UNITED NATIONS UNIVERSITY

UNU-MERIT

Working Paper Series

#2015-002

The effect of supplementation with locally available foods on stunting. A review of theory and evidence

Mutinta Nseluke Hambayi, Wim Groot and Nyasha Tirivayi

Maastricht Economic and social Research institute on Innovation and Technology (UNU-MERIT)
email: info@merit.unu.edu | website: http://www.merit.unu.edu

Maastricht Graduate School of Governance (MGSoG)
email: info-governance@maastrichtuniversity.nl | website: http://mgsog.merit.unu.edu

Keizer Karelplein 19, 6211 TC Maastricht, The Netherlands
Tel: (31) (43) 388 4400, Fax: (31) (43) 388 4499

UNU-MERIT Working Papers

ISSN 1871-9872

Maastricht Economic and social Research Institute on Innovation and Technology, UNU-MERIT

Maastricht Graduate School of Governance MGSoG

UNU-MERIT Working Papers intend to disseminate preliminary results of research carried out at UNU-MERIT and MGSoG to stimulate discussion on the issues raised.

The effect of supplementation with locally available foods on stunting. A review of theory and evidence

Authors:

Mutinta Nseluke Hambayi, Wim Groot, Nyasha Tirivayi

Affiliations:

Mutinta Nseluke Hambayi is affiliated with Maastricht School of Governance, Maastricht University P.O Box 616, 6200 MD Maastricht, Netherlands. Wim Groot is affiliated with the Department of Health Services Research, Maastricht University, PO Box 616 6200 MD Maastricht, Netherlands. Nyasha Tirivayi is affiliated with the United Nations University (UNU-MERIT), Keizer Karelplein 19, 6211 TC, Maastricht, Netherlands.

Corresponding author information:

Please address all inquiries to the corresponding author, Mutinta Nseluke Hambayi, at: Maastricht School of governance, Maastricht University P.O Box 616, 6200 MD Maastricht, Netherlands.

Email: Mutinta.Hambayi@wfp.org

Running head: The effect of supplementation with locally available foods on stunting. A review of theory and evidence

Abstract

Introduction

There is vigorous debate and mixed evidence concerning what diets or how many food groups can be used to prevent stunting in resource poor settings. Inherently, recommendations focus on food supply, availability and access other than household functions, behaviours and child care practices.

Objective

We review the evidence on the effects of supplementation using locally available diverse and non-diverse foods on stunting among children below the age of five years.

Methods

We review evidence from Sub-Saharan Africa, where 22 of the 34 countries that contribute to ninety percent of the global burden of stunting are. We searched the empirical literature that captured anthropometry outcomes for children of age 0-5 years. Studies assessing the effects of fortified foods, or food used for treatment rather than prevention were excluded.

Findings

Four studies are reviewed. Only one study provided food supplements comprising seven locally available food items, while the others provided fewer food items. The studies show that supplementing with diverse local foods has neither superior nor inferior linear growth benefits than supplementing with non-diverse local foods. We however find positive and consistent significant effects especially of milk and maternal factors on preventing wasting and underweight.

Conclusions

Our review demonstrates that supplementing with locally available foods is feasible in resource poor settings. Our findings partially substantiate the challenges of prescribing the quality or a threshold of food groups for the prevention of stunting. Due to limited evidence, further research on local diverse and non-diverse supplementation is required.

Key words: Locally available foods, supplementation, linear growth, stunting, controlled trials, nutrition reviews

JEL Classification: I10, I12

Background

The role of dietary diversity, defined as the number of different foods eaten over a given period of time in nutrition is well established. However, less is known about the role of local diets in preventing stunting[1]. Stunting is a syndrome characterized by being too short for age due to failure to reach one's genetic potential in linear growth [2]. It starts before and can continue after birth [3]. Height-for-age is one of the measures used to detect chronic under nutrition [4]. Stunting affects 165 million children globally[5]. Ninety percent of the global burden of stunting is found in 34 countries, out of which 22 are in Sub Saharan Africa (SSA)[5]. In SSA stunting has been endemic and chronic for decades, affecting four in every ten children[6]. Stunting has lifetime negative effects and affects health, schooling abilities and economic benefits in adult life[5]. Prevention of stunting in early childhood is therefore important for economic growth [7]. Overall there is concern that policy frameworks and programs have failed to prevent stunting in Africa. Clearly stunting remains a major public health problem in low-income settings where food insecurity is a foremost challenge [8, 9].

Central to the discipline of nutrition is the emphasis on addressing under nutrition by promoting consumption of a diversified and well-balanced diet as the most sustainable strategy [10, 11]. This approach is based on the argument that the dietary choices for resource poor families are premised on the avoidance of calorie shortages [12]. Consequently, local diets are often staple based, bulky, monotonous with limited animal source foods [13]. This has led to assertions that dietary inadequacy is such a common occurrence in resource poor settings that linear growth cannot be achieved from a local diet alone without nutrient supplements[14]. However, such explanations tend to overlook the fact that there is no consensus on what constitutes an ideal diet that prevents stunting[1]. Few studies have rigorously examined the effects of interventions using local foods and the extent to which a non-diverse local diet is a risk to stunting in resource poor settings remains unknown. While the preponderance of interventions focus on fortified food supplements, it is arguably not yet clear whether such supplements are the solution and only guarantee of achieving nutrition security since nutrition also involves other underlying factors such as child care practices, water and sanitation. To date, few studies have sought to understand how some children eating few locally available foods overtime manage to grow optimally [3], hence some scholars have urged researchers to identify the practices and behaviours of caregivers who raise unusually well-nourished children, despite being poor and living in difficult conditions [15, 16].

Scope of the study

The aim of the review is to assess the effects of supplementing with local foods on stunting. We contribute to the debate on whether dietary diversity in local contexts is the solution to stunting, compared to non-diverse local diets. The study causal inference is derived from a systematic review of studies conducted in Africa. The review examines behavioural, biological and household production function theories to interpret the result. We find that over the past decade, few studies use local foods in controlled trials. Supplementation with one or more foods gave a mixed result. However, milk and maternal characteristics influenced wasting and underweight, positively and consistently. This review adds value by a) partially substantiating the debate on food grouping b) using current data from 2000 to 2014 c) and only reviewing studies that used unfortified local foods.

We organize the paper as follows. Section 2 discusses theories and pathways to explain stunting. Section 3 presents methods used in the review. Section 3 and 4 describes the empirical strategy and findings, while section 5 discusses the study implications. Section 6 concludes.

Theory

At the individual level, several sociological and economic theories explain the link between local diets and stunting [17-21]. The neo classic epidemiological Mosley-Chen theory postulates that the determinants of health, are complex and act in a cumulative manner of events to produce an outcome [17]. The determinants are: (1) maternal factors (2) environmental contamination (3) nutrient deficiency (4) injury and (5) personal illness control [19]. Hence local diets would directly influence health through the nutrition deficiency pathway. In the framework of Grossman's model [20, 21], local diets are an input to health production as households invest in the purchases of local foods to achieve good health.

Factors that mediate the impact of local diets on stunting can be explained by various behavioural theories. The Health Behaviour model predicts that dietary practices based on information, motivation and skills of caregivers influence diet composition which in turn affects stunting [18]. The Social Ecological model defines interrelationships between the environment and dietary habits [22]. For example local foods can be influenced by agro ecological and climatic factors which in turn influence food availability, types of food grown and hence habitual diets. The intra household resource allocation theory demonstrates how intra household food allocation, purchasing priorities and bargaining power influence household and individual dietary intake[23]. The Positive Deviant theory (PD) can be used to explain why some children grow well from consuming locally available foods in food insecure regions. The PD theory states that some households in local contexts adopt uncommon behaviours and strategies that enable them to find better solutions to problems than their peers, while having access to the same resources and facing similar or worse challenges. In practice they frequently have children who are *unusually healthy* under hostile conditions [15, 24]. These theoretical notions provide a framework for identifying the pathways between the consumption of diverse and non-diverse local foods and stunting.

Methods

Search strategy and study selection

The literature search was conducted between January 2013 and August 2014. The main focus of this review is to assess whether providing diverse or non-diverse rations composed of locally available foods (animal or vegetable source), results in significant linear growth thereby preventing stunting. The search covered all title qualifying publications from 2000 to 2014. Only studies from Sub Saharan Africa were included in order to contextualize the review to similar local foods [25], account for the peculiar circumstances of the high disease burden in Africa known to contribute to stunting

[9], and to strengthen the predictive power of theories by applying the cultural relevancy cited in health behaviour models [18, 26].

The search unearthed eight efficacy trials from previous systematic reviews which covered the period 1999 to 2006 [27] and eight studies which covered the period 1991 to 2009 [28]. Six of the eight studies were the same efficacy trials in both reviews. For this analysis, all these studies were excluded for; either using fortified food blends supplements, and not specifying the type of food items given (in case of one study) [29], and having been conducted outside SSA. Further triangulation searches by year were performed using Google Scholar.

Inclusion and exclusion criteria

Studies were included in the review based on the following criteria:

Study design: only randomized controlled trial (RCTs), case-comparison-, quasi-experimental, or longitudinal studies were included. There is debate on whether observational studies should be included in systematic reviews. On one hand, systematic review methodologists are concerned about their inclusion, while on the other hand, the World Health Organization's (WHO) Nutrition Guidance Expert Advisory Group (NUGAG) members are concerned about their exclusion [30]. While systematic reviews (SRs) in public health nutrition are criticized for using observational studies, because of the misunderstanding that SRs include only evidence from RCTs and always exclude evidence or observational studies in humans [30]. Our review excluded an observational study that qualified despite the fact that the evidence on locally available foods is still limited and emerging because we sought to consider only robust studies [31].

Statistical analysis: We only selected studies that employed quantitative and econometric methods in analysis such as logistic regressions. Therefore descriptive studies were not included.

Intervention and target group: Studies met the criteria if they had children of age 0-59 months as the unit of analysis, included child anthropometry outcomes, and specified "stunting" or linear growth as the either primary or secondary outcome of a dietary diversity indicator. Any study with an intervention that prescribed a diet of one or more local foods in order to improve measureable nutrition outcomes was included[14]. Studies that included a specific food item in the intervention along with health and nutrition education were considered since care giver behaviour is influenced by information, motivation and skills on how to make child feeding choices [32]. We included studies that compared non-fortified foods with fortified foods, although only the results of the non-fortified food is reported as this study is intended to assess the effect of habitual food items on stunting.

Studies assessing the effects of minerals and vitamin supplementation, fortified foods, fortified ready-to -use food products, food used for treatment rather than prevention were excluded. Both free-text and subject headings were used, in the Medical Subject Headings (MeSH). We use an adapted search strategy for identifying randomized trials [33]

Search terms used;

"randomized controlled trial","controlled clinical trial", "randomized [tiab]", "case-, comparison-, quasi-experimental, longitudinal and observational studies" [tiab], "dietary diversity, stunting" "stunting, food groups, [34]", dietary diversity stunting, children, under five years under two years, children,0-23, 0-59, [tiab], child growth, dietary diversity, Africa, developing countries complimentary foods, trial [tiab], "household dietary diversity nutrition", chronic malnutrition, children [tiab],

We searched relevant databases and search engines with literature from peer reviewed journals. These include PubMed, WHO database, and Wiley Online Libraries, Science Direct, Springer, Google scholar, Scopus, Medline, BioMed central and the Cochrane data base of systematic reviews. Following a trail of cited papers, we utilized the snowball technique where one selected study led to a relevant-to-criteria heading or topic. The search was further supplemented by accessing selected systematic reviews and published papers where the treatment and outcomes met the inclusion criteria. We used three earlier nutrition systematic reviews to close any gaps and cross check study overlaps, an indication of iteration in the search process[35]. This gave us confidence that we exhausted both saturation and chronology in the referenced literature. For example, we found that none of the systematic reviews met the criteria because the studies reviewed looked at fortified foods or were not done in Sub Saharan Africa, or that they were interventions where food was given for the treatment of malnutrition [27, 28]. The most recent systematic review reviewed eight RCTs which were excluded because of study site and year criteria [36].

Outcome measures

The framework for analysing nutrition outcomes in the review follows the WHO classification [5, 37].The primary outcome stunting is defined as height for age Z score ≤2. Secondary outcomes include wasting which is defined as weight for height Z score ≤2 and, underweight which is defined as weight for age Z score ≤2. Since all but one study had children below the age of two, length measurement is reported and hence the outcomes are expressed as length for age Z score (LAZ), weight for length Z score (WLZ) and weight for age Z score (WAZ).

Methodological appraisal

We evaluated the methodological strength of the studies at two levels. First, we followed the quality appraisal criteria for use and application of reviews for public nutrition and public health, which assesses whether a study has a:

a) clear study objective, answerable question and protocol
b) pre-specified eligibility inclusion criteria
c) reproducible methodology for stated evidence
d) critical statement of findings and their validity and
e) structured presentation of findings [30, 38].

Second, we used the quality and validity grading for quantitative studies with a component rating based on 1) selection bias, 2) study design 3) confounders 4) blinding 5) data collection methods 6) participation rate. Risk of bias was assessed for all studies using the following ratings; 1= low, 2= medium and 3= high [39]. The flow chart of evidence search and selection is shown in Figure 1

Description of empirical studies

Characteristics of empirical studies

Table 1 summarizes the characteristics and findings of the selected empirical studies. Characteristics include study type, country, sample size, age, study design, number and type of food items in the intervention (used as a marker for the concept of dietary diversity), independent variables, dependent variables, treatment effects (size effect-SE /odds ratio-OR). In total, four studies qualified for the review. Collectively, these studies were conducted in four countries, with a sample size that ranged from 129 children [40] to 532 [41] respectively. Baseline characteristics within each study were similar between study and comparison groups. Three out of the four studies targeted non-malnourished children less than twenty four months old while one targeted children up to forty months old [42]. The start of the intervention varied considerably, ranging from three months of child's age [43] to eleven months[42]. All interventions lasted for a time between five to twelve months, with an average duration of 7.2 months. There were variations in diet exposure among the studies. Animal source foods such as meat, milk or milk powder and eggs were provided in three studies. One study provided both meat and eggs and also included fruit, sugar, oil and legumes all in one package [40]. Another provided olive and fish oils [43]. All studies reported child anthropometric outcomes and morbidity. Outcomes were measured at different intervals, from three month intervals, to baseline and end line intervals. Child gut integrity and cognitive development were reported as additional outcomes in one study [43]. Caregivers in all studies received nutrition counselling to enhance knowledge and encourage child feeding of foods from the locally available foods. Information on hygienic practices was also given. The food items were distributed as take home rations [40, 41]. We also consider that these interventions were a supplement to the usual sources of food and nutrition i.e. breastfeeding and locally available foods.

Methodological quality of studies

Regarding the study design and causal inference, two of the studies were RCT's [41, 43] one was quasi experimental [40] and one was a case comparison [42].

All the studies reported statistically significant effects, either as mean effects, or changes in both primary and secondary outcome over the duration of the supplementation. Effects were indicated by effect sizes, p-values or percentage changes. Studies also report differences between treatment and comparison groups. The results are therefore not directly comparable but give a plausible general indication of the observed effect. The results are presented as a narrative of the study findings. Two independent authors verified the review process.

Findings

Effect of diverse and non-diverse local food rations on stunting

Table 1 summarizes the findings of the selected empirical studies. The evidence from the review is mixed. This is despite the moderate to high strength in study designs [41, 43], the use of recommended animal source foods, the supplements/rations containing one to seven foods, and the studies targeting the "window of opportunity" i.e. children below the age of 24 months [9, 44]. Three of the four studies find no significant effect of introduced locally available foods on stunting. We find one positive effect for linear growth but this was not sustained (Table 1). There was evidence of failure to reverse progression to stunting [40, 41] or to sustain benefits [43]. The enrolment age ranged from 3 months [43] to 25 months[42]. The other two studies had mean enrolment age of 6 and 14 months respectively [40, 41].

We find that none of the studies reported their findings by age groups to which would have shown whether there were any potential effects or if benefits were heterogeneous with age. Since growth velocity varies by age and risk to stunting increases between 12 and 18 months in areas endemic to stunting, the lack of age group analysis may have masked some positive results [6]. One study instructed parents to give meat as the only complementary food in the "early weeks" of the study or with a minimum of other foods for an unspecified duration to maximize the 15g intake of meat per day [41]. The study does not state whether this instruction was adhered to by parents or if other locally available foods were withheld as most children were enrolled from the age of six months which is deemed the appropriate age to introduce other foods. This could bias the finding. One study targeted children from the age of three months contrary to exclusive breastfeeding guidelines [43]. The overall lack of effect in the studies could be of the result of other factors than food. Also, food was also given as take home rations likely to be shared as evident in most cultures [40, 41]. Overall, these inconsistencies in findings are similar to previous studies of various age groups and contexts [27, 45, 46]

Though animal sources foods are perceived to be a vital source of micronutrients necessary for growth, only milk increased linear growth [41, 42]. We also find that the studies do not clarify whether the food intervention was part or the core of the family diet or if the families that were given the nutrition counselling increased their consumption of the food that was promoted. As other studies note, there are inconsistencies on the number and motivation for the type of foods given in these types of interventions [47]. Hence the complex interactions and cumulative effects cannot be captured well by attempting to study the effects of single dietary components [48], yet this was the focus of two studies under review [41, 43].

The studies find significant positive effects of the provision of local foods on the prevention of wasting and underweight [40, 43]. Unlike wasting which is a measure of current under nutrition, there is some evidence to suggest that linear growth is influenced by change over time. Similar to other studies on stunting, maternal characteristics of education and height were associated with significant changes in length Z-Scores [40, 42].

Discussion

Our objective was to do an evidence based review on the effects of interventions that use locally available foods to prevent stunting. We find a consistent result that stunting was not impacted by local foods in the four studies. The studies did show consistent positive effects on wasting and underweight, with maternal indicators mediating these effects. We note that one study in this review was the first ever to investigate the effect of a single animal source food compared to that of fortified food blends [41].

This review largely confirms previous findings that show minimal impact of and little variation in the effects of supplementing with one or more local food groups on stunting [1, 49]. There are several possible explanations for these findings. Firstly, the overall lack of effect on stunting maybe explained by the fact that interventions that focus on the child and not pre natal nutrition are better suited for the treatment of short term under nutrition in children, such as wasting, or might work better in contexts of acute food insecurity [50, 51]. Moreover, long term effects were not determined at the end of the interventions due to short duration and other factors such as high disease burden [48]. Since the reviewed studies were preventive and excluded malnourished children, our findings contradict previous evidence where preventive rather than recuperative models were reported to work better on nutrition indicators such stunting [50]

Secondly, research by Jacques and Tucker (2001), concludes that in practice, there is insufficient knowledge and consensus on what actually is the healthiest diet[52]. This is clearly shown by the large number of existing dietary scores that attempt to express overall dietary quality [53]. However, the extent to which dietary quality scores and data-driven approaches help to generate new insights into the relationships between dietary intake and diet-related diseases such as stunting remains debatable [54]. For this reason, it is often difficult to separate out the specific effects of nutrients or foods despite the common practice of examining the role of single nutrients or foods in relation to disease risk [52]. The studies reviewed were heterogeneous in food type, number of foods, food groups, duration and the mean age at start of the controlled trials. Therefore we find insufficient evidence to conclusively assert that a diverse or non-diverse diet has superior or inferior nutritional benefits.

Thirdly, although only RCTs can prove a causal relation between a dose and a response, conducting nutrition related trials is a difficult task and inherently flexible [30, 55]. The relationship of a diet "exposure" and health outcome is challenging to establish because conceptually, pathways are many as explained by biological [17], socio economic [2, 20] and family functional behavioural models [17, 18, 56]. For example, contrary to the Grossman model, there is evidence at household level to suggest that considering a household as a unitary unit in the production of health model is not a sufficient approach [21, 23, 57]. How the child is fed depends on household decisions on how to maximize a health-nutrition production function under resource constraints. Decisions are not entirely unitary and intra household resource allocation or gender differences exist[58]. The investment decisions that households make reflect that although health is a means to an end- "it's desired but not above all else" [59].Therefore our findings need to be interpreted with caution.

Consistently, our review finds that maternal characteristics such as education and height mediate the effects of local foods on linear growth [28, 60]. The effect of maternal influences on a child's improved nutrition status can be examined through the framework of the Health Behaviour Model [18]. In the health behavioural model, reasoned action is influenced by the expected value of benefits on the basis of knowledge. It has been noted that where appropriate foods are available, the barrier to good nutrition is attitude and knowledge on feeding practices [28, 61]. Evidence shows the influence of maternal factors on the nutrition of deprived children whose mothers had limited education[62]. Therefore one pathway from poor dietary intake to appropriate care giver behaviour and linear growth is through the education and behaviour change effect.

Finally, we agree with the suggestion that the applicability of theories in the field of nutrition in different cultural contexts should be explored [17, 20, 63]. Krebs, Wright [41] highlight that stunting may have different origins in diverse settings. Jacques and Tucker [52] assert that a nutrient- or food-based approach to examining disease risk seems backward. He concluded "Why not identify healthy eating patterns and then study the components of those diets?" Briend and Dewey [64], propose that "dietary counseling should move away from "fit for all' and provide nutritionally adequate and locally adapted diets with a better understanding of how to provide and deliver effective nutrition dietary counseling."

Research implications

The evidence from this review suggests that we cannot conclude whether one or more local foods are the key to why some children thrive in resource poor contexts. Also few studies have been designed to capture this effect. The review cautions the presumption or widely held paradigm that dietary diversity is the standard input for preventing stunting. We note that the weaknesses in the studies reviewed may relate to the short duration of exposure to the intervention, the lack of age specific category analysis and the heterogeneity of explanatory and outcome variables. At present dietary diversity scores are the primary indicator for assessing dietary adequacy. Future research could establish other measures to relate one or more types of food exposure to nutritional status. Future research on non-diverse and non-stunted, and diverse and stunted populations could address some of the gaps identified.

Conclusion

This review set out to assess the effects of interventions using locally available foods to prevent stunting. We find that only four studies have been designed to answer this question directly using unfortified foods. We find insufficient evidence to conclusively assert that a locally available diverse or non-diverse diet has superior or inferior benefits on stunting. The review partially substantiates the challenges of attributing stunting to the quality of diet and threshold of food groups. The findings of our review certainly contribute to the debate on the entire concept of the diversity of food groups, especially whether or not dietary diversity is important for the prevention of stunting or whether dietary diversity should be a key notion in nutrition messages. Future research should also focus on the interaction between caregiver practices and local diets.

As some of our findings show positive effects from local foods such as milk, perhaps nutrition programs should consider investing in all inclusive social and behaviour change strategies to influence decisions that optimize the use of local foods and available resources within household production functions. Future research should focus on learning what behaviours are adopted by families to gain positive nutritional returns under nutritional stresses. Our study and previous reviews point to the complex nature of addressing stunting and we therefore recommend an approach that ensures that policy and dietary guidelines are informed by what works locally and responds to changing food patterns and the environment.

Authorship Contributions

Mutinta Nseluke Hambayi led the literature search and drafting of the first version of this manuscript. Wim Groot and Nyasha Tirivayi supervised overall content with continual guidance, feedback, and support. Wim Groot and Nyasha Tirivayi critically reviewed and revised the subsequent drafts of it prior to finalisation. All authors read and approved the final submission.

References

1. Theron, M., et al., *Inadequate dietary intake is not the cause of stunting amongst young children living in an informal settlement in Gauteng and rural Limpopo Province in South Africa: the NutriGro study.* Public health nutrition, 2007. **10**(04): p. 379-389.
2. Frongillo, J.E.A., M. de Onis, and K.M. Hanson, *Socioeconomic and demographic factors are associated with worldwide patterns of stunting and wasting of children.* The Journal of nutrition, 1997. **127**(12): p. 2302.
3. Victora, C.G., et al., *Worldwide timing of growth faltering: revisiting implications for interventions.* Pediatrics, 2010. **125**(3): p. e473-e480.
4. Turck, D., et al., *World health organization 2006 child growth standards and 2007 growth reference charts: a discussion paper by the committee on nutrition of the European society for pediatric gastroenterology, hepatology, and nutrition.* Journal of pediatric gastroenterology and nutrition, 2013. **57**(2): p. 258-264.
5. World Bank, W., unicef, *Joint Child Malnutrition estimates* 2012.
6. World Bank, *(2010) Nutritional Status and Poverty in Sub-Saharan Africa.* 2010.
7. Hoddinott, J., et al., *Adult consequences of growth failure in early childhood.* The American journal of clinical nutrition, 2013. **98**(5): p. 1170.
8. Piwoz, E., S. Sundberg, and J. Rooke, *Promoting healthy growth: what are the priorities for research and action?* Advances in nutrition (Bethesda, Md.), 2012. **3**(2): p. 234-241.
9. Bhutta, Z.A., et al., *What works? Interventions for maternal and child undernutrition and survival.* The Lancet, 2008. **371**(9610): p. 417-440.

10. Meenakshi, J.V., et al., *How Cost-Effective is Biofortification in Combating Micronutrient Malnutrition? An Ex ante.* World Development, 2010. **38**(1): p. 64.
11. Arimond, M. and M.T. Ruel, *Dietary diversity is associated with child nutritional status: evidence from 11 demographic and health surveys.* The Journal of nutrition, 2004. **134**(10): p. 2579.
12. Ecker, O. and M. Qaim, *Analyzing Nutritional Impacts of Policies: An Empirical Study for Malawi.* World Development, 2011. **39**(3): p. 412-428.
13. Onyango, A.W., *Dietary diversity, child nutrition and health in contemporary African communities.* Comparative Biochemistry and Physiology, Part A, 2003. **136**(1): p. 61-69.
14. Schönfeldt, H.C. and N. Gibson Hall, *Dietary protein quality and malnutrition in Africa.* British Journal of Nutrition, 2012. **108**(S2): p. S69-S76.
15. Wishik, S.M. and S. Vynckt, *The use of nutritional'positive deviants' to identify approaches for modification of dietary practices.* American Journal of Public Health, 1976. **66**(1): p. 38-42.
16. Victora, C.G., *Commentary: Participatory interventions reduce maternal and child mortality among the poorest, but how do they work?* International journal of epidemiology, 2013. **42**(2): p. 503.
17. Mosley, W.H. and L.C. Chen, *An analythical framework for the study of child survival in developing countries.* Bulletin of the World Health Organization, 2003. **81**(2): p. 140-145.
18. Simons-Morton, B., *Health Behavior in Ecological Context.* Health Education & Behavior, 2013. **40**(1): p. 6-10.
19. Hill, K., *Frameworks for studying the determinants of child survival.* Bulletin of the World Health Organization, 2003. **81**(2): p. 138-139.
20. Andersen, R., *[Besprechung von:] Grossman, Michael: The demand for health. A theoretical and empirical investigation. New York, London 1972.* Journal of economic literature, 1973. **11**(4): p. 1417-1419.
21. Jacobson, L., *The family as producer of health - an extended Grossman model.* Journal of health economics, 2000. **19**(5): p. 611-637.
22. McLeroy, K.R., et al., *An ecological perspective on health promotion programs.* Health Education & Behavior, 1988. **15**(4): p. 351-377.
23. Tirivayi, J.N., *The welfare effects of integrating AIDS treatment with food transfers : evidence from Zambia*. 2011, Maastricht university
24. Zeitlin, M.F., et al., *Positive deviance in child nutrition: with emphasis on psychosocial and behavioural aspects and implications for development*. 1990: United Nations University Tokyo.
25. Paul, K.H., et al., *Beyond food insecurity: how context can improve complementary feeding interventions.* Food Nutr Bull, 2011. **32**(3): p. 244-53.
26. Chiappori, P.A., et al., *"Collective" Models of Household Behavior: The Sharing Rule Approach*. 1992: DELTA.
27. Dewey, K.G. and S. Adu-Afarwuah, *Systematic review of the efficacy and effectiveness of complementary feeding interventions in developing countries.* Matern Child Nutr, 2008. **4 Suppl 1**: p. 24-85.
28. Imdad, A., M.Y. Yakoob, and Z.A. Bhutta, *Impact of maternal education about complementary feeding and provision of complementary foods on child growth in developing countries.* BMC Public Health, 2011. **11**(Suppl 3): p. S25.
29. Gartner, A., et al., *Has the first implementation phase of the Community Nutrition Project in urban Senegal had an impact?* Nutrition, 2007. **23**(3): p. 219-28.
30. Brannon, P.M., C.L. Taylor, and P.M. Coates, *Use and Applications of Systematic Reviews in Public Health Nutrition.* Annu Rev Nutr, 2014.
31. Remans, R., et al., *Multisector intervention to accelerate reductions in child stunting: an observational study from 9 sub-Saharan African countries.* The American Journal of Clinical Nutrition, 2011. **94**(6): p. 1632-1642.
32. Penny, M.E., et al., *Effectiveness of an educational intervention delivered through the health services to improve nutrition in young children: a cluster-randomised controlled trial.* The Lancet, 2005. **365**(9474): p. 1863-1872.

33. Lefebvre, C., E. Manheimer, and J. Glanville, *Searching for studies.* Cochrane handbook for systematic reviews of interventions. New York: Wiley, 2008: p. 95-150.
34. Adair, L., *Only Mothers Know: Patterns of Infant Feeding in Traditional Cultures*. 1986, American Anthropological Association. p. 756-757.
35. Moher, D., et al., *Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement.* International Journal of Surgery, 2010. **8**(5): p. 336-341.
36. Sguassero, Y., et al., *Community-based supplementary feeding for promoting the growth of children under five years of age in low and middle income countries.* Cochrane Database Syst Rev, 2012. **6**: p. CD005039.
37. UNICEF, W., *Child Stunting Conceptual Framework (UNICEF/WHO 1990; 2013).* 2013.
38. Moher, D. and A.C. Tricco, *Issues related to the conduct of systematic reviews: a focus on the nutrition field.* The American journal of clinical nutrition, 2008. **88**(5): p. 1191-1199.
39. Oxman, A.D. and G.W. Group, *Grading quality of evidence and strength of recommendations.* Bmj, 2004. **328**(19): p. 1490-4.
40. Tomedi, A., et al., *Feasibility and effectiveness of supplementation with locally available foods in prevention of child malnutrition in Kenya.* Public Health Nutrition, 2012. **15**(04): p. 749-756.
41. Krebs, N.F., et al., *Randomized controlled trial of meat compared with multimicronutrient-fortified cereal in infants and toddlers with high stunting rates in diverse settings.* The American journal of clinical nutrition, 2012. **96**(4): p. 840-847.
42. Long, J.K., et al., *Meat and milk intakes and toddler growth: a comparison feeding intervention of animal-source foods in rural Kenya.* Public health nutrition, 2012. **15**(06): p. 1100-1107.
43. van der Merwe, L.F., et al., *Long-chain PUFA supplementation in rural African infants: a randomized controlled trial of effects on gut integrity, growth, and cognitive development.* The American journal of clinical nutrition, 2013. **97**(1): p. 45-57.
44. Prentice, A.M., et al., *Critical windows for nutritional interventions against stunting.* The American journal of clinical nutrition, 2013. **97**(5): p. 911.
45. Mary, A. and T.R. Marie, *Dietary Diversity Is Associated with Child Nutritional Status: Evidence from 11 Demographic and Health Surveys1,2.* The Journal of Nutrition, 2004. **134**(10): p. 2579.
46. Ali, D., et al., *Household Food Insecurity Is Associated with Higher Child Undernutrition in Bangladesh, Ethiopia, and Vietnam, but the Effect Is Not Mediated by Child Dietary Diversity.* The Journal of Nutrition, 2013. **143**(12): p. 2015-2021.
47. Girard, A.W., et al., *The effects of household food production strategies on the health and nutrition outcomes of women and young children: a systematic review.* Paediatric and Perinatal Epidemiology, 2012. **26**(s1): p. 205-222.
48. Masset, E., et al., *Effectiveness of agricultural interventions that aim to improve nutritional status of children: systematic review.* BMJ, 2012. **344**.
49. Darapheak, C., et al., *Consumption of animal source foods and dietary diversity reduce stunting in children in Cambodia.* International Archives of Medicine, 2013. **6**: p. 29.
50. Ruel, M.T., et al., *Age-based preventive targeting of food assistance and behaviour change and communication for reduction of childhood undernutrition in Haiti: a cluster randomised trial.* Lancet, 2008. **371**(9612): p. 588-95.
51. Horton, R., *Maternal and child undernutrition: an urgent opportunity.* The Lancet, 2008. **371**(9608): p. 179-179.
52. Jacques, P.F. and K.L. Tucker, *Are dietary patterns useful for understanding the role of diet in chronic disease?* The American journal of clinical nutrition, 2001. **73**(1): p. 1-2.
53. Ocké, M.C., *Evaluation of methodologies for assessing the overall diet: dietary quality scores and dietary pattern analysis.* The Proceedings of the Nutrition Society, 2013. **72**(2): p. 191-9.
54. Kennedy, G., et al., *Proxy measures of household food consumption for food security assessment and surveillance: comparison of the household dietary diversity and food consumption scores.* Public Health Nutrition, 2010. **13**(12): p. 2010-2018.
55. Lichtenstein, A.H., E.A. Yetley, and J. Lau, *Application of systematic review methodology to the field of nutrition.* The Journal of nutrition, 2008. **138**(12): p. 2297-2306.

56. Paudel, R., et al., *Risk factors for stunting among children: a community based case control study in Nepal.* Kathmandu Univ Med J (KUMJ), 2012. **10**(39): p. 18-24.
57. Hoddinott, J., H. Alderman, and L. Haddad, *Testing competing models of intrahousehold allocation.* Intrahousehold Resource Allocation in Developing Countries, 1997: p. 129-41.
58. Tirivayi, N. and W. Groot, *Health and welfare effects of integrating AIDS treatment with food assistance in resource constrained settings: a systematic review of theory and evidence.* Social Science & Medicine, 2011. **73**(5): p. 685-692.
59. Wagstaff, A., *The demand for health: theory and applications.* Journal of epidemiology and community health, 1986. **40**(1): p. 1-11.
60. Kabahenda, M.K., et al., *Promoting dietary diversity to improve child growth in less‐resourced rural settings in Uganda.* Journal of Human Nutrition and Dietetics, 2014. **27**: p. 143-151.
61. Bourguignon, F., *The cost of children: May the collective approach to household behavior help?* Journal of Population Economics, 1999. **12**(4): p. 503-521.
62. de Neubourg, C., et al., *Cross-Country MODA Study.* 2012.
63. Becker, M.H., et al., The Health Belief Model and prediction of dietary compliance: a field experiment. Journal of health and social behavior, 1977. 18(4): p. 348-366.
64. Briend, A. and K.G. Dewey, Complementary Feeding: Keeping The Message Simple. Journal of Pediatric Gastroenterology and Nutrition, 2013: p. 1.

Tables and Figures

Figure1. Flow chart of evidence search and selection

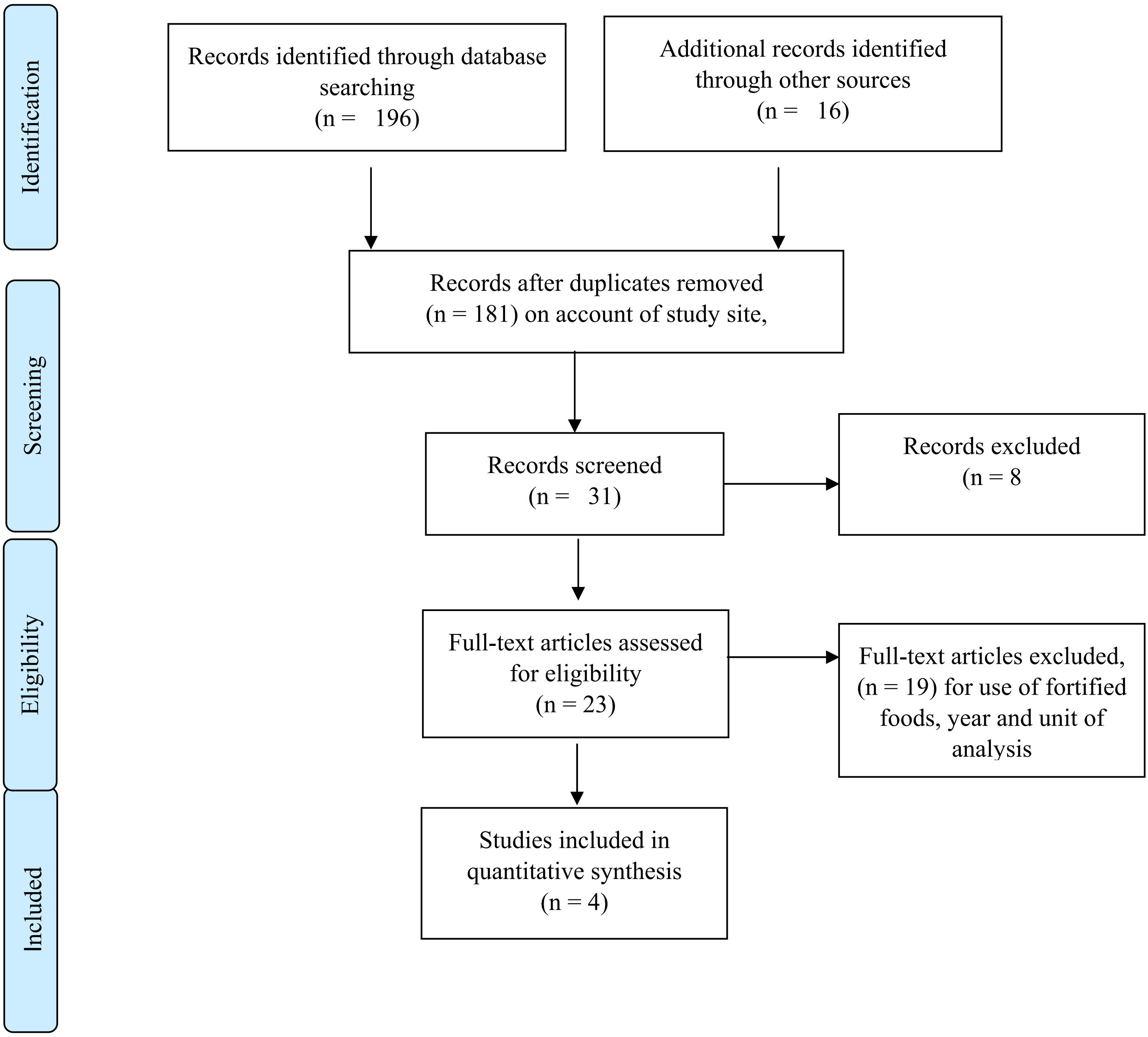

Table 1: Empirical Studies on interventions using locally available foods and stunting; 2012-2014[1].

Citation, and Study country	Design, sample size, Age range at enrolment[2]	Duration (in months) and Data collection intervals	Number and food items	Mean age at enrolment	Independent Variables	Dependent Variables	Statistical method of analysis/ Treatment[3] effects (SE/OR)	Heterogeneous effects - scoring[4]	Findings on Stunting	Study strength and Global Rating [5]
Tomedi, Rohan-Minjares [40] Kenya	Quasi-Experimental Intervention group n= 129 children*, Control n = 147 Enrolled from 6-20 months.	7 months 4 times at unspecified intervals	7 food groups Millet 150g, Pigeon peas 25g, Milk125g, Eggs 50g, Vegetable oil 10g, Mango 100g, Sugar 10g	Age at baseline Intervention group 14.0 Control group 13.2 No other significant differences at baseline	Dietary Diversity (24hr recall), disease, maternal education,	Stunting Wasting Underwt	***Multivariate mixed effect models*** Stunting - SE 0.12 vs 0.09; P<0.09 Wasting SE 0.13 vs 0.07; P<0.001 Underweight SE 0.07 vs 0.05 P<0.001 Wt/age 0.82 (P<0.001), wt/ht (1.19, P< 0.001) ht/age -0.20 (p<0.09)	50% (4/8)	No differences on stunting between groups but significant effect on wasting (0% vs 8.9%, P=0.0002) and underweight (6.3%vs 23% p=< 0.0001) significant at 7 months	Moderate = 2 Less than four strong rating and one weak rating on, low replicability, non-randomized, non-blinded

1 Although search period extended from 2000, the criteria yielded four studies from 2012-2014

2 Sample for treatment and control not necessarily adding to give total due to exclusions and withdrawals. Cited as reported.

3 SE of intervention group cited first and compared to control or non-intervention group

4 Quality grading source: http://www.nccmt.ca/uploads/registry/QATool.pdf, Mc Master University school of Nursing 2011

5 Quality grading source: http://www.nccmt.ca/uploads/registry/QATool.pdf, Mc Master University school of Nursing 2011

Long, Murphy [42] Kenya	Case comparison study randomized n= 303 enrolled from 11-40 months old; Meat n= 81 Milk n= 97 Plain porridge = 96	5 months 2 times, baselines and end line	Animal source Foods (ASF) with 1 food group without ASF and 2 food groups in intervention group respectively fed on Millet porridge, Porridge and milk, Porridge and meat	Mean Age at baseline Meat 25.7 Milk 25.2 Plain porridge 25.4 Similar baseline characteristics	Dietary diversity(24 hr recall) age, SEC severity of child illness exposure, maternal height, B/feeding,	Stunting, Wasting,	***Multiple regression, fixed effects covariates for heterogeneity***. Effects Linear growth significant for milk than meat group (P= 0.0025) MUAC slope for Plain porridge greater than meat (p=0.0046), milk MUAC greater than meat (p=0.0418) milk and plain porridge Meat SE 0.321 vs 0.309 vs 0.304 Wasting - Meat SE 0.348 vs 0.341vs 0.349 Baseline morbidity severe (25%) moderate (58%)	63% (5/8)	No significant difference in stunting between meat, plain porridge and milk group or meat and plain porridge. Neither milk nor meat had any greater effect on growth than porridge. Effect significant for milk group (p<0.05) compared to meat group on linear growth. Energy intake important for toddler growth but meat has inconclusive effect on growth. Baseline milk intake, maternal height associated with great height plus MUAC and weight outcomes for milk only (P= 0.05).	Moderate = 2 Moderate on account of allocation bias, no control, and slight change in protocol.
Krebs, Wright [41]DRC(Guatemala, Pakistan) Zambia	RCT n= 532 infants from 6 months for each of the countries Meat n=532 Cereal n=530	12 months 4 times at baselines, 6, 9 and end line at 18 months	1 food group in design Meat (beef or Pork 30-45g), given as only food at entry for few weeks to maximize infant meat intake, mashed or pureed. Information on child feeding according WHO guidelines given to caregivers	Age at entry 6 months Significant difference only on paternal education at baseline	Treatment-meat mother -education height, morbidity e.g. malaria, child gender	Linear Growth Velocity (Stunting) wasting , underweight and Dietary Diversity score, Food variety score,	***Multivariate, linear and logistic models*** Linear velocity 1.00 (95% CI 0.99-1.02) vs 1.02 (95% CI 1.00, 1.04) cm/month for meat and cereal group.	87% (7/8)	Linear velocity did not differ between treatment groups (-ve). Progressive linear growth faltering not reversed or prevented. Only mother education and mother height associated with linear velocity (P< 0006 and 0.003 respectively). Stunting increased by 33% The lack of effect of meat or fortified food blends to reverse stunting progression argue for multifaceted pre and early post-natal periods.	Strong = 1 Four strong ratings with no weak rating. scored 1 on all component ratings

van der Merwe, Moore [43] The Gambia	RCT n= 172 for children 3 to 9 months old Treatment group range in sample size n= 73 to 87) Control range in sample size 65 to 85. Sample size varied depending on analysis covariate	6 months 2 times baseline 3 months and at 9 months end line	1 food item and family foods. Treatment food is purified fish oil 2mls/ or 2ml olive oil, duration 6 months. Both commodities designed to achieve increase in n-3 poly Unsaturated fatty Acids (PUFA) and family foods, rice porridge, margarine, bread, mayonnaise, bananas, cooking oil	Age at entry 3 months	Fish oil or Olive oil	Stunting, Wasting, gut integrity, Cognitive development	***Multivariate, linear and binomial regression models*** Stunting Effect Size-0.79 z score (95% CI - 0.27, 0.90; p= 0.084); MUAC Zscore 0.31 (95% CI 0.06, 0.56; p=0.017); Wasting ES= 0.12 (-0.14, 0.38); p=0.377 Morbidity, and maternal education showed no difference either	63% (5/8)	Linear growth positive for fish oil but effect not sustained at 12 months, Mid Upper Arm circumference (MUAC) sustained at 12 months. No differences for morbidity between treatment groups Trial has insufficient evidence to test hypothesis that dietary fish oil improves n-3 3 LC - PUFA improves growth performance in rural African children or gut integrity and fish oil increase in n-3 PUFA but not sustained.	Strong = 1 Four strong ratings with no weak rating. scored 1 on all component ratings

The UNU-MERIT WORKING Paper Series

2015-01 *How does firms' perceived competition affect technological innovation in Luxembourg?* by Wladimir Raymond and Tatiana Plotnikova

2015-02 *The effect of supplementation with locally available foods on stunting. A review of theory and evidence* by Mutinta Nseluke Hambayi, Wim Groot and Nyasha Tirivayi