fortified crops.

Finally, related to the trade-off between agricultural exports and nutrition outcomes, it is interesting to note that several studies, particularly from the 1980's and 1990's and some new recent studies (Wood et al. 2013) describe that the transition from subsistence farming to commercial agriculture - often linked to exports - can lead to a risk for a tradeoff that the nutritious food items are exported

and that actual access and utilization of nutritious foods at the local household level decreases. This is the so-called 'curse of the cash crops'. The case study of Malaysia and Ghana, described above, also indicated that as low-income countries transition to specialized production of fewer crops, it is important to ensure food supply diversity through the global market. Managing such transitions carefully can have important implications for nutritional diversity and related health outcomes (Webb et al. 2012). Options to reduce the risk of this tradeoff can include women empowerment (e.g. by ensuring income generating activities for women), making markets of nutritious food items work for the poor (e.g. by supporting access and trade of nutritious food items on local small markets), and nutrition education at a population level (including men, women, children).

**Table 4: Promising areas of agricultural investments**

Areas of investment	Examples of specific interventions	Delivery channels	References
Agricultural diversification	Promoting animal production - including aquaculture, small scale fisheries, dairy development, poultry, animal husbandry	Extension workers Community based investments	Leroy and Frongillo, 2007; Kawarazuka 2010
	Diversified home-gardens	Small shops and agro-dealers	Ruel, 2001; Masset et al. 2011
	Legume intercropping/ rotation cropping	Private sector (supermarkets, seed companies,...)	b4fn, 2013
	Agroforestry with fruit trees		Jamnadass et al, 2013
	Promoting specific nutrient dense vegetables, fruits and staples (e.g. green leafy vegetables, orange flesh sweet potato)		Masset et al. 2011; Smith and Eyzaguirre 2007. Harvest PLus
	Irrigation		Domenech, 2013
	Value chain development for nutritious food items		Hawkes and Ruel, 2011
Access to finance for farmers	Microcredits combined with nutrition knowledge	Financial institutions	Hamad et al. 2012
	Social cash transfers combined with nutrition knowledge	Public-private partnerships	See Social protection section
Agricultural research and development	Biofortification of local varieties	Research institutes Private sector investors (e.g. seed companies)	Harvest Plus; Ruel and Alderman, 2013
Fertilizer use	Promoting integrated soil fertility management practices	Extension workers, Landscape-based projects	Bationo et al. 2007
	Increase access to and use of micronutrient fertilizers e.g. including zinc	Fertilizer companies, extension workers, small agro-dealers	Graham et al. 2007; Welch, 2010
	Increase access to fertilizers e.g. fertilizer subsidy program, increased access to finance for farmers	Public-private partnerships	Evenson and Collin 2003; Denning et al. 2009
Reducing potential tradeoffs of commercial agriculture	Empowering women in agricultural and income generating activities	Extension workers	
	Increase access to and use of nutritious foods: nutrition education, imports of nutritious foods, promotion of local foods,...	Public-private partnerships?	

## IV. Social Protection: Conditional Cash Transfers

Social safety nets (SSNs) are programmes that combine actions targeted to tackle immediate and underlying causes of maternal and child undernutrition. These programmes can reduce the vulnerability of households through the provision of a transfer that helps them to smooth their consumption over time and transfers can be in cash, in-kind or both. Most of the time, these programs provide incentives that are based on conditions that encourage parents to meet certain behavioral requirements (e.g. enrolling their children at school and regular attendance of household members to health check-ups). SSNs include conditional and unconditional cash transfer programs, in-kind household food distributions, and school feeding programmes (Ruel 2013). The various components of these programmes can serve as critical leverage for nutrition-specific interventions.

As noted in our first report, there are four different pathways in which these programmes can have a long-lasting impact for nutrition outcomes: (1) the women’s knowledge and awareness pathway (food utilization), (2) the women’s empowerment pathway, (3) the food access pathway and (4) the reduction of the gender gap in education pathway; which in turn can all impact our outcome areas of interest. Most programmes, particularly conditional cash transfers, target transfers to women, on the premise that increasing women’s control over resources will lead to greater investments in children (Ruel 2013).

In our analysis we wanted to see if we could isolate and quantify the impact of social protection programs, particularly, conditional cash transfers on our key outcome areas. **Table 5** below highlights some of the trials identified for our analysis and the outcomes that were used to track progress. There is a growing body of literature on the impact of CCTs and although they are implemented worldwide, the experimental evidence of effectiveness comes mostly from Latin America, as seen below.

The data from these trials were not compatible with our model methodology since the outcomes measurements were too diverse and the raw case data were often not available - only the estimated impact numbers. As a result we were not able to generate our own set of quantitative results. However the trials below are highlighted for reference and some key qualitative findings from the meta-reviews are provided below.

**Table 5: Summary list of social protection - nutrition studies - Analysis from the Literature**

Author	Study Location and CCT	Outcomes tracked
Attonasio et al (2005)	Colombia (Familias en Accion)	Health services uptake (attendance of preventative care visits) immunization coverage, reported incidence of diarrhea or respiratory diseases, child height for age
Gertler (2000) (2004)	Mexico (Progresa)	Daily visits to nearby health facilities, reported morbidity, prevalence of stunting
Maluccio (2004) (2005)	Nicaragua (Red de Proteccion Social)	Attendance of preventative care visits, immunization coverage, prevalence of stunting, prevalence of anemia
Rivera (2004)	Mexico (Progresa)	Prevalence of anemia, height increase
Morris (2004)	Honduras (PRAF) and Brazil (Bolsa Alimentacao)	Attendance of preventative care visits, immunization coverage, height of age score, weight for age score
Behrman (2005)	Mexico (Progresa)	Height increase, immunization coverage
Thornton (2006)	Malawi	Health services uptake (proportion of people who go back to get their results)
Olinto et al (2003)	Brazil (Bolsa Alimentacao)	Household expenditure on food. Change in diet diversity

**Illustrative Findings in the Literature:** Most of the conditional cash transfer programmes (CCTs) require a minimum attendance to health check-ups and health related lectures at the frontline services. These components – which are also illustrated in our conceptual framework for the public health and environment model - can raise awareness about the importance of contraceptive methods, diet, proper feeding and care practices; as well as hygiene and sanitation practices (Gertler 2004, Lagarde, Haines et al. 2007).

Several CCT programmes in these trials provide strong evidence of a positive impact on the use of health services, nutritional status and health outcomes. It is hard to link these positive effects to the cash incentives specifically because other components or factors may also have contributed. However several studies provide evidence of positive impacts on the uptake of preventive services by children and pregnant women, which is one of the key pathways for improving health and nutrition outcomes. Conditional cash transfer programmes appear to be an effective way to increase the uptake of preventive services and encourage some preventive behaviors. As noted by Lagarde et al (2009), the success of CCTs is probably dependent on the magnitude of barriers to accessing services. If the main reasons for poor uptake of health services are linked to financial barriers, then CCTs are more likely to be effective mechanisms.

Basset (2009) finds that where utilization of specific nutrition interventions is low, there is significant potential for CCTs to play a greater role in reducing undernutrition. Several key design modification, including limiting CCT eligibility to the “window of opportunity” for nutrition impact, prioritizing nutrition-related conditionality based on best practices in nutrition, could allow CCTs to better contribute to eliminating child undernutrition in the developing world (Basset 2009).

## Limitations and Gaps

There are limitations to this study that need to be highlighted in order to correctly interpret and use the results.

### **Limitations of the Literature**

There are clear gaps in what sort of data is available in the literature. Much of the “nutrition sensitive” body of knowledge is not published currently and there is a lack of consistency and comparability between studies. That is changing with the increased dialogue and calls for action of multi-sectoral approaches (World Bank 2012), however the limitations are there. Some sectors, such as agriculture, social protection and women’s affairs, lack not only evidence on the impact on anthropometric measures (e.g. stunting) but also on other nutrition-related intermediary outcomes (e.g. maternal diet, complementary feeding, etc.). More needs to be published (both positive and negative results) and more operations research type studies need to be documented. This will require less traditional approaches to doing research and moving away from health-centric randomized control trials, and more flexibility from scientific journals to publish “how to” data that is less about mechanism and more about optimizing operations and implementation.

### **Gaps in the Data and Data Sources**

In the process of populating the models, the authors became well aware of two major deficiencies in the data. First, there is no real consensus on what type of data should be collected for specific sectors and disciplines when it comes to nutrition. For example, there is a mixing of methodology and indicators that are tracked with maternal diets for agriculture. Different indicators (such as iron status, energy consumption, zinc content etc.) are collected to measure optimal maternal diets leading to an inability to make comparisons across studies. Second, there is a dearth of databases that have nutrition sensitive indicators collected across different countries. Thus, for the model, sometimes entire regions were not included in the analysis.

### **Limitations of the Model**

There are several limitations of the modeling that must be highlighted and thus, careful interpretation of this data and its usage is advised. First, due to a lack of published literature and lack of cohesive data, the number of studies used overall was small. Conclusions should be treated with caution because of the smaller sampling that was used for the modeling. Second, the authors did not assess the design of each study that was included in the model. Therefore, the quality of some studies could be called into question in their impact and study strength. Third, this study did not do a systematized literature review for every outcome modeled. The study had a short time window and this would require more funds, and more time to do a proper systematized analysis of literature that sourced at least 4 to 5 databases.

The inclusion and exclusion criteria were rigorous, but also quite flexible which also supports that idea that a systematized review was not the mandate. Fourth, not all of the literature review data outputs could be used in the model thus some qualitative analysis has been summarized in the report. There is clearly a need to better understand these areas as they relate to nutrition outcomes. Last, the contextualized factors chosen to be included in the study were done with some background literature searches but again, many more contextual factors could have been

considered and included. In our initial design, a larger number of contextual factors were chosen but once sectoral simulations were undertaken, only core contextual factors were modeled (see **Annex III**). This model provides a glimpse of what could be modeled moving forward and factors that countries should consider based on their local epidemiology.

Finally, some additional limitations apply to the agricultural model. Given the nature of the model, we cannot claim causality for any of the associations between agriculture and nutrition-related indicators. Further, by limiting our analysis to the national level, we do not address important household-level barriers to food production, access and utilization or differences in distribution of income, agro-ecological setting and food security within countries. Our analysis is also limited by data availability, only indicators for which data are publicly available at the national level, were included in our model. For example we did not have access to any data that describe the level of agricultural extension service or the inclusion of nutrition aspects therein.

### **Addressing the gaps**

The authors would like to suggest the following recommendations in filling these gaps and limitations:

1. More field-based research, particularly operations research including quantitative and qualitative methods, should be considered and published in scientific journals in which a peer review process is instituted. This process, however, should be more flexible than the traditional research designs.
2. Consensus on a suite of key indicators to be systematically collected in research and by countries, such as the Minimum Acceptable Diet indicator.
3. Contextualization of nutrition sensitive interventions in research and decision-making using a set of indicators that could ensure some degree of comparability.
4. Consensus on a basket of nutrition-sensitive interventions in agriculture and other sectors that can be tracked over time as this research area grows.
5. Examining agriculture through large-scale investments, rather than narrow community-based homestead interventions, can provide insight for Ministries of Agriculture on the indirect impact for nutrition of major decisions (e.g. on domestic production and trade).
6. Costing tools could provide an entry point for additional learning and decision making in which this quantitative modeling could be used as a first step resource.

## Summary and Implications

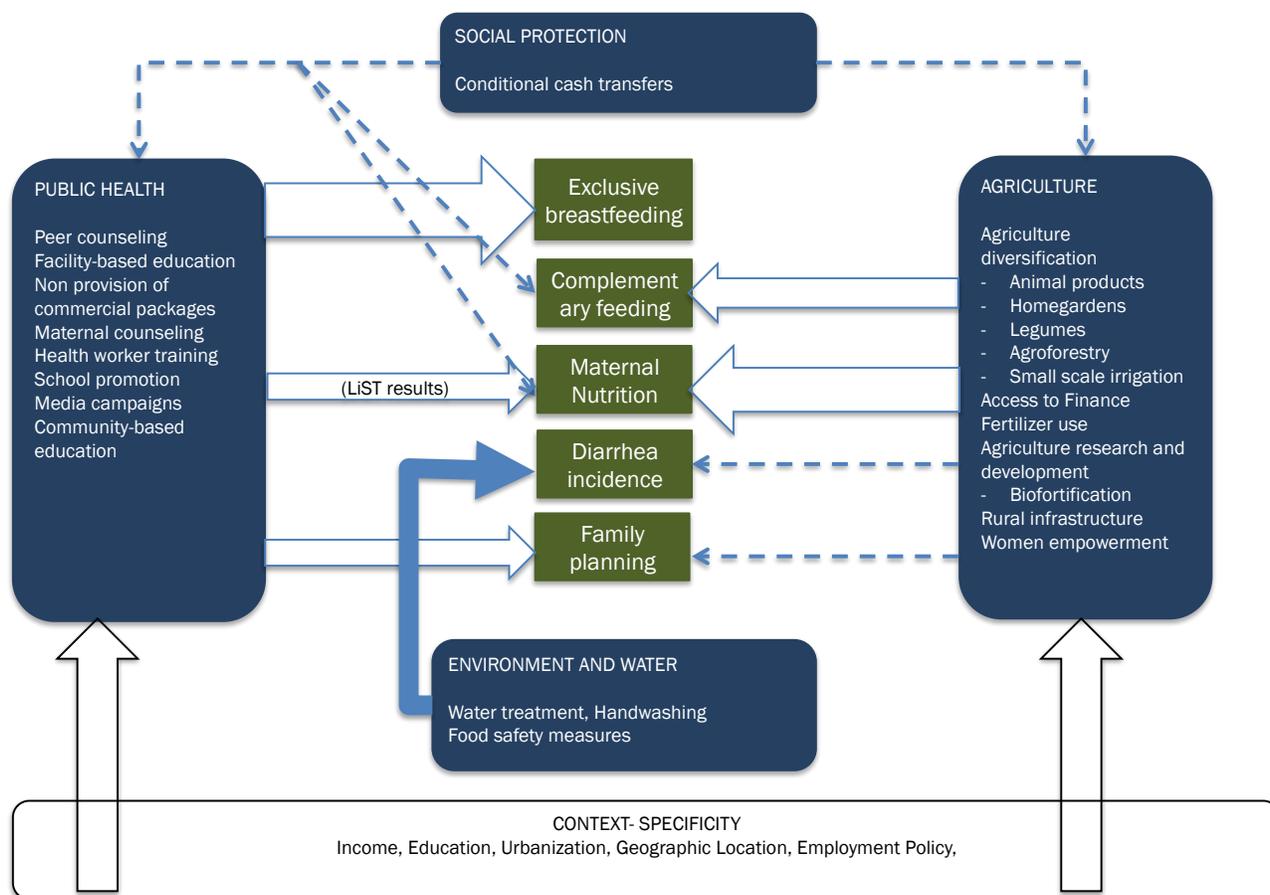
Over the last few years there have been growing calls for countries to either employ new programs or to adapt existing programs and policies in the relevant sectors for nutrition, across the Ministries of Agriculture, Social Protection, Education, and Water and the Environment for example, as part of their wider commitments to improve nutritional outcomes.

As countries in the Scaling Up Nutrition Movement are faced with increasing demands to take a holistic multi-sectoral and multi-stakeholder approach to their nutritional programming there is a mounting need for decision-support tools that can provide guidance not just on what to do but also on how to effectively choose between the wide ranges of investment options that fall under the nutrition-sensitive heading. Such decision-support tools need to be based on the best available evidence and should optimally, take into consideration the specific context or “starting point” for each country.

This study represents a first step in attempting to fill the gaps of providing evidence based recommendations on decisions that can be made across key sectors to effect the risk factors or to increase the uptake of nutrition-specific interventions that have a direct impact on stunting among children under five years of age.

The study focused on the following intermediary outcomes: exclusive breastfeeding; complementary feeding; maternal nutrition; family planning; and diarrhea incidence. Proxy indicators were chosen under each outcome to run the model. **Figure 19** below shows the summary of findings.

For public health we identified a series of investments that can be made to improve the intermediary outcomes. For the uptake of exclusive breastfeeding for six months from birth we found the strongest body of evidence for peer counseling, which adds further weight to the promotion of this community based intervention. Facility based promotion and combined public health interventions were also found to be positively associated with the uptake of exclusive breastfeeding. The analysis from available studies (mostly targeting adolescents) also showed an increase on the uptake of contraceptive use for participants exposed to school promotions, media campaigns and community-based education. There were not enough data to run quantitative models for interventions in the public health aiming at improving diet practices for mothers and young children, Finally, qualitative reviews found promising results for: 1) Safety of complementary foods; 2) Use of mass media campaigns to increase uptake of exclusive breastfeeding and 3) Social protection to address utilization of public health services and formal schooling. As with the LiST tool, WASH interventions such as hand-washing and water treatment were found to be significantly associated with reduced diarrhea incidence among mothers applying recommended practices.



**Figure 19: Summary schematic of model and major findings.** Key sector investments were modeled against five intermediary outcomes: exclusive breastfeeding; complementary feeding; maternal diets; water, sanitation and hygiene (WASH); and family planning. Investments that significantly contribute to these are listed under each sector. Thickness of arrows indicates significance and level of evidence. Dotted arrows indicate qualitative narrative, not quantitative. Major contextual factors that influence these relationships are listed in grey.

For agriculture, a quantitative contextual model identified four promising areas for nutrition-sensitive investments: agricultural diversification, access to finance for farmers, investment in agricultural research and development and fertilizer use. These investments mostly interact with nutrition factors as packages rather than standalone investments. Economic and rural development and trade were found to be important confounding factors and need to be taken into consideration when making decisions on agricultural investments. In addition, the literature review strongly points to gender empowerment as a key entry point for agriculture-nutrition interventions.

The impact of contextual factors are specifically highlighted and analyzed in detail in this report since the context-specificity (particularly the socio-economic conditions) is even more important when it comes to nutrition-sensitive investments in sectors like agriculture.

We were not able to generate intervention model findings in the public health sector for complementary feeding and maternal nutrition. However the contextual findings are of interest,

particularly when viewed with the findings of other models. When analyzing contextual factors, a significant association was found between the Minimum Acceptable Diet (proxy for complementary feeding) and the level of income (measured as GNI per capita), female to male adult literacy rate and rural setting, which explained 59% of the variation. Our findings also show that urban settings, female to male secondary school enrollment, adolescent birth rate and female labor participation rate explain 54% of the variation in the percentage of low birth weight. The level of income, the adolescent birth rate and the maternity leave in interaction with higher female to male ratio of labor participation explained 31% of the variation of exclusive breastfeeding.

When analyzed against specific contextual factors, peer counseling was found to increase exclusive breastfeeding duration closer to WHO recommendation of 6 months. It was also found that peer counseling has a higher effect for countries where the rural population percentage is 30 or higher, where the maternity leave duration is less than 20 weeks, where the female (formal) labor participation is below 40%, where the female to male literacy rate is lower than 80% and where the adolescent birth rate is significantly high (over 60%).

It should be clear that the conclusions should not be seen as standalone answers or direct recommendations for the optimization of investments in nutrition. They should be used as part of a suite of tools and wider resources that policy makers consult with in the decision-making process being cognizant of the trade-offs and the “do no harm approach”.

Evidence published in the literature remains scant and varied for nutrition-sensitive interventions, and more implementation science should be published. Using a quantitative statistical simulation model can only go so far as the current literature and data allows. This has resulted in some interesting insights but not in a complete tool that is sufficiently practical for countries looking to scale up nutrition. Planning and costing tools could provide an entry point for additional learning and decision making in which this quantitative modeling could be used as a first step resource.

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## **Annex I: Methodology**

See attached file of methodology of the study.

## **Annex II: Trials included in the meta-analysis (Public Health)**

See attached file with compiled excel worksheets with the data sets used for the analysis.

## **Annex IV: Moderator Analysis**

See attached file for moderator analysis details.

## **Annex II: Tables of indicators and data (Agriculture)**

See attached file with excel worksheets with the list of indicators and the datasets used for the analysis.