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Supplementary feeding for improving the health of disadvantaged infants and children

What works and why?

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Systematic
Review
Summary 5

Health Services



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About this summary

Supplementary feeding for improving the health of disadvantaged infants and children: what works and why?, 3ie Systematic Review Summary 5, is a summary of the full review, *Supplementary feeding for improving the physical and psychosocial health of disadvantaged infants and children aged three months to five years: what works and why? A combined systematic and realist review*, which is available with all of its appendixes on the [3ie website](#).

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Supplementary feeding for improving the health of disadvantaged infants and children: what works and why?

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Summary

This report – a summary of a systematic review and a realist review – examines the evidence on whether supplementary feeding, a strategy to provide additional food to disadvantaged children, can improve the health of children between three months and five years of age. It covers both physical health (including weight, height and illness) and psychosocial health (including mental development, attention, language and memory).

Children who survive early and persistent undernutrition may experience lifelong consequences: undernutrition may cause permanent changes in physiology and metabolism, and has been increasingly linked to chronic diseases including obesity, hypertension, diabetes, stroke and coronary heart disease. These long-term consequences of undernutrition highlight the need for governments, funding agencies and non-governmental organisations to intervene early in childhood.

Supplementary feeding: a strategy to improve the health of disadvantaged children

Objectives

Supplementary feeding programmes for children vary greatly, but the long-term goals generally include improved survival, improved growth and health, and normal cognitive and behavioural development. Some supplementary feeding programmes have the intermediate goal of curing (or at least ameliorating) existing undernutrition, while others aim to prevent undernutrition.

Programme design

Supplementary feeding programmes are designed to intervene early in the life of disadvantaged children for long-term effects on health and wellbeing. Programmes usually provide additional food to increase the amount of energy that children receive, but the focus can also be on providing supplementary foods that contain micronutrients (vitamins and minerals). Some programmes emphasise the use of locally available ingredients in supplementary foods, while others provide pre-cooked or ready-to-mix food or pastes (typically based on a regional staple such as peanuts) that can be consumed from the packet or as a spread.

Programmes can be delivered in the community (such as in health facilities, refugee camps or preschools and day-care centres) or in the home (in programmes that deliver food directly to homes or distribute supplementary foods in community settings to be taken home). An additional component is often nutrition education for parents or caregivers. Programme designs often include some form of monitoring to check that the targeted child receives the food as intended.

Theory of change

The underlying causes of undernutrition may be broader social, economic and political factors that cause food insecurity. An assumption of supplementary feeding programmes is that supplementary feeding will be sufficient to ameliorate the impact of this food insecurity, and that programmes can be implemented effectively despite the challenging context. Programmes are also affected by the community context, household context and child-specific factors such as the initial nutritional status of the child.

The key assumption underpinning supplementary feeding programmes is that the food provided is consumed by the child as intended. Therefore, programmes need to consider how the contextual factors discussed above may affect delivery. Successful programme implementation relies on making every effort to meet this assumption, using strategies such as supervising the child, confirming that the supplementary food is palatable to the child and acceptable to the family, and ensuring that the programme is accessible to the relevant families.

To be effective, the supplementary food provided needs to be nutritionally adequate (in terms of protein and micronutrients), and to fill the gap between the energy a child receives from usual meals at home and his or her energy requirements. Another assumption is that the delivery of additional energy and micronutrients will indeed lead to physical and psychosocial health outcomes, and this assumption is strongly supported by research.

Review findings

What difference do supplementary feeding programmes make?

The systematic review showed that providing supplementary food to young children in low- and middle-income countries had small but statistically significant positive effects on weight and height (0.12 kg gain for weight and 0.32 cm increase in height over six months in the most rigorous trials). Positive effects were also seen for other physical outcomes such as height-for-age scores, weight-for-height scores and haemoglobin levels. Although results were mixed, there is some evidence that children given supplementary food showed improvements in psychomotor development compared to those who were not given additional food. Two of three studies showed significant positive changes in cognitive development. Only eight of 34 studies in the systematic review assessed the impact of supplementary feeding on psychosocial development: the results suggest supplementary feeding has a small to medium effect.

What factors affect the success of supplementary feeding programmes?

The systematic review showed that supplementary food was more effective for children less than 2 years of age, and for those who were poorer or less well-nourished. Studies that provided a greater proportion of the recommended daily allowance for energy and supervised feeding to ensure the child consumed the food as intended showed greater effectiveness. The importance of supervision is highlighted by the finding that when the food was home-delivered or in the form of take-home rations, children took in an average of 36 per cent of the energy in the supplementary feed. However, when the food was given at preschool or day-care centres, children took in an average of 85 per cent of the energy in the supplement.

The realist review found that prerequisites for programme success included the quality and quantity of the supplement, and a reliable supply chain. Five key mechanisms were identified as supporting programme success: (1) the supplement matched the child's needs; (2) measures were in place to ensure that the child received and consumed the supplement as well as the usual diet; (3) the caregiver was capable of learning and changing in response to any intervention; (4) the caregiver was receptive and responsive to the particular intervention offered; and (5) programme staff were motivated and capable of maintaining the supply chain, supporting caregivers in delivering the supplement and adapting their efforts in accordance with local progress data.

Implications

For programme design and implementation

The reviews found that supplementation is more effective if provided during the critical window for growth, which is before the age of 2 years. It takes time for supplementary foods to affect some aspects of growth and cognitive development, so programmes that continue for between 18 months and two years may be better able to demonstrate outcomes. There is also some evidence that poorer and undernourished children may be more responsive to supplementary feeding, so if funding is limited it can be appropriate and cost-effective to target these children.

Children take in more total energy if supplementary feeding is delivered in a supervised feeding or day-care centre, or at preschool, which leads to greater benefits in terms of growth and development. To meet the energy gap between the child's needs and current intake, programmes should aim to supply more than 30 per cent of the dietary reference intake for energy. Children are more likely to consume supplementary food that is palatable, culturally acceptable and energy- and nutrient-dense.

Family capacity is key to sustainability: by working with parents, caregivers and the community, programmes can enhance their motivation and capacity to deliver supplementary foods to their children. While emphasis should still be placed on providing adequate nutrition to the child most in need within the family, providing rations to reduce sharing of the supplementary food may be a useful strategy for programmes to adopt, and programmes may wish to also measure outcomes on a family basis, rather than just an individual basis.

Regularly monitoring children's dietary intake, growth and development can provide programme staff with useful information on how to adapt to local settings.

For future research

The results of the reviews suggest that more high-quality research on supplementary feeding programmes for young children is required, particularly on their potential to improve psychosocial outcomes. Other gaps in research include the optimum age for feeding programmes (with a focus on whether such programmes are effective in older children), the impact of gender (including whether supplementary feeding is more effective for girls, and how to reduce gender-based inequities in household distribution of food) and the sustainability and implementation of large-scale programmes.

Contents

Acknowledgements	i
Summary	ii
List of figures	vi
1 Supplementary feeding: a strategy to improve the health of disadvantaged infants and children	1
1.1 The challenge of undernutrition	1
1.2 Supplementary feeding for disadvantaged children	1
1.3 The need for evidence on the effectiveness of supplementary feeding.....	2
1.4 The review approach.....	2
1.5 Structure of this report.....	4
2 How are supplementary feeding programmes designed and implemented?	1
2.1 Design of supplementary feeding programmes	1
2.2 Implementation of supplementary feeding programmes	2
3 How does supplementary feeding work? The theory of change	4
3.1 Context	4
3.2 Intervention components.....	5
3.3 Intermediate outcomes.....	5
3.4 Impact.....	6
The final component of the theory of change is the longer-term impact, which is improved child development, in terms of growth and cognitive outcomes.	6
4 What difference do supplementary feeding programmes make?	7
4.1 Physical health.....	7
4.2 Psychosocial health	8
5 What factors affect the success of supplementary feeding programmes?	10
5.1 Findings from the systematic review.....	10
5.2 Findings from the realist review.....	11
6 Implications for programme design and implementation, and future research ..	19
6.1 Implications for programme design and implementation.....	19
6.2 Implications for future research	20
Appendix A: Review methodology	23
Appendix B: Studies included in the systematic review	26
Appendix C: Additional studies included in the realist review	29
References	33

List of figures

Figure 1 Studies included in the reviews	3
Figure 2 Energy gap met by supplementary feeding programmes.....	2
Figure 3 Theory of change for supplementary feeding.....	4
Figure 4 Child's capacity to eat the supplement and effect on the success of supplementary feeding programmes.....	12
Figure 5 Caregiver's capacity and effect on the success of supplementary feeding programmes	14
Figure 6 Caregiver's interaction with supplementary feeding programmes and effect on programme success	15
Figure 7 Physiological mechanisms that affect success of supplementary feeding programmes	16
Figure 8 Programme staff capacity and effect on success of supplementary feeding programmes	18

1 Supplementary feeding: a strategy to improve the health of disadvantaged infants and children

Globally, undernutrition is the single biggest contributor to disease.¹ Undernutrition is of particular concern in young children as it can compromise their physical and intellectual development.^{2,3} This report is a summary of a systematic review and a realist review. It examines whether supplementary feeding, a strategy to provide additional food to disadvantaged children, can improve the health of children between 3 months and 5 years of age. It looks at both physical health (including areas such as weight, height and illness) and psychosocial health (including areas such as mental development, attention, language and memory).

1.1 The challenge of undernutrition

The 2015 *State of Food Insecurity in the World* report revealed that, despite significant progress towards reducing world hunger, almost 795 million people worldwide are chronically undernourished. Undernutrition is responsible for about 35 per cent of deaths of children under 5 years of age, and for 35 per cent of child morbidity.⁴ Children who survive early and persistent undernutrition may experience lifelong consequences: undernutrition may cause permanent changes in physiology and metabolism^{5,6} and has been increasingly linked to chronic diseases, including obesity, hypertension, diabetes, stroke and coronary heart disease.⁵⁻¹⁰

Studying the specific effects of undernutrition, separate from the effects of other deprivations experienced by children living in poverty, can be difficult. However, undernutrition early in life has been linked to lowered cognitive functioning (such as memory and attention) and poorer school performance.¹¹⁻¹⁵ Maternal and foetal undernutrition have also been linked to lower educational attainment and lower economic productivity in later life.¹² Several mechanisms have been suggested to explain this link. Studies have shown that malnutrition can decrease motivation and increase anxiety;^{16, 17} similar effects in malnourished children may limit their capacity to interact with their environment and to learn from these interactions.¹⁷⁻¹⁹ Another potential mechanism is that chronic malnutrition in early childhood may result in partially irreversible changes to the brain.²⁰

The long-term consequences of undernutrition highlight the need for governments, funding agencies and non-governmental organisations to intervene early in childhood.

1.2 Supplementary feeding for disadvantaged children

'Supplementary feeding' describes programmes that provide additional food to children to ameliorate or prevent undernutrition. The focus is usually on increasing the amount of energy a child receives, but supplementary foods can also contain micronutrients (vitamins and minerals). The combined systematic and realist reviews looked at supplementary feeding programmes that provide additional energy to children between the ages of 3 months and 5 years, whether in the form of beverages, meals or snacks, with or without additional nutrients and micronutrients. Programmes may provide supplementary foods in preschool, day-care or community settings, or give rations for children to take home, or deliver supplementary foods directly to homes. Some

programmes also provide additional nutrition education to parents and caregivers. The reviews did not include programmes that provide micronutrients only (such as vitamin supplementation) or programmes that use therapeutic foods for children with severe acute malnutrition.

1.3 The need for evidence on the effectiveness of supplementary feeding

Effective programme design calls for evidence on which interventions improve the physical and psychosocial health of disadvantaged children, and whether the effectiveness of interventions is affected by the context and manner of implementation.

In a systematic review, researchers collect all of the studies available on a topic, assess their quality, include the studies that meet rigorous inclusion criteria, and synthesise the results to draw conclusions for policy and practice. To date, there have been only a few systematic reviews on supplementary feeding. Earlier reviews examined only the evidence relating to children under 2 years of age, or evidence from certain types of study designs (randomised controlled trials).^{21, 22} Reviews conducted in the past concluded that there was insufficient high-quality data to draw conclusions about the effectiveness of supplementary feeding²² and noted the lack of evidence on whether supplementary feeding can ameliorate the effects of undernutrition on psychosocial and physical development.⁴

Therefore, there is a need for an up-to-date review of the evidence on the effectiveness of supplementary feeding for children under 5 years that includes a range of study designs and outcomes.

1.4 The review approach

This report summarises the results of both a systematic review and a realist review.

As discussed above, a systematic review involves searching for all studies conducted on a topic, assessing the quality of these studies and whether they meet inclusion criteria, and synthesising the findings to draw conclusions for policy and practice. Researchers can register their protocols for systematic reviews to improve communication and accountability with the research community. This systematic review was registered with the Campbell and Cochrane Collaborations.

As shown in Figure 1, an initial search identified nearly 33,000 potentially relevant studies, which were narrowed down to 34 studies that met the criteria for inclusion. This covered a range of study designs, including randomised controlled trials, quasi-experimental studies and regression-based designs. Of these studies, 26 had data of an appropriate type and quality to use in a quantitative meta-analysis (a statistical technique for summarising the results of several studies into a single estimate). Of the 34 studies included, 31 were from low- and middle-income countries, while three were conducted in resource-poor communities in high-income countries.

In a realist review, researchers outline theories about how a programme might work, examine whether evidence supports these theories, and draw conclusions with a view to understanding and explaining how and why a programme does or does not work in a specific context or for a particular group of people. The realist review included the 34

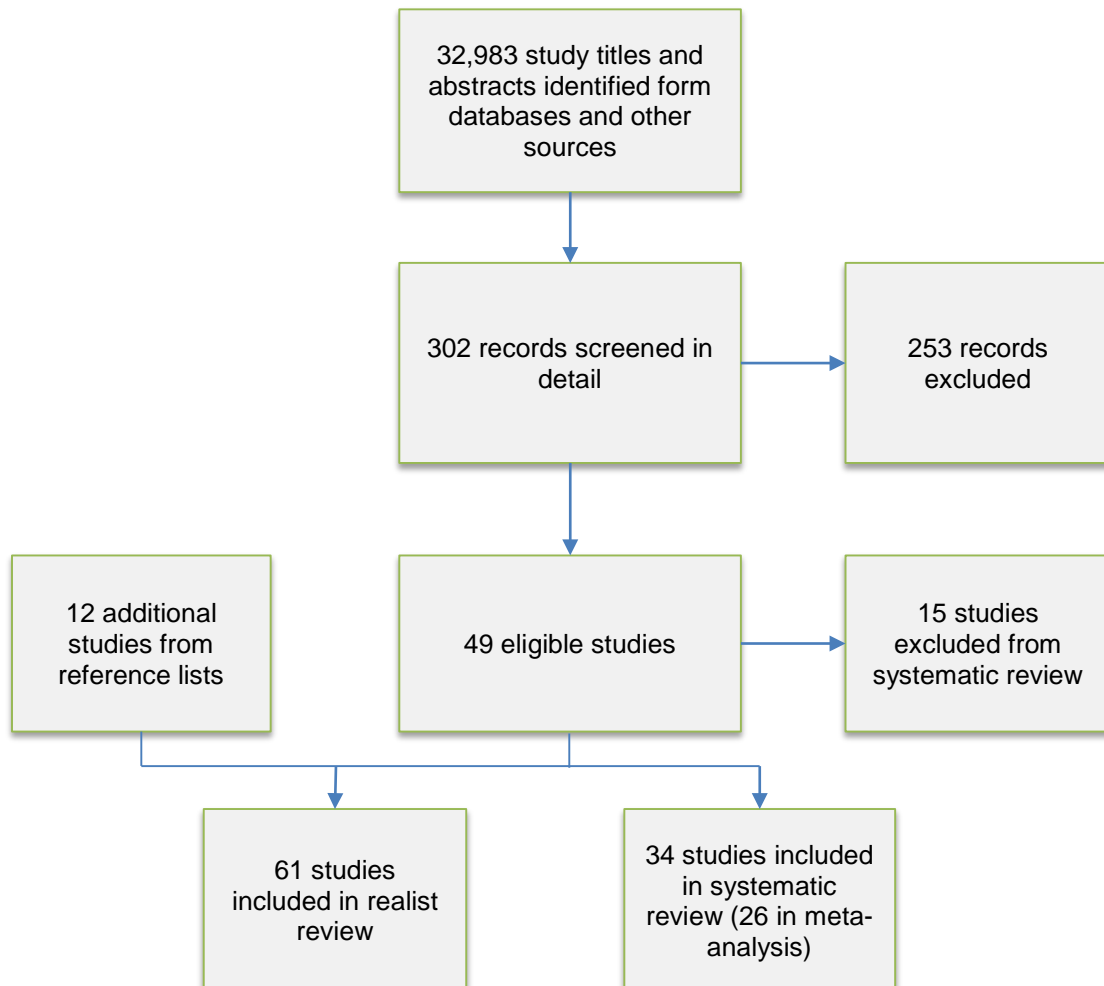
studies from the systematic review, an additional 15 studies that were considered in the systematic review but excluded, and 12 additional papers describing qualitative studies, theories or methodological issues. The realist review applied the reporting guidelines developed by the RAMESES (Realist and Meta-Narrative Evidence Synthesis Evolving Standards) international collaboration.

Both reviews shared the same objectives:

- To assess the effectiveness of supplementary feeding programmes, provided with or without nutritional education, in improving the physical and psychosocial health of disadvantaged children aged 3 months to 5 years
- To assess which elements of the programmes' context and implementation affect their success or failure.

More details on the methodologies are available in the appendix to this report.

Figure 1 Studies included in the reviews



1.5 Structure of this report

Chapter 2 provides an overview of the design and implementation of supplementary feeding programmes. Chapter 3 discusses the theory of change and how such programmes are believed to work. Section Chapter 4 examines the effectiveness of supplementary feeding programmes, reporting on outcomes such as weight gain, psychosocial development and haemoglobin levels. Chapter 5 examines factors that affect the success of supplementary feeding programmes, such as the ability of children and caregivers to engage with the programme, and the motivation, training and flexibility of programme staff. Chapter 6 draws out implications for policy, programme design and implementation, and future research.

2 How are supplementary feeding programmes designed and implemented?

Supplementary feeding programmes for children vary greatly, with differences in the goals of the programme, the type of supplementary foods provided and the location for delivery. This chapter presents an overview on the design of supplementary feeding programmes, and the typical contexts in which they are implemented. It also presents further details on the types of feeding programmes for children that were included in the systematic and realist reviews.

2.1 Design of supplementary feeding programmes

The key elements of programme design for supplementary feeding programmes follow.

2.1.1 Curative or preventative approaches

Supplementary feeding programmes with the goal of curing (or at least ameliorating) existing undernutrition can be blanket (delivered to all children in an area with high rates of moderate acute malnutrition) or targeted (delivered to children identified in screening programmes as having moderate acute malnutrition). Both these types of curative programmes provide cooked meals and take-home rations, and both were included in the reviews. In contrast, therapeutic feeding programmes, which are designed for children screened to have severe acute malnutrition, use specially designed therapeutic food and milk and were therefore excluded from the reviews.

Other supplementary feeding programmes aim to prevent undernutrition. Preventative programmes delivered to children aged 6–24 months are known as complementary feeding programmes, a term that reflects their customary role in complementing breastfeeding. Programmes for older children are known as preschool or nursery school feeding programmes.

Whether preventative or curative, the long-term goals of supplementary feeding programmes generally include improved survival, improved growth, lowered morbidity, and normal cognitive and behavioural development.^{19, 23}

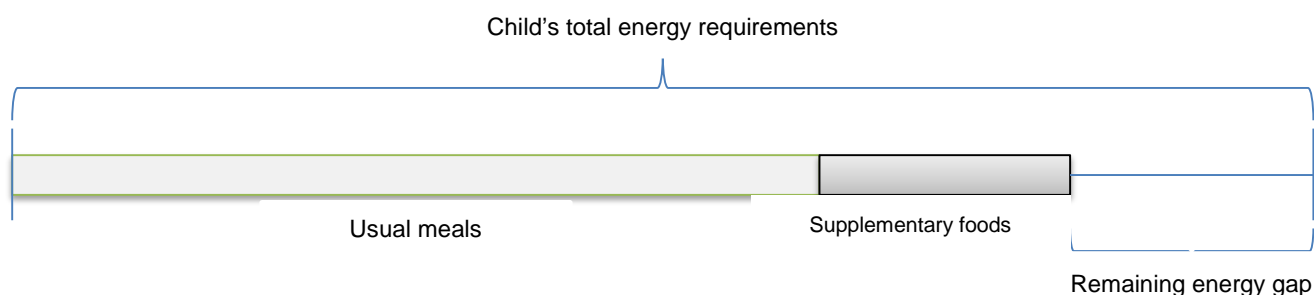
2.1.2 Nutrition education

Supplementary feeding programmes are often delivered alongside nutrition education for parents or caregivers. Such education may include instruction on how to prepare and administer supplementary foods provided by the programme, with an emphasis on using clean water. Some programmes provide nutrition education only, without providing supplementary food. Such programmes were excluded from the reviews.

2.1.3 Type of supplement

The reviews excluded programmes that provide micronutrients only, such as powders or sprinkles containing micronutrients, and focus instead on those that provide energy (along with nutrients and/or micronutrients) through food and drinks. These can include milk, snacks, cooked or uncooked meals, and take-home rations for the child or family. Supplementary feeding programmes are generally designed to meet 40–50% of the estimated gap between the child's energy needs and the energy they are receiving from usual meals. This is shown in Figure 2.

Figure 2 Energy gap met by supplementary feeding programmes



Some programmes emphasise the use of locally available ingredients, while others provide pre-cooked or ready-to-mix food or pastes (typically based on a regional staple such as peanuts) that can be consumed from the packet or as a spread.²⁴⁻²⁸ Such supplements, known as 'ready-to-use therapeutic food', are designed to be easy for the caregiver to prepare and easy for the child to consume.

2.1.4 Setting and monitoring

Supplementary feeding programmes can be delivered in the community (such as in health facilities, refugee camps, or preschools and day-care centres) or in the home (in programmes that deliver food directly to homes or distribute supplementary foods in community settings to be taken home). Programme designs often include some form of monitoring to check that the targeted child continues to receive the food as intended. Monitoring is intended to reduce 'leakage'. Leakage is the term used to describe situations where other family members receive the food intended for an undernourished child, or when the child is fed less at home because the family knows the child is getting additional food while in care.

2.2 Implementation of supplementary feeding programmes

Supplementary feeding programmes have been implemented worldwide, in low-, middle- and high-income countries. Thirty-one of the studies included in the reviews were from low- and middle-income countries, including India, Bangladesh, Jamaica, Indonesia, Columbia, Ecuador, Malawi, Niger, Nigeria, Kenya, Peru, South Africa, Vietnam, Thailand, Brazil, Haiti and Mexico. One study was conducted across four countries: Bolivia, New Caledonia, Congo and Senegal. All of these studies were conducted in poorer settings, including urban and peri-urban slums, and poor rural areas. The three studies from high-income countries were from Australia (providing supplementary food to Aboriginal children), Canada and the United States.

Ten studies – nine in low- and middle-income countries and one from a high-income country²⁹ – delivered the feeding programme at a day-care centre or other community locations, while the remaining studies delivered foods directly to homes. Fourteen studies (13 in low- and middle-income countries and one in a high-income country) conducted strict monitoring of the supplementary feeding, 15 studies conducted moderate monitoring (13 in low- and middle-income countries and two in high-income countries) and five studies provided little monitoring.

In all of the studies, participants were children aged between 3 months and 5 years, from low-income areas or low-income families. In most studies, a high proportion of children had a low weight or height for their age, but very few children were severely malnourished or ill.

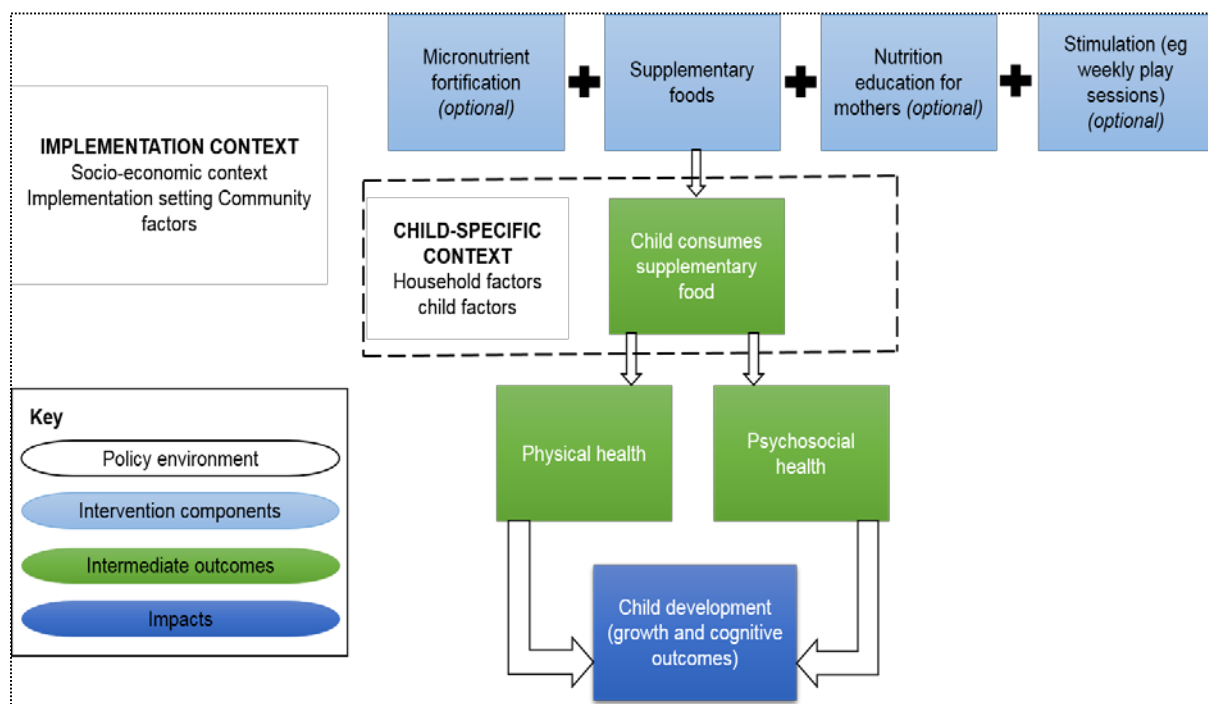
As discussed above, the studies included in the reviews evaluated interventions that provided supplementary food or drink, with or without added micronutrients, whether this food was ready-to-use therapeutic food, milk, locally produced food or cereal mixtures. The proportion of the child's daily recommended intake of energy provided by the supplementary food varied widely, from 8% to 136%. Seven of the programmes^{4, 30-35} provided additional rations for the family (to reduce redistribution of the child's supplement).

Nine studies provided supplementary foods in combination with other interventions. Four studies involved giving psychosocial stimulation (for example, weekly play sessions with a community health aide),³⁵⁻³⁸ four programmes provided other health interventions (such as a community-wide sanitation programme or visits from health workers) and two of these also provided maternal education.^{28, 39, 40} Two programmes provided nutritional education.^{41, 42}

3 How does supplementary feeding work? The theory of change

As discussed in the previous chapter, supplementary feeding programmes are designed to intervene early in the life of disadvantaged children for long-term effects on health and wellbeing.^{43, 44} Figure 3 presents a theory of change, a conceptual model that outlines how supplementary feeding interventions are thought to result in their intended outcomes. This chapter explains the components of the theory of change and explores the underlying assumptions.

Figure 3 Theory of change for supplementary feeding



3.1 Context

The underlying causes of undernutrition may be broader social, economic and political factors that cause food insecurity. It is assumed that the supplementary feeding programme will be sufficient to ameliorate the impact of this food insecurity, and that programmes can be implemented effectively in spite of the challenging context.

This broad context also includes community factors, such as sanitation and water, which greatly affect a child's health. Other community factors may include whether the programme is acceptable to the community, and whether a suitable location, such as a preschool or day-care centre, is available from which to deliver the programme.

Another component of the theory of change is the child-specific context, which acknowledges the importance of the household in which the child lives. Families determine how food is distributed within the household. As discussed in section 2, the effectiveness of supplementary feeding programmes can be reduced if other family

members receive the food intended for an undernourished child, or if the child is fed less at home because the family knows the child is getting additional food while in care. Food distribution can also be affected by local cultural norms, and by the family's size and socioeconomic status. The child-specific context also highlights factors such as the individual child's food preference, appetite, age, gender and baseline nutritional status.

The key assumption underpinning supplementary feeding programmes is that the food provided is consumed by the child as intended. Therefore, programmes need to consider how the contextual factors discussed above may affect delivery, ranging from the political situation through to the individual child's appetite and food preference.

3.2 Intervention components

As shown in the theory of change, the definition of supplementary feeding programmes used for the systematic and realist reviews included programmes with additional components such as psychosocial stimulation and maternal nutrition education. However, the focus is on the consumption of supplementary foods. Successful programme implementation relies on ensuring that the child receives and consumes the food, using strategies such as supervising the child, confirming the supplementary food is palatable to the child and acceptable to the family, and ensuring the programme is accessible to the relevant families.

3.3 Intermediate outcomes

The desired outcome for supplementary feeding programmes is improvement in the physical and psychosocial health of the child. Programmes may measure intermediate outcomes to monitor progress. For physical health, intermediate outcomes may include anthropometric measures (such as weight and height), plasma nutrient levels (such as blood haemoglobin) and reduced infections. For psychosocial health, intermediate outcomes may include culturally appropriate screening and diagnosis.

For a supplementary feeding programme to affect a child's health, the food provided must meet the physiological needs of the child in terms of energy and micronutrients.^{23, 31, 45, 46} Therefore, it is assumed that the supplementary food is nutritionally adequate (in terms of protein and micronutrients) and that it fills the gap between the energy a child receives from usual meals at home and his or her energy requirements.² Supplementary feeding helps to provide a more consistent diet, protecting the child against intermittent or seasonal food shortages.⁴⁷⁻⁴⁹

Another assumption is that the delivery of additional energy and micronutrients will indeed lead to physical and psychosocial health outcomes. The biological mechanisms of this link are well-documented in nutritional literature, and will be explained only briefly here. An improved diet can help bones and brains mature, and the child is able to grow taller and put on weight.⁵⁰ The additional micronutrients may help to increase appetite, reduce the risk of infection and help the child recover faster from infections.^{5, 6, 11, 24}

3.4 Impact

The final component of the theory of change is the longer-term impact, which is improved child development, in terms of growth and cognitive outcomes.

Supplementary food, and the micronutrients it provides, support brain development.^{26, 51, 52} It may be that such development occurs only during a critical age window,⁵³ but this has not been conclusively proven.³⁸ Nutrition can influence the development and function of a young child's brain through several mechanisms: development of brain structure, increased brain volume,² and improved myelination and neurotransmitter function (important aspects of brain function).^{14, 54} Improved nutrition may also improve social behaviour through increased interaction, improved emotional state and lowered anxiety.⁵⁵ Increased social interaction may, in turn, improve cognitive functioning and learning. Better nutrition in the first two years of life is associated with achieving a higher level of schooling.^{56, 57}

Finally, the effects of supplementary feeding may be not only long-term, but also intergenerational. Well-nourished girls grow into well-nourished women who are able to sustain a healthy pregnancy and their offspring are more likely to be born well-nourished.⁵⁸

4 What difference do supplementary feeding programmes make?

This section examines the evidence on improvement in physical and psychosocial outcomes for children resulting from supplementary feeding programmes. It draws on the results of the systematic review of 34 studies (listed in the appendix).

4.1 Physical health

4.1.1 *Weight and height*

Weight gain and linear growth are two common measures used to judge the success of infant feeding programmes, in part because they are simple, rapid and inexpensive to obtain. Weight is often reported as weight gain in kilograms, but it can also be reported as the change in the weight-for-age Z-score, which reports weight against an internationally standardised age- and sex-specific reference determined by the World Health Organization. Similarly, height is reported either as linear growth in centimetres or change in the height-for-age Z-score.⁵⁹

Meta-analyses of studies conducted in low- and middle-income countries show that supplementary feeding has a small, but statistically significant, effect on weight. For example, in a meta-analysis of randomised controlled trials, children given supplementary food gained 0.12 kg more over six months than those who did not receive supplementary food. Of the two studies conducted in high-income countries, one showed no effect on weight, but a study of 116 Aboriginal children in remote communities in Australia found that children receiving supplementary food over a four-month period gained nearly a kilogram more than children who did not receive supplementary food.

Results for height were mixed: meta-analysis of nine randomised controlled trials in low- and middle-income countries found that children who received supplementary food grew an average of 0.32 cm more over six months than those who did not receive supplementary food, but meta-analysis of seven studies with quasi-experimental designs did not show any significant effect on height.

Results from the Oportunidades programme conducted in urban Mexico provide an important reminder of the role of context, as discussed in section 3. Leroy and colleagues⁵⁸ found no significant overall impact on weight or height, but there were significant improvements in weight and height for the youngest children, and improvements in weight for those in the lowest third of the income distribution.

4.1.2 *Haemoglobin*

The concentration of haemoglobin in blood is commonly used as an indicator of nutritional status. Haemoglobin is a protein that carries oxygen around the body. A poor diet – including deficiencies in iron, folate, vitamin B12 and vitamin A – is one of the causes of low haemoglobin concentration.⁶⁰

Supplementary feeding improves haemoglobin levels in children. In a meta-analysis of five randomised controlled trials, supplementary feeding improved haemoglobin levels, and two quasi-experimental trials showed that supplementary feeding reduced the risk of anaemia.^{28, 61}

4.1.3 Illness and death

Studies assessing whether supplementation reduces illness and death show mixed results. Four studies found no difference in the incidence of illness between children who received supplementary food and those who did not, while two studies reported that children who received supplementary food were more likely to be unwell.^{24,30,33,42,77} A range of illnesses were studied as outcomes, including fever, diarrhoea and respiratory infection.

Looking at deaths, Meller and colleagues³⁹ found that a supplementary feeding programme in Ecuador reduced the rate of deaths from 2.5% to 1–1.5%; a 40–60% decrease in the number of deaths. This promising result, however, was not observed in a study in Niger, where there was no difference in deaths between children who received supplementary food and those who did not.

4.2 Psychosocial health

Most of the included studies measured a physical outcome, particularly height or weight, while only eight assessed psychosocial outcomes.

Interestingly, these studies suggest that supplementary feeding has a larger effect on psychosocial outcomes than on physical outcomes. This could be because the studies that assessed psychosocial outcomes were also the studies that had more control over implementation and provided higher-energy supplementary foods. However, it could also be because psychosocial outcomes are more sensitive to nutritional intervention.²¹ 'Brain sparing' is the hypothesis that when a child is given supplemental energy, protein and micronutrients, his or her body will use these resources for brain development first, and for growth and other aspects of health later.⁶² This hypothesis has been supported in studies of animals and of prenatal and newborn growth in humans,^{63, 64} and highlights the importance of including psychosocial outcomes when considering the effectiveness of supplementary feeding programmes.

4.2.1 Psychomotor development

Psychomotor development refers to children developing skills that require both mental skills and motor skills. For example, a common test for psychomotor development, the Bayley Psychomotor Development Index,⁶⁵ tests skills such as rolling, crawling and using utensils. Supplementary feeding programmes may have a positive effect on the psychomotor development of children in low- and middle-income countries, but the evidence for this is mixed.

Of five studies conducted in low- and middle-income countries, two showed that supplementary feeding has a significant effect on psychomotor development, one study showed positive changes for boys but not for girls, one study was mixed and one small study showed no effect.

The possible link between increased nutrition and psychomotor development is complex: increased energy leads to increased myelination (leading to improved electrical activity in the brain), increased alertness and curiosity,⁶⁶ as well as increased motor activity, which in turn leads to improved psychomotor development.⁶⁷ Context is again relevant:

Gardner and colleagues⁶⁶ suggest that the effects of nutrition on increased motor activity might be dependent on the home environment or the age of the child, or both. They hypothesise that the quality of play and exploration might be more important for child development than the quantity of increased activity. Clearly, more carefully developed studies of the mechanisms which may link improved nutrition to psychosocial development are needed.

4.2.2 Mental development, intelligence and cognition

Two out of three studies conducted in low- and middle-income countries showed that supplementary feeding has moderate effects on mental and cognitive development; the other study showed no effect. A study conducted in Indonesia showed that, compared to children receiving lower-energy supplementary foods, children aged 12 months receiving higher-energy supplementary foods for a year walked earlier, had higher scores on the Bayley Scale and showed more mature social and emotional regulation.^{68, 69} The other study showing effects was conducted in Colombia, and showed that after 21 months of supplementation, the cognitive ability of the group that received supplementary food improved significantly more than that of the group that did not receive supplementary food.³⁷

Only two studies looked at the long-term effects of supplementation on intelligence or cognition. One study found that children receiving supplementation, combined with weekly home visits to demonstrate play with homemade toys, had higher scores than children in the control group in 14 out of 15 cognitive and intelligence tests. Another group received supplementation only (without the visits) and a significant effect was seen only for children whose mothers had higher vocabulary scores at baseline.⁷⁰ This suggests that supplemental feeding may be most effective when mothers have higher capacity to provide intellectual stimulation to their children, again highlighting the importance of context.

5 What factors affect the success of supplementary feeding programmes?

This section explores the factors that affect the success of supplementary feeding programmes, which vary in complexity, from simple factors that can be easily targeted (such as the child's age) to more complex factors such as developing a relationship of trust between the caregiver and the programme staff. This section presents the findings of the systematic review and the realist review in three categories: factors related to the child, factors related to the caregiver and factors related to programme delivery. As will be demonstrated, however, these categories are interrelated.

5.1 Findings from the systematic review

This section outlines factors that affect the success of supplementary feeding programmes based on the findings of the 34 studies included in the systematic review.

5.1.1 Factors related to the child

Supplementary feeding programmes can have a greater impact on child growth if supplementary foods are provided when children are 2 years old or younger. Results from the studies in the systematic review were mixed, but generally showed that children grew more if they received supplementary foods earlier in life. The period between 6 months and 24 months is a time of rapid growth,²¹ so this age may be a critical window for supplementation. Supplementary feeding does, however, also improve the growth of older children.^{21, 23}

Whether there is a critical window for supplementation for psychosocial development is less clear. One study tested and refuted the idea of a critical age for supplementation and mental development; one study found that younger children benefitted more; and several studies showed benefits for older children.³⁸

Few studies have examined the issue of whether girls and boys benefit equally from the provision of supplementary foods. Sub-group analysis of data from studies in the systematic review showed no differences in effect by sex. One primary study showed mixed effects for sex, but two primary studies found that supplementary food has a greater effect on the physical and psychosocial development of girls.^{29, 71-75}

It is also unclear whether supplementary feeding programmes are more effective if targeted to poorer and more undernourished children. Two studies suggested that age is also a factor: undernourished children grew more in response to feeding than better-nourished children, but only in the youngest age-group.^{27, 40} Another study found that children from families of moderate socioeconomic status did not respond as well to supplementary feeding as children living in slums, possibly due to the impact of poor environmental conditions.⁷⁶ While it is logical that children who are more undernourished would benefit more from supplementary feeding, for a programme to show positive outcomes, more than just supplementary food may be required to overcome the effects of deprived environments.

5.1.2 Factors relating to programme delivery

For supplementary food to be effective it must fill the gap between the foods currently received and the child's nutritional needs. However, in several studies in the systematic review, the supplementary food did not provide sufficient energy to meet this need. Analysis of papers from the systematic review showed that studies that provided more than 30 per cent of the recommended daily intake of energy were more effective at promoting child growth.

In poorer communities, caregivers may lack the resources and capacity to prepare and distribute the supplementary food as intended, or the food may be shared with other members of the household. To avoid these issues, some programmes provided supplementary food at day-care, preschool and feeding centres. These methods of 'on-the-spot' feeding, compared to feeding at home, did lead to the child consuming more of the supplementary food. Nutritional analyses of studies in the systematic review showed that if the programme was delivered at home, children took in around 36 per cent of the energy provided by a supplementary food. In day-care and feeding centres, however, the children benefitted from an average of 85 per cent of the energy provided by the supplementary food. Analysis of quasi-experimental studies did not find significant differences in child growth between programmes delivered in centres compared to homes (although gains in growth were larger when programmes were delivered at a day-care centre or preschool).^{28, 32, 41, 71, 72, 77, 78}

Another option for programme design is to provide the supplementary food in the home, but also incorporate a variety of design features to reduce the likelihood that food will be distributed to other family members instead of the targeted child. Some programmes gave the family extra rations to reduce sharing of supplementary foods. Other programmes supervised and monitored intake when rations were home-delivered. Comparing studies with strict supervision and those with moderate supervision showed mixed results, but the studies with strict supervision were the only ones to show a significant effect on child height.^{25, 26, 30, 32, 36, 72, 74, 79-81}

5.2 Findings from the realist review

This section outlines factors that affect the success of supplementary feeding programmes based on the findings of the 61 studies included in the realist review (listed in the appendix).

5.2.1 Factors related to the child

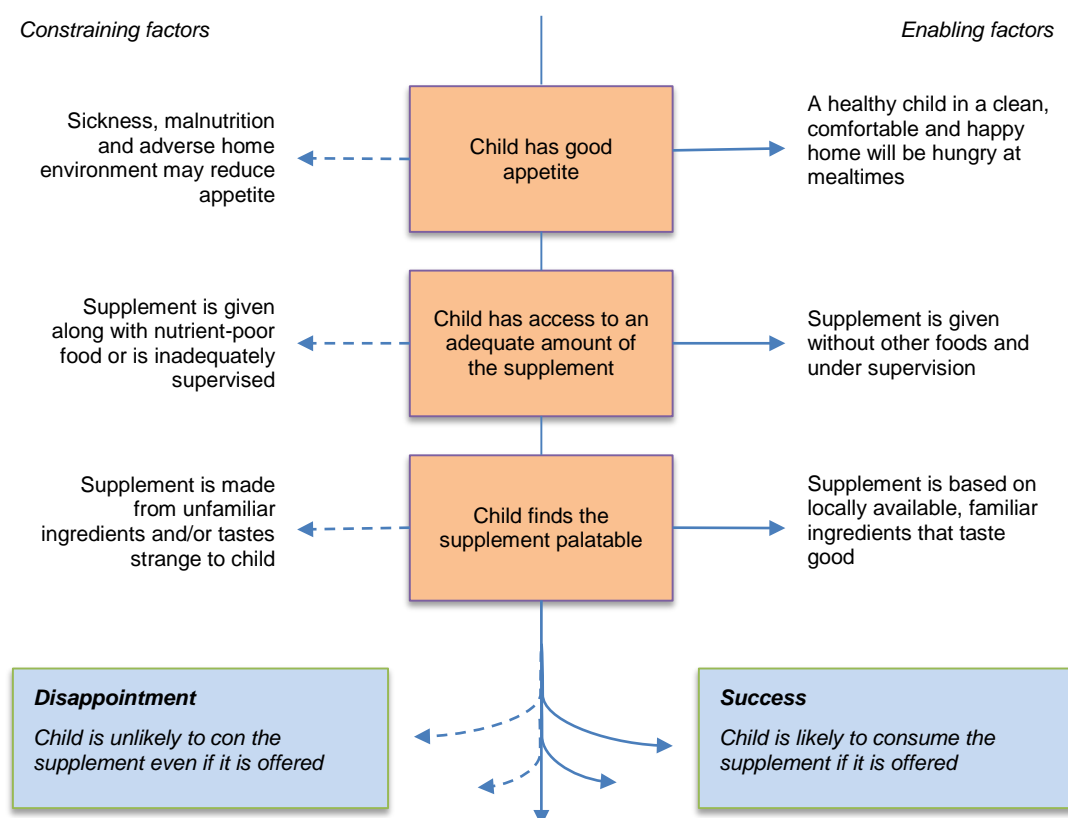
The success of a supplementary feeding programme depends on the child consistently eating the supplement as planned. Figure 4 shows how the child's capacity to eat the supplement can affect programme outcomes.

A child with a normal appetite is more likely to eat or drink the supplement than a child with a reduced appetite.³⁰ Appetite can be affected by factors such as nutritional status, home environment and illness (including sub-clinical illness that may be difficult for programme staff to observe).^{58, 79, 82, 83}

Even if the child has a normal appetite, young children cannot eat large amounts of food. Therefore, the supplement needs to be dense in energy or nutrients, so that the child is physically able to consume the entire supplement.^{77, 84}

Finally, the child must be willing to eat the supplement, and therefore must find the supplement palatable.⁷¹ Studies in the realist review suggested that this would be more likely if the supplement was based on local ingredients which he or she already found palatable.^{33, 40, 47, 61, 71} Supplements with a high fat or protein content may also be more palatable, but this was not tested in any study.⁷¹

Figure 4 Child's capacity to eat the supplement and effect on the success of supplementary feeding programmes



5.2.2 Factors related to the caregiver

The capacity of the child's primary caregiver (often the mother) is an important factor in success of supplementary feeding. This section discusses factors that affect a caregiver's ability to receive and act on health-related education and support (summarised in Figure 5) and factors that affect the caregiver's ability to respond to a specific supplementary feeding programme (summarised in Figure 6).

Some supplementary feeding programmes had disappointing results, and this was attributed, at least in part, to caregivers having limited ability to engage with the programme, due to the stresses of poverty and a poor home environment.^{30, 32, 58, 83} Feeding programmes tended to be more effective when the caregiver had sufficient time and resources to prepare and administer the supplementary food as intended by the

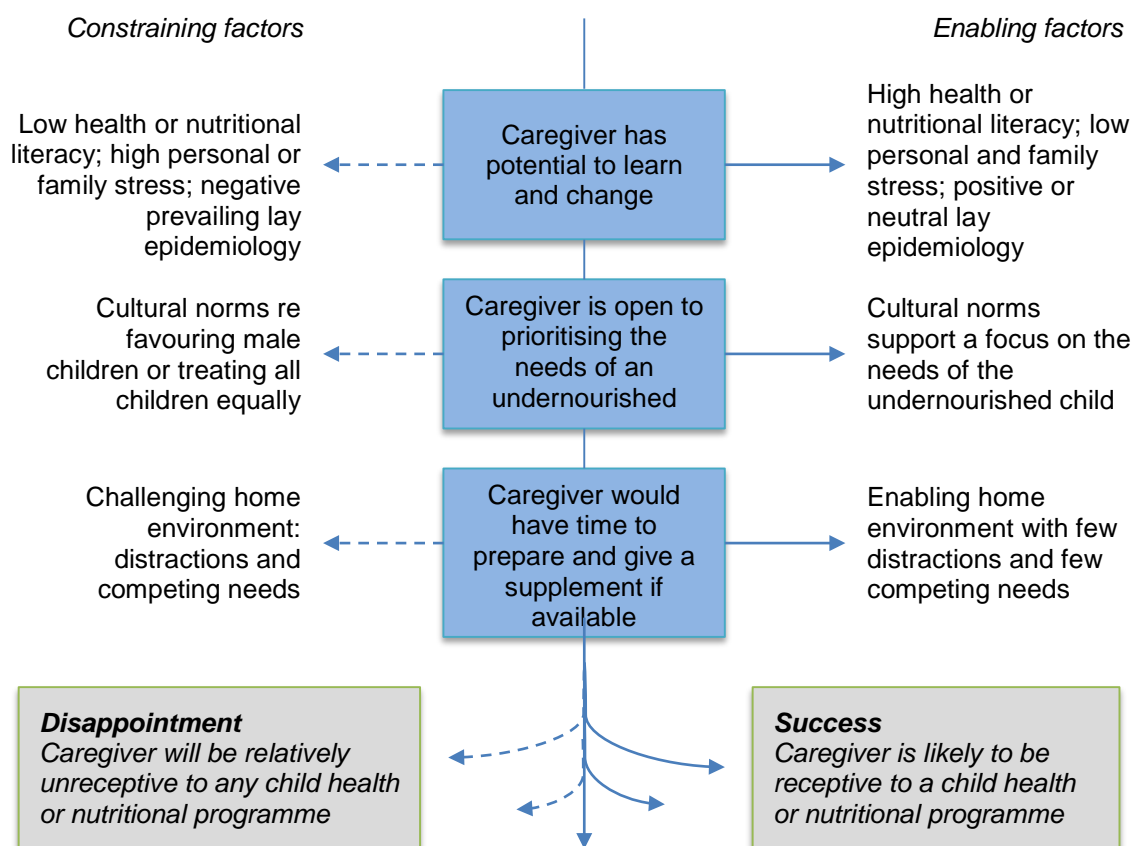
programme. Understandably, caregivers who prepared supplementary food in a home environment with sufficient space, clean water and few distractions found it easier than those who prepared supplementary food in a challenging home environment with more distractions and competing demands on their time.⁸³ For children in day-care centres, lack of sufficient staff (and, more generally, a poor quality day-care environment) sometimes led to insufficient time and resources to feed the children adequately.^{83, 85} In some cases, the wider community lacked resources such as good sanitation and clean water, exacerbating stress.^{76, 83}

Caregivers' education level and their ability to understand and act on health information (a skill referred to as health literacy) are important contributors to infants' dietary intake and nutritional status.⁵⁴ Caregivers will also be better able to engage with supplementary feeding programmes if they have higher education and health literacy levels.⁸⁶ For example, a study in Jamaica found that supplementation had long-term effects only for children whose mothers had high vocabulary scores when tested at the start of the study.³⁶ For this reason, many studies included nutritional counselling in their programme design.^{25, 27, 28, 33, 34, 36, 37, 39-42, 58, 61, 87} The health literacy of the broader family community is also important. For example, a study conducted in Bangladesh attributed poor results in part to engaging with the mother only, instead of also engaging with other members of the family who made decisions about nutrition.⁸⁷

Some communities may have strong social norms about nutrition and infant feeding that compete with the instructions from the programme. For example, for a supplementary feeding programme to be successful, a caregiver needs to believe and act on the idea that an undernourished child may need to be treated differently and 'favoured' over other children in the family. For example, a qualitative study from Niger showed that mothers had deeply held views about not favouring one particular child over the others, even when that child was unwell or had greater nutritional needs.⁸⁸ If the caregiver does not accept that the child needs special treatment, the supplementary food intended for the child may be shared with other members of the family, particularly working adults.^{58, 86, 89}

This can reduce the effectiveness of the supplementary feeding programme. A study in Mexico found that two-thirds of the participating families shared the supplementary food with other family members.⁵⁸ In other studies, the targeted child received the supplement as intended, but was fed less at other times.^{26, 30} For younger children, it is also important that mothers understand the importance of continuing to breastfeed even if the child is receiving complementary foods. The effect of complementary foods on breastfeeding practices was examined in three studies, with mixed results.^{28, 30, 90}

Figure 5 Caregiver's capacity and effect on the success of supplementary feeding programmes



The factors discussed above and shown in Figure 5 would affect a caregiver's response to any health promotion programme, but other factors are relevant in the case of a specific supplementary food programme.

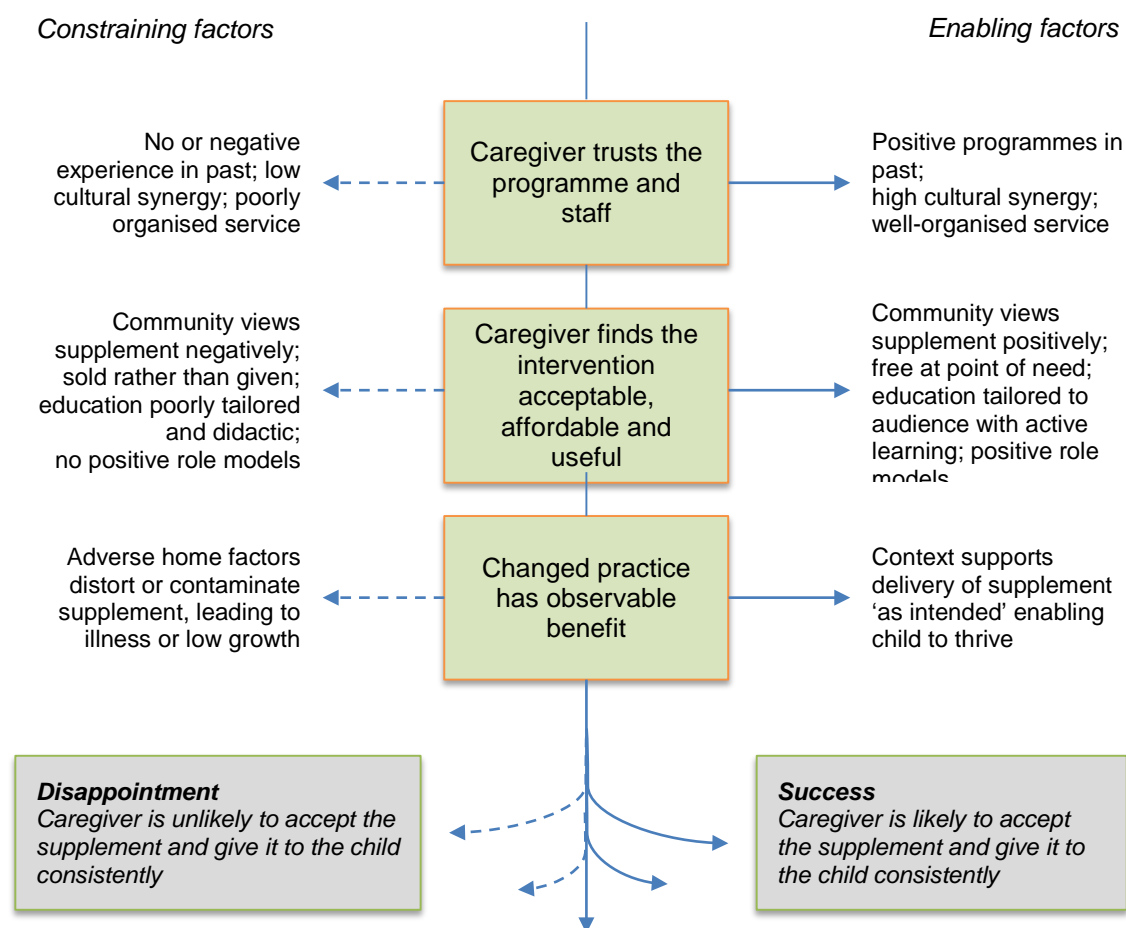
Caregivers need to trust the programme in order to comply with its instructions. Factors that lead to trust include previous positive experiences with similar programmes; local staff preparing and delivering local food, ensuring cultural relevance; the perception that the programme is accountable to the local community; and a sense that the programme is well-organised, efficient and responsive. Conversely, a history of negative experiences, a perception that the programme was top-down and inflexible, or the absence of a previous working relationship with the community made trust more difficult to establish. In some communities, supplementary foods were perceived negatively, leading to poor results, while in other communities supplementary foods were seen as a 'prestige food' or 'health boost' so caregivers were interested in and motivated to co-operate with the programme.⁴⁷

In addition to accepting the programme, caregivers must find participation convenient and useful. For example, one study found that the dropout rate was proportional to the distance between the feeding centre and the child's home.⁷⁸ Programmes that include

nutritional counselling or other educational components are considered more useful when they use active, hands-on teaching methods and include wider advice on child nutrition (such as advice on breastfeeding and complementary feeding).^{37, 82, 91} Studies are often conducted as part of a programme trial and rarely involve a cost to participants, but experiences with rolling out the programme following the trial showed that supplementary foods needed to be provided for free.

Programmes are also more acceptable to caregivers if the changed feeding practice produces an observable, positive change in the child's health status. For example, caregivers stopped providing the supplementary food when the child became ill with fever or diarrhoea.^{30, 88}

Figure 6 Caregiver's interaction with supplementary feeding programmes and effect on programme success

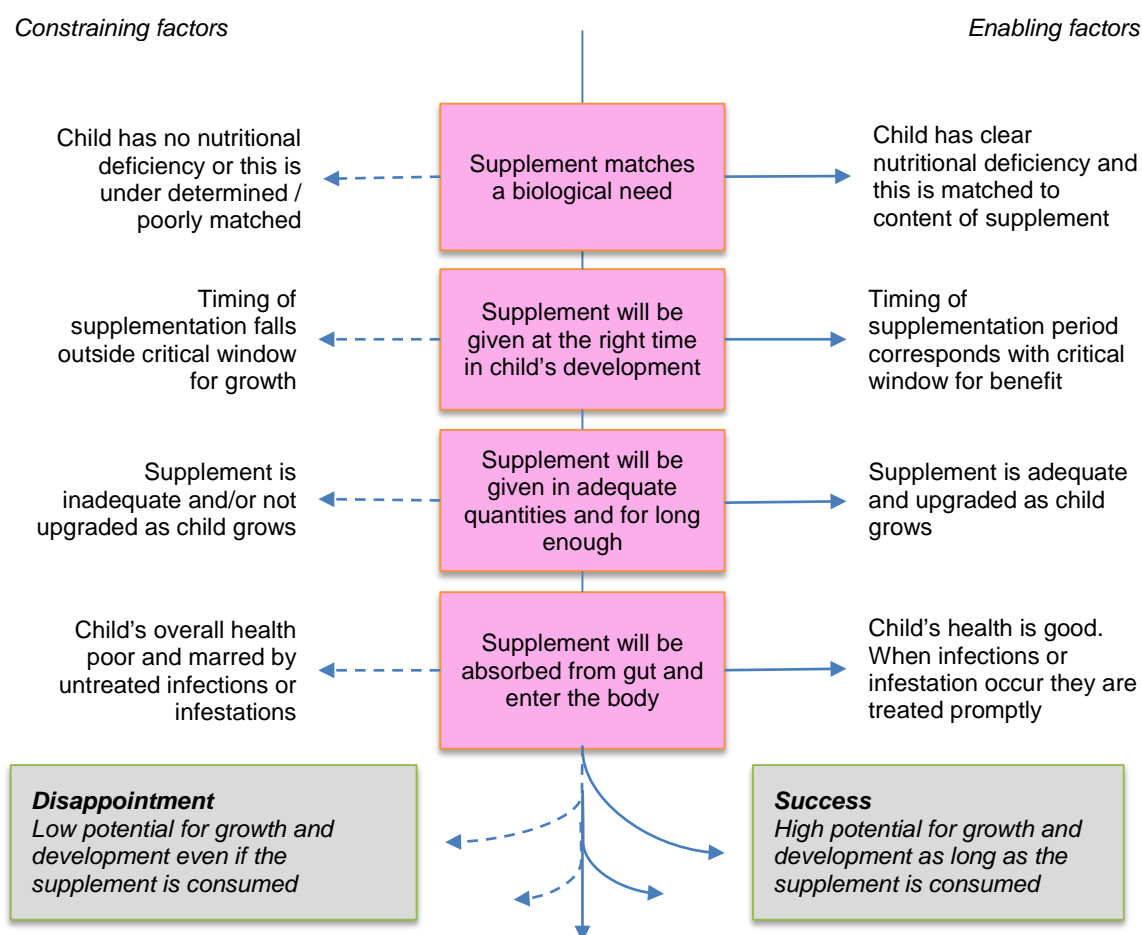


5.2.3 Factors related to programme delivery

When selecting the type and quantity of supplementary foods to provide, programmes should consider that a higher amount of energy than would normally be given in a meal may be required to compensate for the redistribution of supplementary food within the family.⁸⁴ Programmes should also consider whether the supplementary food should be adjusted as the child grows. Finally, the food should be nutrient- and energy-dense, because children may feel full before they have eaten enough to satisfy their nutritional

requirements.⁸⁴ Figure 7 summarises the mechanisms relating to supplementary foods that affect the success of supplementary feeding programmes.

Figure 7 Physiological mechanisms that affect success of supplementary feeding programmes



Breakdown in the supply chain can also severely limit effectiveness of a supplementary feeding programme. In a study in Indonesia, 50 per cent of the caregivers reported 'gaps in delivery'; 36 per cent reported that such gaps occurred more than twice.³² Another study in India reported that supplies failed to reach the programme staff 20–30% of the time.⁹² Similar failures have been seen in preschool and school feeding programmes, highlighting the challenges of delivery in low- and middle-income countries.^{84, 93}

Programme staff are crucial to the success of supplementary feeding programmes, and skilled local staff are particularly essential in adapting the programme design to the specific local setting. Figure 8 below summarises the mechanisms through which programme staff influence the effectiveness of a supplementary feeding programme: staff capability and motivation; whether and how they engage with caregivers and promote active learning; and whether and how they monitor the programme's success and adapt their efforts in the light of process data.

An important first step is for programme staff to be well-trained, so that they have a thorough understanding of the intervention. Staff need to know how to prepare and deliver the supplementary food safely and consistently. Staff must also be highly motivated and capable of preparing and delivering the supplement safely and consistently. Finally, they need to be flexible and able to adapt the programme as they learn what works and what does not. In low-resource settings, trained staff may be in short supply. Much effort may need to be put into a training programme to ensure that all team members understand the intervention and are capable and willing to deliver it according to protocol.

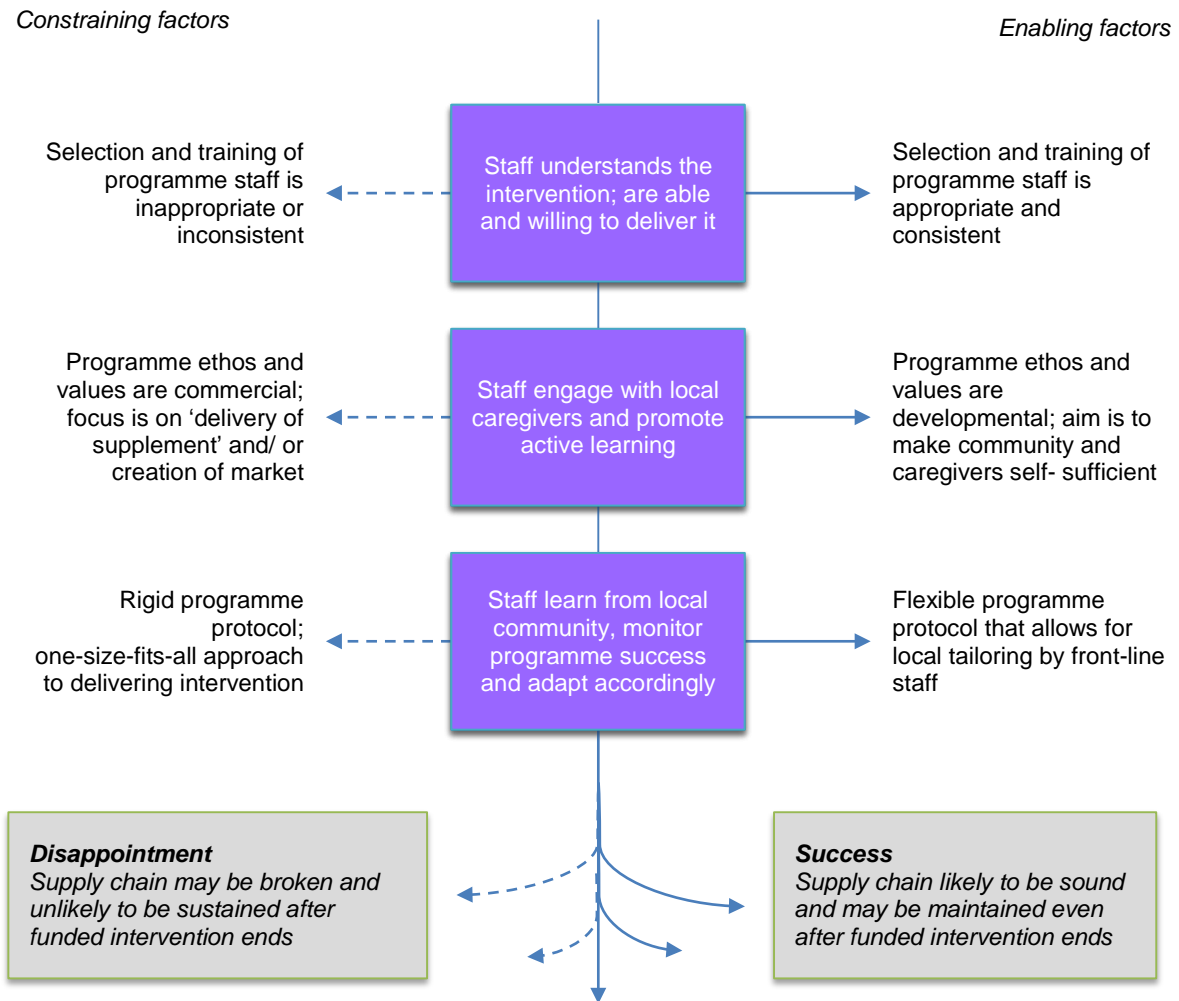
As has been emphasised throughout this section, the caregiver has an important role in ensuring the child receives the supplementary food as intended. Therefore, programme staff must be motivated and capable of engaging with caregivers, understanding the barriers to behaviour change and supporting the caregivers to deliver the supplement. If programme staff are able to increase the caregiver's capacity to provide supplementary foods the programme will be more successful and, importantly, more sustainable.

Some studies in the realist review emphasised building the capacity of the caregiver. For example, one study provided a take-home ration, and a health worker went to the child's home twice a day to help prepare and administer the food, a technique that both supervised the child's food intake and provided practical education to the caregiver.²⁵ Other examples of intensive input from programme staff included visiting the household twice a week to collect empty and partly used wrappers (thereby checking if supplementary food had been consumed), visiting weekly³⁰ or visiting at random times to check whether food had been consumed.^{28, 58} Such visits help to build the relationship between health worker and caregiver, improving trust and communication.

Other studies did not focus on education and engagement, and found other ways to deal with the challenge of low caregiver capacity. Delivery programmes at schools and feeding centres was one technique. Other studies used pre-cooked or ready-to-use food or pastes (typically based on a regional staple such as peanuts) that could be consumed from the packet or as a spread.²⁴⁻²⁸ These kinds of supplementary foods solved issues such as the practicalities and challenges of food preparation, the limited capability of caregivers, the problem of portion size measurement and some limitations of the home environment (such as a lack of fuel for cooking).^{30, 89} Another advantage of these ready-to-use foods was the energy-dense formulation, allowing the child to gain a large energy intake from a small amount of food. This may reduce the risk of supplementary food displacing other food or breastmilk from the diet, or the risk of food being distributed to other family members.⁸¹ There may be a trade-off, however, between the advantages of a commercially produced supplementary food, and the sustainability of a programme that is more locally embedded, based on local ingredients and linked to caregiver education.

A third mechanism by which programme staff deliver effective feeding programmes is by adapting their efforts in light of process data. In one study, caregivers' use of the supplement and the optimal amounts to be fed were reviewed every month; if the mother reported non-acceptability, the child was fed in the mother's presence to demonstrate that he or she could consume the recommended amounts, and additional packets were given for the other siblings if requested.³⁰

Figure 8 Programme staff capacity and effect on success of supplementary feeding programmes



6 Implications for programme design and implementation, and future research

Supplementary feeding programmes have great potential to improve the physical and psychosocial health of children from disadvantaged communities, which may have a long-term influence on the opportunities they have in life. The systematic and realist reviews found evidence that supplementary feeding programmes do work, but are currently underperforming. The ideas underpinning feeding programmes are sound, with biological evidence to support supplementary foods for undernourished children; however, effective implementation is crucial. Effective implementation means ensuring that children receive supplementary food as planned, and this requires tailoring programmes to the context and needs of the children and their caregiver. This section highlights some of the key findings of the reviews, and the implications for programme design and implementation. It also highlights specific issues for future research so that programmes have a strong evidence base to draw on for design.

6.1 Implications for programme design and implementation

Supplementation can be more effective if delivered earlier in life. Young children respond better to supplementary foods if they are provided during the critical window for growth, which is before the age of two.^{19, 23} The period after exclusive breastfeeding is a key period to work with the family to ensure that appropriate complementary foods are provided. It takes time for supplementary foods to affect some aspects of growth and cognitive development, so programmes that continue for between 18 months and two years may be better able to demonstrate outcomes.^{22, 36, 94}

If targeting is required, target the poorest or most undernourished children or areas. There is some evidence that poorer and undernourished children may be more responsive to supplementary feeding, so if funding is limited it can be appropriate and cost-effective to target these children. Supplementary foods alone, however, are insufficient to overcome the detrimental effects of living in poverty and of discriminatory social norms that may affect girl-children or children with disabilities, so additional support may be required to have a significant effect.⁸⁴

Supervision increases the total energy consumed by children. Children take in more total energy if supplementary feeding is delivered in a supervised feeding or day-care centre, or preschool, which leads to greater benefits in terms of growth and development.⁸⁴

Family capacity is key to sustainability. By working with parents, caregivers and the community, programmes can enhance their motivation and capacity to deliver supplementary foods to their children. This kind of support can help to see the effects of a programme sustained over time. Evidence from the realist review and from other studies on household food distribution suggests that educating families about why some children may have a greater need for supplementary food may be necessary to overcome cultural norms related to the sharing of food.

Consider families in programme design. Some programmes provided extra rations for other family members, to reduce 'leakage' (where the supplementary food is shared by the family rather than provided directly to the targeted child). Beaton and Ghassemi²³ suggest that, rather than seeing 'leakage' as a problem, it could be seen as providing a

benefit to the family. While emphasis should still be placed on providing adequate nutrition to the child most in need within the family, providing rations to reduce sharing of the supplementary food may be a useful strategy for programmes to adopt, and programmes may wish to also measure outcomes on a family basis rather than just an individual basis.

Providing supplementary foods that meet the energy gap between the child's needs and current intake will usually require more than 30 per cent of the dietary reference intake for energy. Programmes that provided a moderate (30–59%) or high (60% or more) percentage of the dietary reference intake energy resulted in greater growth than those that provided less than 30%. Adapting the amount of energy and protein provided in the supplementary food to meet needs as children age is also important.

Children are more likely to consume supplementary food that is palatable, culturally acceptable and energy- and nutrient-dense. Young children have smaller appetites, so food that is energy- and nutrient-dense will be easy for them to consume. Ready-to-use therapeutic food may be ideal for younger children or for children who are severely malnourished: it is energy-dense and requires little or no preparation on the part of the caregiver. For older children, however, energy-dense local foods may be more palatable and more acceptable to the family, and programmes based on such foods may be more sustainable. Interventions that deliver locally sourced foods can also stimulate the local economy.

Programme staff can better adapt the programme if they monitor, evaluate and research. The findings of the reviews highlight the importance of research and evaluation to understand the factors that will affect the success of a supplementary feeding programme. Regularly monitoring children's dietary intake, growth and development can provide programme staff with useful information on how to adapt to local settings.

These findings are based on research mainly in low- and middle-income countries. The included studies covered many countries and regions, including Latin America, Africa, Asia, North America and Australia. Most of the studies were conducted in low-income countries, unsurprising given that 81 per cent of people who suffer from hunger live in low- or middle-income countries.⁹⁵ However, the results of these reviews can probably not be generalised to high-income countries.

6.2 Implications for future research

It seems inevitable that reviewers will call for more research, but the reviews demonstrated that there are specific areas where research is urgently needed to inform programme design.

6.2.1 Supplementary feeding and psychosocial development

Only eight out of 34 studies in the systematic review assessed the impact of supplementary feeding on psychosocial development, yet the potential of supplementary feeding programmes to improve psychosocial outcomes is a strong argument for investing in such programmes. Early cognitive development and social–emotional development are major determinants of school progress in developed and developing countries, which in turn is related to adult employment status, income and contributions to family, community and society.¹² The systematic review findings suggest that

supplementary feeding interventions can improve psychomotor and cognitive development, and some researchers even argue that psychosocial outcomes are more sensitive to nutrition intervention than growth outcomes.²¹ A related area is understanding the extent to which the effect of early undernutrition on the brain can be reversed.⁸² Psychomotor and cognitive testing can be time-consuming and expensive when programmes are delivered on a large scale, but more feasible tests have been developed.⁹⁶

6.2.2 Feeding older children

Although the systematic review found that supplementary feeding interventions are generally more effective if implemented earlier in life, there is a lack of research on feeding interventions for older children. Only four studies included older children, and these studies were all completed before 1990 and were not as well implemented as more recent studies. More research is required to fully understand the optimum age for supplementary feeding programmes.⁸²

6.2.3 Gender and income equity

The systematic review provided some evidence that supplementary feeding might be more effective for poorer children, and possibly for girls, but more evidence is needed, particularly data disaggregated by sex. Surprisingly few studies have addressed this question, given the importance of gender equity. Both qualitative and quantitative research is required in this area, and on the question of how to reduce inequities in the distribution of food in households.

6.2.4 Large-scale feeding programmes

Most of the evidence presented in the reviews comes from smaller-scale studies; only four evaluations of larger-scale studies met inclusion criteria (Brazil's Milk Supplement Programme,⁵⁸ PANN in Ecuador,²⁸ Progresá in Mexico²⁷ and Vietnam's Integrated Health and Nutrition Programme). While these studies contribute greatly to the evidence base, more high-quality research, particularly randomised controlled trials, is needed to understand the sustainability and implementation of large-scale programmes.

There may be a trade-off, however, between the advantages of a commercially produced supplementary food, and the sustainability of a programme that is more locally embedded, based on local ingredients and linked to caregiver education. Issues of sustainability and the advantages of a local focus have not been studied.

6.2.5 High-quality study designs and reviews

Many studies were of relatively low quality in terms of implementation and design. Encouragingly, more recent studies were generally of better quality. Research is required to address methodological issues such as adequate power to detect change, methods of randomisation, allocation concealment, blinding of outcome assessment and attrition. Research that examines the causes of attrition and explores how it can be reduced is also needed. Finally, programmes would benefit from mixed-methods evaluations of both outcomes and the process of delivering those outcomes, to gain a better understanding of how and why supplementary feeding programmes succeed, and for which groups of

children. Finally, we were not able to assess whether the food actually reached those children who were most in need. Rondo⁹⁷ and Beaton and Ghassemi²³ pointed out that feeding programmes in developing countries often fail to reach those who need it most. Lutter²⁸ has called for all studies of supplemental feeding to assess reach.

Appendix A: Review methodology

This appendix provides an overview of the review methodology, including search strategies, critical appraisal and analysis techniques, and strengths and limitations of the review. Further details are in the technical report, which is available at www.campbellcollaboration.org/lib/project/102/.¹

Summary of the review methodology (study protocol)

This review drew on both systematic and realist review methodologies, incorporating rigorous quantitative meta-analysis and the nuanced question of 'what works for whom in what circumstances'.

Search

The systematic review included experimental or quasi-experimental studies that evaluated physical and psychosocial outcomes of supplemental feeding programmes for disadvantaged children aged 3 months to 5 years. Studies conducted in all countries were eligible for inclusion, but results were analysed separately for low- and middle-income countries and for higher-income countries, using the 2011 World Bank List of Country Economies to classify country income.⁹⁸

Outcomes included growth, psychomotor development, cognitive and mental development, attention, language and memory. Secondary outcomes included biochemical markers of nutrition (Vitamin A, haemoglobin and haematocrit), physical activity, morbidity and mortality.

Studies were included if they evaluated programmes targeting children from socio-economically disadvantaged groups, or programmes that included both high and low socioeconomic groups if results could be stratified by some indicator of socioeconomic status.

To be classified as a supplementary feeding programme, the interventions had to provide energy and nutrients through meals, snacks, beverages and/or take-home rations. Interventions that provided only vitamin supplements were excluded. Programmes with co-interventions (such as psychological stimulation, micronutrient fortification or nutrition education) were included.

Studies could include either no-treatment controls (children in the control group received no supplementary food) or placebo controls (children in the control group received low energy foods or drinks).

We believe that our review provides a comprehensive coverage of the literature. We screened almost 33,000 studies from a well-designed literature search; we also carefully scanned reference lists of included studies and of reviews. We searched nine electronic

¹ Kristjansson, E, Francis, DK, Liberato, S, Benkhalti Jandu, M, Welch, V, Batal, M, Greenhalgh, T, Rader, T, Noonan, E, Shea, B, Janzen, L, Wells, GA and Petticrew, M, 2015. Food supplementation for improving the physical and psychosocial health of socio-economically disadvantaged children aged three months to five years: a systematic review. *Campbell Systematic Reviews* 2015, 11 doi:10.4073/csr.2015.11.

databases up to the end of January 2014: Cochrane Central Register of Controlled Trials (CENTRAL), Ovid MEDLINE, PsycINFO, ERIC, Social Sciences Citation Index, Conference Proceedings Citation Index, Cochrane Database of Systematic Reviews, Database of Abstracts of Reviews of Effects (DARE) and Proquest Dissertations and Theses. We also searched ClinicalTrials.gov, and the reference lists of relevant articles and reviews. Finally, we performed hand-searches of reference lists of included articles and other reviews.

The realist review used all included and excluded studies from the systematic review, 'sister studies' (that is, studies that described process evaluations of the same interventions) and other studies that provided information on conceptual issues or process factors. Each paper was assessed against two criteria for inclusion in the realist review: (1) relevance: is this paper relevant to our research question (could it help the process of theory-building) and (2) rigour: is the study, or aspects of the study we wish to draw upon, sufficiently rigorous for us to be able to trust the findings? In making our final selection of studies to include, we prioritised those that offered rich descriptions of the interventions and programmes, which allowed us to identify mechanisms and make informed judgements about the interaction between context, mechanism and outcome.

Analysis and synthesis

For the systematic review, at least two people independently reviewed searches, selected studies for inclusion or exclusion, extracted data and assessed risk of bias. We also extracted process data, including the proportion of the recommended daily intake for energy, mode of delivery, supervision and leakage. Whenever appropriate, we conducted meta-analyses and sub-group analyses using Review Manager.

For the realist review, three people independently reviewed all included and excluded studies from the systematic review. Two authors extracted data on context, mechanisms and outcomes from the intervention studies, process evaluations and discussion papers. Differences between researchers were resolved by discussion. Theories were developed and explored, looking particularly for disconfirming cases (that is, examples of studies where the theory appeared not to hold), leading to either rejection or refinement of the theory.

Included studies

The literature search identified 32,983 articles. We retrieved 302 papers for the quantitative review; each was read in full. After carefully applying the inclusion/exclusion criteria, we included 34 studies: 21 randomised controlled trials, 11 quasi-experimental designs and two studies that used propensity score matching. We used data from 26 of these studies in meta-analyses.

For the realist review, we included the 34 included studies from the systematic review (including 'sister' papers from these studies that described process evaluations), 15 studies that had been considered for the systematic review but not included and 12 additional papers describing qualitative studies, theories or methodological issues.

Results of quality assessment (critical appraisal)

We minimised bias by having at least two independent people involved in every aspect of identifying potential studies, deciding whether studies should be included or excluded, extracting data and conducting analysis and synthesis.

We assessed the quality of randomised controlled trials using the Cochrane Collaboration 'risk of bias' tool.¹⁰⁰ This was used by two researchers independently to assess bias in six areas: randomisation sequence, allocation concealment, incomplete outcome data, selective reporting, blinding participants and/or personnel and blinding outcome assessment. Only one study received low ratings of risk in all categories. Most of the other randomised controlled trials received three 'low risk' ratings, while the other ratings were unclear, and a few were high risk. Unclear ratings were usually because the primary studies did not provide enough information to make judgements. Blinding of participants and personnel is not usually possible in supplementary feeding studies; however, blinding of outcome assessment is possible, yet was not done in most studies.

We assessed the quality of quasi-experimental studies using the 'risk of bias' tool from the Cochrane Effective Practice and Organisation of Care Group. This tool was used by two researchers independently to assess risk of bias in eight areas: allocation sequence, allocation concealment, similarity of baseline outcome measurement, similarity of baseline characteristics, incomplete outcome data, blinding of allocation, protection against contamination and selective outcome reporting. All studies had low risk in five or six out of eight categories; no studies used allocation concealment or allocation sequencing. Blinding of outcome assessment was rarely reported.

Remaining sources of bias may include publication bias if evaluations of feeding programmes were missed from the search (although this is unlikely) and bias in the methods used to correct for clustering.

Overall, the quality of the primary studies was rated as low to moderate. Many studies had high rates of attrition and several did not conceal whether children were part of the intervention group or the control group when assessing outcomes. One key limitation of the realist review was the lack of descriptive detail in many of the primary studies. In particular, very few studies provided details on how programme staff were selected and trained, how they engaged with the programme and how (or if) they adapted the intervention to local circumstances. Such detail is essential for identifying, refining and testing programme theories, and the findings and conclusions of this review should therefore be seen as preliminary.

Appendix B: Studies included in the systematic review

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The long-term goals of supplementary feeding programmes generally include improved survival, improved growth and health, and normal cognitive and behavioural development. This summary report is based on a combined systematic review and a realist review. It examines the evidence on whether supplementary feeding can improve the health of infants and children between three months and five years of age. The systematic review showed that supplementary food was more effective for children below two years of age and for those who were poorer or less well nourished. The realist review found that prerequisites for programme success included the quality and quantity of the supplement and a reliable supply chain. The results of the review suggest that more high-quality research on supplementary feeding programmes for infants and young children is required, particularly on their potential to improve psychosocial outcomes.

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