Renfu Luo
Huan Zhou
Linxiu Zhang
Alexis Medina
Hongbin Li
Jaimie Lien
Jianhua Cai

Nourishing the future

Targeting infants and their caregivers to reduce undernutrition in rural China

October 2018

Impact Evaluation Report 81

Health

International Initiative for Impact Evaluation

About 3ie

The International Initiative for Impact Evaluation (3ie) promotes evidence-informed equitable, inclusive and sustainable development. We support the generation and effective use of high-quality evidence to inform decision-making and improve the lives of people living in poverty in low- and middle-income countries. We provide guidance and support to produce, synthesize and quality assure evidence of what works, for whom, how, why and at what cost.

3ie impact evaluations

3ie-supported impact evaluations assess the difference a development intervention has made to social and economic outcomes. 3ie is committed to funding rigorous evaluations that include a theory-based design, and use the most appropriate mix of methods to capture outcomes and are useful in complex development contexts.

About this report

3ie accepted the final version of the report, *Nourishing the future: targeting infants and their caregivers to reduce undernutrition in rural China*, as partial fulfilment of requirements under grant PW2.03 awarded through Policy Window 2. The content has been copy-edited and formatted for publication by 3ie. Despite best efforts in working with the authors, some figures and tables could not be improved or references fully corrected. We have copy-edited the content to the extent possible.

The 3ie technical quality assurance team comprises Francis Rathinam, Deo-Gracias Houndolo, an anonymous external impact evaluation design expert reviewer and an anonymous external sector expert reviewer, with overall technical supervision by Emmanuel Jimenez. The 3ie editorial production team for this report comprises Sahib Singh and Akarsh Gupta, with Beryl Leach providing overall editorial supervision.

All of the content is the sole responsibility of the authors and does not represent the opinions of 3ie, its donors or its board of commissioners. Any errors and omissions are also the sole responsibility of the authors. All affiliations of the authors listed in the title page are those that were in effect at the time the report was accepted. The publication was delayed due to the need to get clarifications from the authors, which they provided in September 2018. Please direct any comments or queries to the corresponding author, Linxiu Zhang, at lxzhang.ccap@igsnrr.ac.cn.

Funding for this impact evaluation was provided by 3ie's donors, which include UK aid, the Bill & Melinda Gates Foundation and the Hewlett Foundation. A complete listing of all of 3ie's donors is available on the 3ie website.

Suggested citation: Cai, J, Luo, R, Li, H, Lien, J, Medina, A, Zhou, H and Zhang, L, 2018. Nourishing the future: targeting infants and their caregivers to reduce undernutrition in rural China, 3ie Impact Evaluation Report 81. New Delhi: International Initiative for Impact Evaluation (3ie). Available at: https://doi.org/10.23846/PW2IE81

Cover photo: Sean Sprague / Alamy Stock Photo

Nourishing the future: targeting infants and their caregivers to reduce undernutrition in rural China

Renfu Luo
Peking University

Huan Zhou
Sichuan University

Linxiu Zhang
Chinese Academy of Sciences

Alexis Medina
Stanford University

Hongbin Li
Tsinghua University

Jaimie Lien
Tsinghua University

Jianhua Cai
National Health and Family Planning Commission

Impact Evaluation Report 81

October 2018

International Initiative for Impact Evaluation

Acknowledgements

We acknowledge financial support from the International Initiative for Impact Evaluation (3ie, grant number PW2.03.CH.IE). We are grateful to the many officials from the National Health and Family Planning Commission who have helped us throughout this project, as well as to the many students both in China and abroad who participated in our research.

Executive Summary

The problem: Research increasingly indicates the importance of the nutritional programming that occurs in the first 2–3 years of life. Quality nutrition during this brief window has been shown to have large and significant effects on health and development throughout childhood and even into adulthood. Despite the widespread understanding of this critical window, and the long-term consequences of leaving nutritional deficiencies unaddressed, little is known about the status of infant nutrition in rural China, or about the relationship between infant nutrition and cognitive development in rural China.

Population: In April 2013 and October 2013, we conducted a survey of 1,808 infants aged 6–12 months living in 351 villages across 174 townships in nationally designated poverty counties in rural areas of southern Shaanxi province, China. This sample served as our sample for a cluster-randomized controlled trial (RCT).

Intervention: There are three groups in the cluster-RCT. The caregivers of children in Treatment Group 1 (Free Delivery Group) received one-on-one health education training on nutrition and feeding practices. Sample caregivers also received a free supply of micronutrient supplement packets containing a home fortification powder every six months, along with instructions on how to use the powder. The caregivers of children in the Treatment Group 2 (Text Messaging Group) received the same treatment as the Free Delivery Group. However, the Text Messaging Group caregivers also were enrolled in a daily text message reminder program. The third group served as the Control Group (no intervention).

Outcomes: The primary outcomes at interest are the consumption of nutrition supplement packets, nutrition and health of child (hemoglobin concentration and anemia prevalence), and child development (Mental Development Index and the Psychomotor Development Index scores). Infants were administered a finger prick blood test for hemoglobin (Hb), and the Bayley Scales of Infant Development. They were also measured for length and weight. Caregivers were administered a survey of demographic characteristics and feeding practices. We administered follow-up surveys at six-monthly intervals.

Process of randomization: We first randomly selected 11 nationally designated poverty counties in southern Shaanxi province. From these 11 counties, all townships in each county were included except for the one township that housed the county seat and any townships that did not have any villages with at least 800 people. Then we randomly selected two villages from the list in each township. Our final sample consisted of 351 villages in 174 townships. Each village (cluster) was randomly assigned into one of three groups: Free, Text and Control. Assignment was cluster-randomized at village level and stratified at county level, with 117 villages in each treatment group.

Results: We found that 48.8% of sample infants were anemic, 3.7% were stunted, 1.2% were underweight and 1.6% were wasted in the baseline; approximately 20.0% of the sample infants were significantly delayed in their cognitive development, while just over 32.3% of the sample infants were significantly delayed in their psychomotor development. After controlling for potential confounders, infants with lower Hb counts

were significantly more likely to be delayed in both their cognitive ($p < 0.01$) and psychomotor development ($p < 0.01$).

We further found that assignment to the Text Messaging Group led to a positive increase in full compliance (coefficient = 0.25; 95% CI = 0.20, 0.31) with the study intervention at six months after the start of intervention. Moreover, the text message was more likely to increase the consumption of the home fortification powder six months after the start of intervention if the primary caregiver was the child's mother (marginal effect = 12.19; 95% CI = 0.69, 23.68) or if the primary caregiver knew how to read text messages (marginal effect = 9.72; 95% CI = 0.20, 19.25) and send text messages (marginal effect = 14.68; 95% CI = 5.37, 23.98).

We also found that a decrease in the rate of anemia (coefficient =-0.06; 95% CI = -0.12, -0.01). As for child development, we found that after six months of supplementation, the effect of free micronutrient powder (Free MNP) on the Mental Development Index (MDI) sub-index was 2.23 points ($p = 0.044$; 95% CI 0.061, 4.399) in the intent-to-treat analysis and each additional sachet consumed increased MDI by 0.028 points ($p = 0.034$; 95% CI 0.002–0.054), which implied the effect of full compliance is therefore 5.04 points (0.29 SD) at six months after the start of intervention. However, by 12 or more months after the start of the intervention, the effect on anemia prevalence and MDI test score subsided.

Policy recommendations: The Chinese government is launching a national program to provide micronutrient powder sachets through local health centers. The implication of this study is that the government should focus more on compliance with this program. More research is needed to find more efficient ways to improve compliance as well as caregivers' nutritional knowledge and feeding behaviors.

Contents

List of figures and tables

Appendix table

Abbreviations and acronyms

3ie	International Initiative for Impact Evaluation
CI	Confidence interval
NGO	Non-governmental organization
WHO	World Health Organization
BSID	Bayley Scales of Infant Development
NPFPC	National Population and Family Planning Commission
MDI	Mental Development Index
PDI	Psychomotor Development Index
LAZ	Length-for-age z-scores
WAZ	Weight-for-age z-scores
WLZ	Weight-for-length z-scores
ICC	Intra-Cluster Correlation
SD	Standard Deviation
ITT	Intention to Treat
ATT	Average Treatment Effects on the Treated
ANOVA	Analysis of Variance
IRB	Institutional Review Board
MNP	Micronutrients Powder Group
UNICEF	United Nations Children's Fund

1. Introduction

Anemia is one of the most prevalent nutritional disorders among preschool-aged children in developing countries.[1] Worldwide, nearly half of all children aged 0–59 months are estimated to be anemic.[2]

Despite the widespread understanding of this critical window and the long-term consequences of leaving nutritional deficiencies unaddressed, little is known about the status of infant nutrition or the relationship between infant nutrition and cognitive development in rural China. Although researchers have attempted to measure the prevalence of nutritional deficiencies in China overall, evidence on the situation in rural China is mixed. The Chinese Food and Nutrition Surveillance System found anemia prevalence among infants aged 6-12 months, in rural areas, to be around 28 per cent in 2010. [3]

Other, more geographically focused studies have found anemia prevalence ranging from 22.6 per cent (in Guangxi) [4] to 58.2 per cent (in Gansu) [5] among the same age group. Moreover, most of these studies have been based on relatively small sample sizes, limited sample areas or both. To our knowledge, while there has been one study on the impact of mothers' nutrition on early infant development in China. [6] No studies have reported on the status of infant development or examined the correlation between infant micronutrient deficiencies and development among infants aged 6-12 months in China.

Although anemia is broadly influenced by many factors, including nutrition, infectious disease and genetics, iron deficiency is the major cause of anemia, accounting for about half of the global incidence of anemia. [7–9] The development of micronutrient packets containing microencapsulated iron, administered daily (regularly), offers a way to provide a regular dose of key micronutrients, particularly iron, to iron-deficient children. This type of micronutrient supplementation has been recommended by WHO as a strategy for the prevention of anemia in children aged 6–23 months. [10]

In China, it is postulated that 90 per cent of anemia in infants and children stems from iron deficiency. [11] Existing research on micronutrient supplementation in China, however, is mostly limited to studies based on small samples and non-randomized controlled trial (RCT) design in Shaanxi, Sichuan, Gansu, Shanxi, Guangdong and Inner Mongolia provinces. [12–17]

While micronutrient supplementation has potential if caregivers systematically give their children the supplement, there are indications that compliance has been a barrier to the success of micronutrient supplement programs for infants internationally. Unfortunately, almost no research has been conducted on either how micronutrient supplementation can best be delivered or how caregivers can be persuaded to regularly give their children micronutrient supplements.

One study evaluated the effect of a community-based micronutrient supplement distribution program on household compliance in Kenya.[18] Another study in Bangladesh compared the effectiveness of programs that administered micronutrient supplements to individuals using different approaches (one requiring daily supplementation; the other with more flexibility).[19] Although both studies found low compliance, researchers concluded that the nature of the delivery strategy was associated with decreased rates of anemia among children.[18, 19] The authors of the both studies, however, suggest the relatively low rates of use of the micronutrient supplement are indicative of the generally poor study design. Hence, the research teams both suggest that systematic research is needed to evaluate the impact of alternative delivery strategies on caregiver compliance and infant health outcomes.

Given this gap in the literature, we study how text messaging can influence the effectiveness of micronutrient supplement programs. Text-messaging technology has changed the face of communications globally and in China. A large percentage (67%) of households in the world have mobile (cell) phones. [20] An even larger percentage (> 90%) of households in China—even in rural areas—have mobile phones. [21]

In this environment, clearly mobile technology is increasingly used as a way to promote health and prevent disease. [22, 23] However, text message-based programs have often met with mixed results. Internationally, the application of text messaging for behavioral change in smoking cessation, anti-obesity behavior modification and diabetes management has shown positive results in New Zealand, Korea and Scotland. [24–26] There is also evidence that text messaging is effective in China. In Shanghai, a short message service (SMS) intervention attempted to promote longer duration of exclusive breastfeeding for mothers. Unfortunately, the Shanghai researchers did not follow an RCT design. [27]

At the same time, there are also examples of text messaging programs that do not work. Text messaging had no significant effects on recycling behavior in Peru.[28] An information-focused texting program did not increase knowledge of sexual health or decrease risky behavior among young people aged 18–35 years in Uganda.[29] Text reminders did not improve the adherence of patients undergoing malaria treatment in Tanzania.[30] In these studies, the factors that were identified as those leading to the failure of the programs included limited phone access, privacy concerns, phone maintenance, and text message content. [28–30] A recent literature review of text messaging's effect on health outcomes concluded that most studies are not carried out systematically and that few used an RCT design. [31] Therefore, based on the state of the literature, we believe a well-designed study on how text messaging can improve health services delivery is needed.

The goal of this study was to provide an overview of infant nutrition in rural China, and to explore the link between nutritional status and child development. More specifically, we measure the prevalence of micronutrient deficiencies (hemoglobin concentrations/anemia) and macronutrient deficiencies (stunting, underweight and wasting) among infants aged 6-12 months living in nationally designated poverty counties in rural Shaanxi province. In addition, we examine correlations between Hb concentrations and infants' cognitive and motor development, using the Bayley Scales of Infant Development (BSID).

Another goal of the study was to test whether nutritional supplementation can improve the nutrition, health and development of children and whether text message reminders sent to the mobile devices of caregivers will improve the effectiveness of a home micronutrient fortification program using a cluster-RCT design. To meet this goal, we had three specific objectives. First, we wanted to measure caregiver compliance to a home fortification program. Next, we wanted to evaluate the impact of text message reminders on compliance. Third, we wanted to examine whether the home fortification program had any impact on child nutrition, health (focusing on the prevalence of anemia) and development.

2. Intervention, theory of change and research hypotheses

2.1 Intervention

The caregivers of children in Treatment Group 1 received one-on-one health education training on nutrition and feeding practices. Sample caregivers also received a free supply of micronutrient supplement packets containing a home fortification powder every six months, along with instructions on how to use the powder. This group served as our Free Delivery Group (or Free Group).

The caregivers of children in the Treatment Group 2 (Text Messaging Group or Text Group) received the same treatment as the Free Group. However, the Text Group caregivers also were enrolled in a daily text message reminder program. In partnership with a cellular communications provider based in Shaanxi province, daily reminder messages were sent to the Text Group. A list of all messages is in Table 1.

Table 1: List of text messages sent as part of the project, in original Chinese and translated English

1、记得给宝宝吃一小袋营养包！营养包可以可添加到已做好的粥、菜、面条、水、奶、果汁或汤中。 Remember to give Baby a vitamin packet! Vitamin packets can be added to porridge, vegetables, noodles, water, milk, juice, or soup.
2、别忘了今天要在给宝宝吃的东西里加一小袋营养包，它能让您的宝宝长得更高、更健壮！ Don't forget to add a vitamin packet to Baby's food today, it can make your baby grow up to be taller and stronger!
3、记得今天给宝宝吃一小袋营养包！添加营养包时，注意粥、菜、面条、水、奶、果汁或汤不能太烫了！ Remember to give Baby a vitamin packet today! When you add the vitamin packet, make sure that the porridge, vegetables, noodles, water, milk, juice, or soup isn't too hot!
4、**提醒您今天在**给宝宝吃的东西里加一小袋营养包，它能让您的宝宝变得健康，少生病！ A friendly reminder to add a vitamin packet to Baby's food today – it can make Baby healthier and less likely to get sick!
5、**宝宝吃**营养包的时间又到了！别忘了今天在宝宝吃的东西里加一小袋营养**包**。 It's time for Baby's vitamin packet again! Don't forget to add a vitamin packet to Baby's food today.

6、记得今天要在给宝宝吃的东西里加一小袋营养包，它能让您的宝宝变得更活泼、更聪明！ Remember to add a vitamin packet to Baby's food today – it can make Baby smarter and more active!
7、营养包, 营养全，宝宝吃了更健康！ 提醒您在宝宝吃的汤或者粥里拌上一小袋营养包吧。 Vitamin packet means balanced vitamins for baby – Baby will be healthier when he eats it! A friendly reminder to mix a vitamin packet into Baby's soup or porridge.

In both the Free and Text Groups we used a Heinz-produced micronutrient powder called NurtureMate. The powder is tasteless and contains a mix of iron, zinc, vitamins A, C, D, B1, B2, B6, B12, and folic acid, among other key nutrients (Table 2). NurtureMate is recommended for babies aged 6–36 months and taking five packets per week. NurtureMate is approved by the Chinese government.

In both intervention groups, households were given a plastic storage envelope in which to store the NurtureMate packets and were instructed to return the empty packets to the survey team at the end of the study. The empty packets were then tallied by the survey team to assess compliance.

Table 2: Composition of the Nurture Mate home fortification powders

Nutrients	Unit	Average content per gram	RDA%	
			6–12 month	13–36 month
Iron	mg	6.0	60%	50%
Zinc	mg	4.80	60%	53%
Vitamins A	μgRE	200	50%	40%
Vitamins C	mg	50.0	100%	83%
Vitamins D	μg	5.0	50%	50%
Vitamins E	mg	1.55	52%	39%
Vitamins B_1	mg	0.30	100%	50%
Vitamins B_2	mg	0.50	100%	83%
Vitamins B_6	mg	0.30	100%	60%
Vitamins B_{12}	μg	0.5	100%	56%
Folic acid	μg	66	140%	75%
Energy	KJ	15	—	—
Protein	g	0	—	—
Fat	g	0	—	—
Carbohydrate	g	0.9	—	—

RDA: recommended daily allowance

2.2 Theory of change

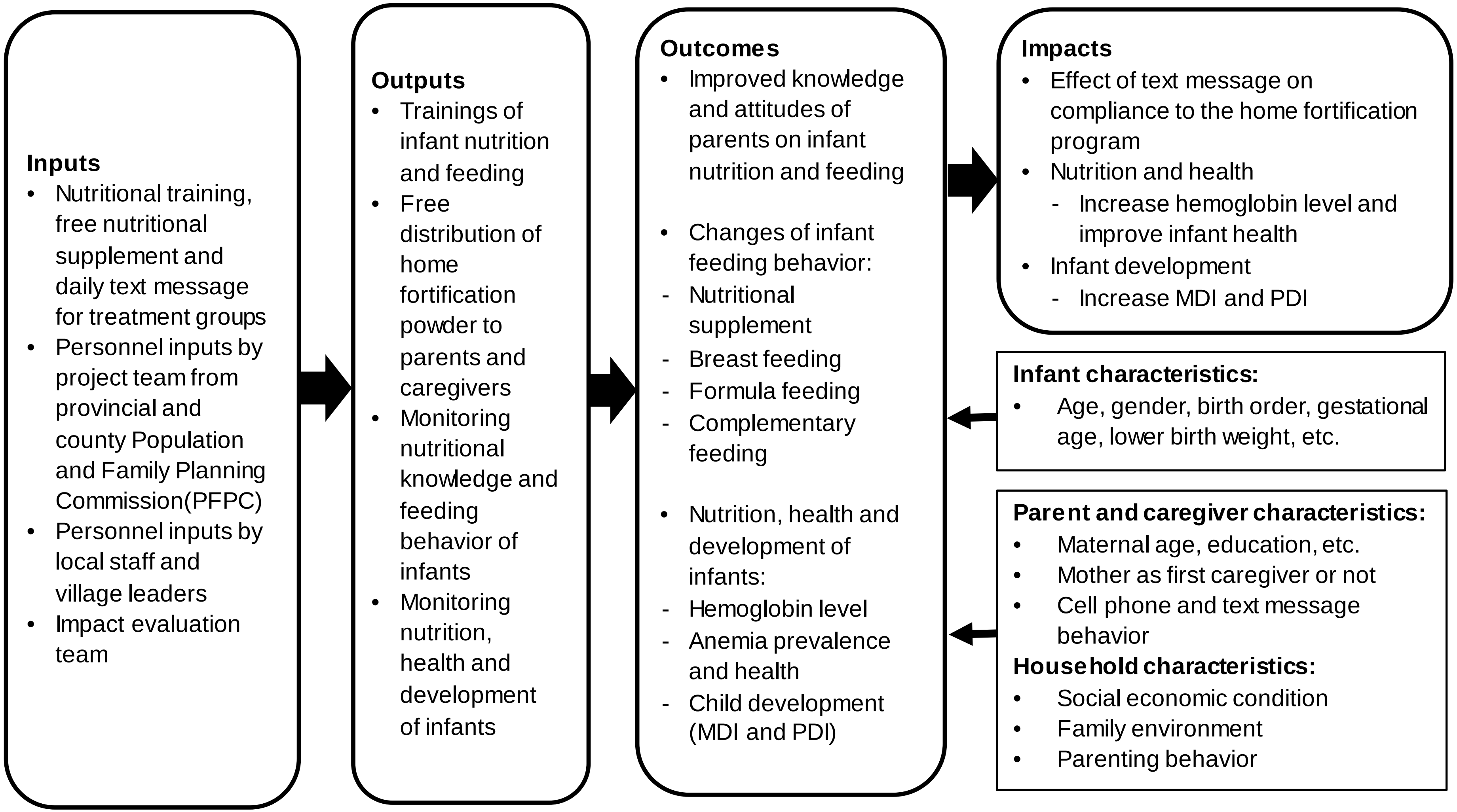
We will be able to examine the mechanisms underlying observed changes using causal chain analysis. We have mapped out the theories of change for the two different interventions and present them in Figure 1. The theory of change for each intervention models the possible effects of the intervention by separating out different channels of influence according to a log frame (inputs → outputs → outcomes → impact).

The analyses of the program impact originate from a theory of change that recognizes that the main effectiveness of interventions is from household compliance to the home fortification program, which in turn can improve the nutrition, health and development of infants.

In order to capture information on targeting in the text messaging intervention, our survey instruments asked caregivers directly whether they received the text messages and how often. We were also able to use sending logs from the text messaging service to get information on implementation.

In order to capture information on caregivers' understanding of the health training material, all survey modules included a short quiz to measure health knowledge, based exclusively on the content of the trainings. The quiz was designed to measure any changes in caregivers' health knowledge between the baseline and follow-up surveys as a way of observing whether they understood the information that was presented to them. To prepare the health knowledge assessments, we conducted extensive research into which types of questions best capture knowledge. We did *not* want to test respondents' test-taking skills (ability to guess, ability to interpret a counterfactual, etc.); rather, we wanted to ask straightforward questions to measure their understanding and internalization of the material. We also conducted extensive pretesting of the surveys to make sure that they asked the questions in a clear, straightforward way, and included both easy and difficult questions. This protocol helped ensure that the surveys captured an accurate distribution of caregiver understanding, rather than underestimating understanding by asking confusing or misleading questions, or overestimating it by asking easy questions.

Figure 1: Theory of Change



Even if the training is effective, however, it is meaningless unless the targeted recipients of the training actually change their behavior. Our surveys collected detailed information on individual- and household-level infant care and feeding behaviors, such as what infants are fed (breast milk, formula, complementary feeding), how much they are fed, and who makes decisions as to their overall care and feeding.

Since both of the treatment groups – Free Group and Text Group – received one-on-one health education training on nutrition and feeding practices, it is impossible to separate out the impact of the health education training. However, by collecting information on infant feeding practices, we can analyze changes in children's diet across the three experimental groups ex post. In this way, it is possible to determine whether the effect of intervention is due to dietary improvements or to the consumption of the home fortification powder.

In order to capture information on targeting in the home fortification program, our household survey asked who in the household (if anyone) actually consumed the nutritional supplement they received for the purpose of triangulation. This captures any substitution away from the intended beneficiary of the implementation.

In order to control the quality of the nutritional supplements, we directly provided households with a pre-approved, name brand supplement for distribution.

In terms of infant cognitive development, we used standardized tests, carefully calibrated and extensively pretested in order to capture actual increases in performance, rather than simply natural increases in performance associated with additional months of life.

Finally, we sent a team of researchers trained in qualitative research methodologies into a subset of survey areas (at least one team per study arm) to conduct qualitative semi-structured interviews. These helped to capture any other gaps in the chain. In addition to asking questions about perceptions and understanding of infant nutrition and, in the intervention villages, perceptions of the interventions themselves, the sociologists also were trained to observe infant care and feeding behaviors in the villages, and to discuss with villagers' reasons for not adopting certain health behaviors (cost, perceived importance, inconvenience, etc.). They also discussed reactions to the nutritional supplements, and attitudes towards undernutrition in general, and towards the NPFPC in particular.

2.3 Evaluation questions

1.) Population
    a. What is the extent of nutritional deficiencies (especially anemia) among infants aged 6–24 months in rural Shaanxi province?

b. How much do caregivers know about nutritional deficiencies and how to address them?
c. From where do caregivers typically get information about infant nutrition (friends, internet)?

2.) Impact evaluation questions
   a. What is the impact of an educational campaign paired with a daily nutritional supplementation program on infant health (including anthropometric measures and nutritional deficiencies) and cognitive development (using specially calibrated instruments for measuring infant development)?
   b. What is the added impact of a text message reminder program on adherence to the daily nutritional supplementation program, infant health (including anthropometric measures and nutritional deficiencies) and cognitive development (using specially calibrated instruments for measuring infant development)?
   c. How do the impacts of these programs vary across demographic groups (age, gender, ethnicity)?
   d. What is the cost-effectiveness of each type of intervention?

3.) Interventions
   a. Why are the programs effective or not (using causal chain analysis)?
   b. What aspects of the programs are successful and which are less successful (using causal chain analysis)? How can the interventions potentially be improved?

3. Context

Figure 2: Map of sample counties in Shaanxi Province

Source： http://map.ps123.net/china/19939.html

Our study was conducted between 2013 and 2015, in 11 nationally designated poverty counties located in southern Shaanxi province (Figure 2). From each of these 11 counties, all townships (the middle level of administration, between county and village) were selected to participate in the study. There were two exceptions to this rule: we excluded the one township in each county that housed the county seat and we excluded any townships that did not have any villages with a population of 800 or more.

4. Timeline

Our baseline and follow-up surveys were conducted in five rounds: the first round in April 2013 and subsequent rounds every six months after that. Sample villages were selected at the time of our first visit in April 2013. At the time of each of the first home visits, we sampled all children (April 2013 for Cohort 1; and October 2013 for Cohort 2) in the desired age range (6–11 months) living in the village. The reason for enrolling two cohorts of children was to ensure that the number of sample children aged 6–11 months met the power requirement (see section 5.5 below). Overall, the baseline sample included 1,834 children. Sample children in Cohort 1 were followed in October 2013, April and October 2014. Sample children in cohort 2 were followed in April and October 2014, and October 2015. The intervention began in April 2013 and finished in October 2014 for Cohort 1, while for Cohort 2, the intervention began in October 2013 and finished in April 2015.

The flow of program implementation and impact evaluation is illustrated in Figure 3.

Figure 3: Timeline of activities

After round one survey in April 2013, interventions began for Cohort 1

The interventions finished for Cohort 1 in October 2014

	Round 1: April, 2013	Round 2: Oct., 2013	Round 3: April, 2014	Round 4: Oct., 2014	Round 5: April, 2015
Cohort 1	**Age: 6-11 Months**	**Age: 12-17 Months**	**Age: 18-23 Months**	**Age: 24-29 Months**	
Cohort 2		**Age: 6-11 Months**	**Age: 12-17 Months**	**Age: 18-23 Months**	**Age: 24-29 Months**

After round one survey in October 2013, interventions began for Cohort 2

The interventions finished for Cohort 2 in April 2015

5. Evaluation: Design, methods and implementation

5.1 Study design and participants

The sample villages were selected in April 2013 as follows. We first randomly selected 11 nationally designated poverty counties in southern Shaanxi province. From these 11 counties, all townships in each county were included except for the one township that housed the county seat (11 townships excluded in 11 sample counties); and any townships that did not have any villages with at least 800 people (two townships did not have any villages with at least 800 people). In total, 174 townships were selected to participate in the study. We used official government data to compile a list of all villages in each township (in total, there were 2,110 villages in 174 townships). Then we randomly selected two villages from the list in each township, using a random numbers generator. We selected an additional 3 villages by randomly selecting 3 townships and 1 village in each selected township. Therefore, our final sample consisted of 351 villages in 174 townships (typically, each village had about 220 households and 1,000 people).

A list of all registered births over the past 12 months was obtained from the local family planning office. All infants in our desired age range (6–11 months) were enrolled. To meet the power requirements of this study (see section 5.5 below), we required a minimum of five infants in each village (prior to attrition). To ensure that there are at least 5 children aged 6–11 months in the village, we excluded villages with less than 800 people in the sampling (only 2 villages with people less than 800 had five or more children aged 6–11 months). The sample villages were all revisited in October 2013 and a new cohort of infants (also aged 6–11 months) was surveyed at that time. Overall, our study included 1,834 infants in 351 villages across 174 townships (about 5.2 sample children per village).

5.2.1 Qualitative analysis

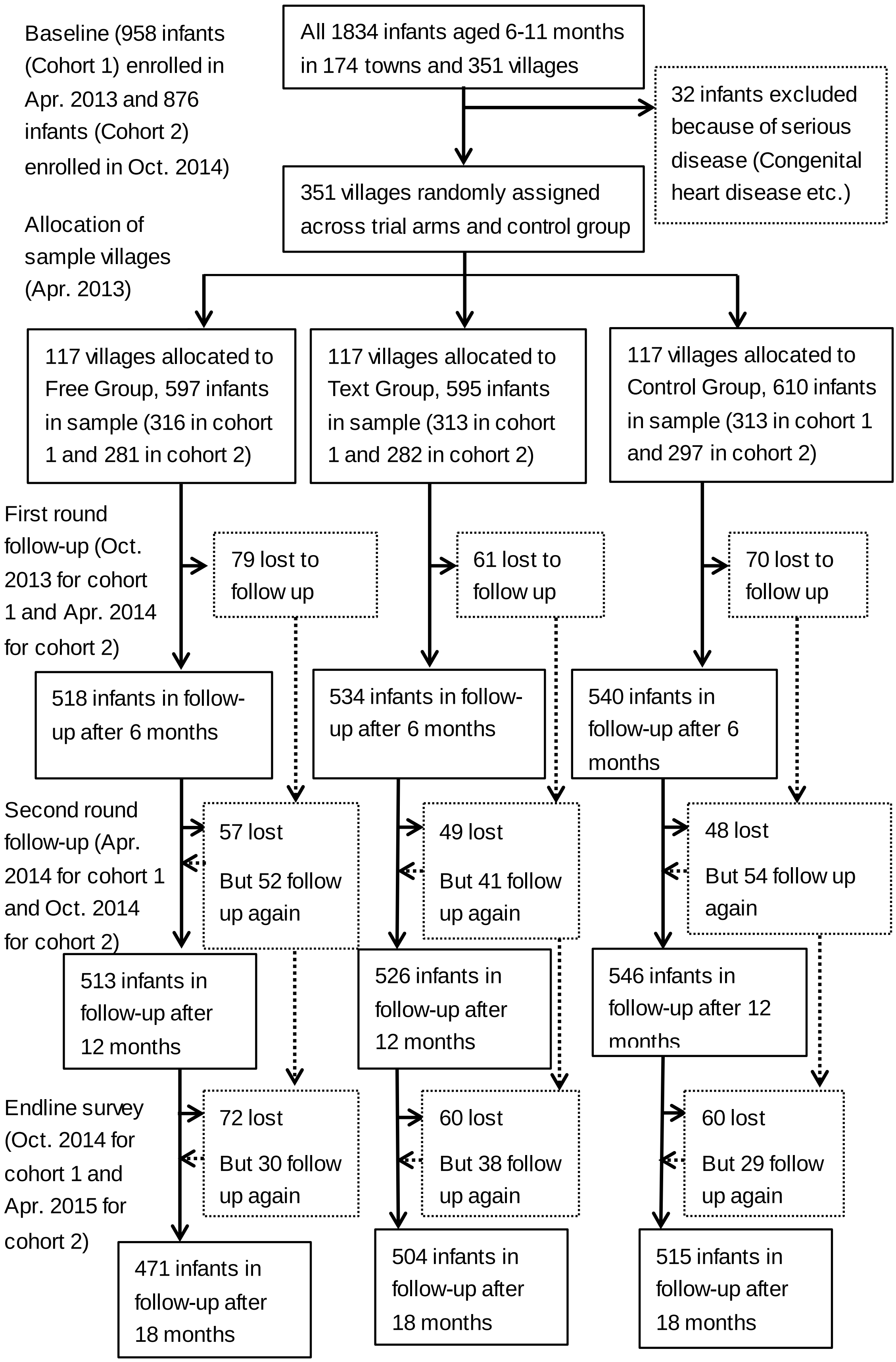
Beside the regular follow-up survey every six months, we also conducted three waves of in-depth interviews with children's primary caregivers in 17 rural villages within 4 nationally designated poverty counties (3 sample counties, 1 non-sample county) in the southern part of Shaanxi province. Our interview subjects were primary caregivers of children living in the sample areas. Children ranged from 6 to 18 months of age and were randomly selected from a list of all registered births over the past 2 years, which we obtained from the local health officials in each town or village. Each primary caregiver of sample children was identified before the interview and all were women. Of the 60 primary caregivers we interviewed, 44 were mothers of sample children and 16 were grandmothers of sample children. The interviewees for the first wave, conducted in July 2013, consisted of 10 primary caregivers, all mothers, from 3 rural villages in Pingli county (the one non-sample county). In April 2014, we interviewed the second wave, consisting of 10 primary caregivers—3 mothers and 7 grandmothers—from 7 villages in Shanyang county (one of our sample counties). In May 2015, we interviewed the final wave, consisting of 40 primary caregivers—31 mothers and 9 grandmothers—from 3 villages in Shangnan county (one of our sample counties) and 4 villages in Danfeng county (1 of our sample counties).

5.2 Randomization and masking

Once the sample selection was complete, villages were randomly assigned, by computer-generated random numbers, into two treatment groups and a control group. A total of 1,834 children were enrolled at baseline (when children were 6–11 months of age) across the two cohorts (Figure 4). We excluded 32 children due to serious illness (2 children were found to have severe anemia and referred to hospital; and another 30 were found to have congenital heart defects or other serious health conditions). Assignment was cluster-randomized at village level and stratified at county level, with 117 villages in each treatment group. A total of 610 children were randomly assigned to the Control Group, 597

children were assigned to Treatment Group 1 (Free Group) and 599 children were assigned to Treatment Group 2 (Text Messaging Group). Participating caregivers and participants were never informed that they were part of an RCT.

Figure 4: Trial profile



Trained enumerators and local health practitioners who assisted with baseline and follow-up surveys were not explicitly informed of the treatment assignment of participants. The study team informed enumerators that they were participating in a general study of health and education of rural children by the Chinese Academy of Sciences and the Chinese Centers for Disease Control and Prevention.

5.3 Procedures

With the assistance of trained nurses from Xi'an Jiaotong Medical School, we collected Hemoglobin (Hb) concentrations from all participating infants and their mothers. Hb concentrations were measured onsite using a Hemocue Hb 201+ finger prick system. The nurses also measured the length and weight of each infant, according to WHO recommendations. [32]

Teams of trained enumerators collected socioeconomic data from all households participating in the study. Each infant's primary caregiver was identified and administered a detailed survey on parental and household characteristics, including each child's gender and birth order, maternal age and education, and whether the family was receiving Minimum Living Standard Guarantee payments (a poverty indicator). The infant's age was obtained from his or her birth certificate. The primary caregiver was individually identified by each family as the individual most responsible for the infant's care (typically the child's mother or grandmother). In order to capture information on targeting in the supplementation intervention, our household survey also collected information about adherence to the home fortification program.

All infants were also administered the BSID Version 1, an internationally scaled test of infant and toddler cognitive and motor development.[33] This test is well-recognized in the psychological literature and is listed by the American Psychiatric Association as a way to diagnose certain developmental disorders.[34] The test was formally adapted to the Chinese language and environment in 1992, and scaled according to a urban Chinese sample.[35, 36] Following the example of other published studies that use the BSID to assess infant development in China,[6, 37, 38] it was this officially adapted version of the test that was used in this study. The test has an inter-rater reliability of 0.99 for each of the two sub-indices, the Mental Development Index (MDI) and the Psychomotor Development Index (PDI). [39] (Both indices are described in more detail below.) The test-retest reliability is high, at 0.82 for MDI and 0.88 for PDI. [39] The parallel forms reliability is also high, at 0.85 for MDI and 0.87 for PDI, indicating that the test scores are consistent when there is a variation in the methods or instruments used in the test. [39]

All BSID enumerators attended a week-long training course on how to administer the BSID, including a 2.5-day experiential learning program in the field. The test was administered one-on-one in the household using a set of standardized toys and a detailed scoring sheet. The BSID takes into consideration each infant's age in days, as well as whether he or she was a premature birth. These two factors, combined with the infant's performance on a series of tasks using the standardized toy kit, contribute to the establishment of two independent, internationally standardized scores: the Mental Development Index (MDI), which evaluates memory, habitation, problem solving, early number concepts, generalization, classification, vocalizations and language to produce a measure of cognitive development; and the Psychomotor Development Index (PDI), which evaluates gross muscle groups (rolling, crawling and creeping, sitting, standing, walking, running and jumping) and fine motor manipulation to produce a measure of psychomotor development.[40] This study represents one of the largest administrations of the BSID ever conducted in China, and to our knowledge, the only administration of the BSID ever conducted in rural communities in China's nationally designated poverty counties.

5.3.1 Qualitative analysis

Caregivers were asked a series of open-ended questions regarding their understanding of child nutrition, their feeding practices in view of this understanding, their perception of the causes and consequences of malnutrition, their understanding of how to promote child development, and the sources of information that formed the basis for their perceptions and conclusions. In-depth interviews were conducted in Mandarin Chinese. All 60 participants gave informed consent. When possible (that is, when caregivers permitted), the interviews were recorded, transcribed and translated into English for analysis. All personally identifiable information was removed from the transcripts. Some participants did not give permission for the interviews to be recorded; in those cases, the field members instead took detailed interview notes. Each interview lasted 30–90 minutes. The interviews were semi-structured; interviewers referred to a scripted interview protocol, but also had the freedom to diverge from this protocol in order to investigate specific stories that emerged.

Interview transcripts, field notes, and audio-recordings were translated and transcribed into English for analysis. Once interviews were transcribed, recurring similarities, differences, and patterns were identified for analysis. Interview responses from caregivers were supplemented with field notes and observations from the research team, in order to provide a more complete representation of potential reasons for child anemia in rural Shaanxi Province.

5.4 Outcomes

Information on the consumption of the home fortification powder was collected at each follow-up survey. “Fully compliant” households were defined as those that administered 5–7 nutritional supplement packets to the target child each week. To ensure the accuracy of measurements, we instructed caregivers to put used empty packets in a pre-prepared plastic storage envelope. Enumerators tallied unused and empty packets to assess compliance.

Anemia status was assessed based on finger blood analysis for Hb. Following internationally accepted standards, anemia was defined as Hb < 110 g/L, moderate anemia was defined as 70 g/L ≤ Hb < 100 g/L, and severe anemia was defined as Hb < 70 g/L. [41,42]

Physical indicators of length and weight were compared with the 2006 WHO child growth standards to calculate length-for-age (LAZ), weight-for-age (WAZ), and weight-for-length z-scores (WLZ). [43] We followed internationally recognized cutoffs to consider children whose LAZ, WAZ or WLZ fell more than two standard deviations below the international mean to be stunted, underweight or wasted, respectively. [44]

Cognitive development (MDI) and psychomotor development (PDI) scores were determined using the BSID protocol. Both sub-indices are scaled to have an expected mean of 100 and a standard deviation (SD) of 16. Scores on each index can range between 50 and 150. [40] Mild impairment for each index is defined as 70 ≤ MDI < 85 and 70 ≤ PDI < 85, while moderate or severe impairment for each sub-index is defined as MDI < 70 and PDI < 70. [40] Infants failing to achieve the minimum MDI or PDI score (50) were assigned a score of 49.[45]

5.5 Statistical analysis and power calculations

The sample size for our study was determined by power calculations performed before enrollment using Optimal Design, a software developed by the University of Michigan.[46] The power to detect a difference in outcome variables (compliance, Hb concentration, anemia rates, MDI and PDI scores) between the treatment and control groups in a cluster-RCT depends on five factors: (1) number of children/village (n); (2) number of villages (J); (3) intra cluster correlation in anemia prevalence (ICC); (4) minimum effect size that we would expect to be able to detect, called minimum detectable effect (MDE); and (5) how outcome variables (nutrition supplement compliance, Hb concentration, anemia rates, MDI and PDI scores) within villages correlate over time (R2).

We assumed a detectable effect of 0.2 SD, an ICC of 0.1, R2 of 0.5 and 4 infants per village after attrition in the case of Hb concentration and anemia rates. [47–51] Based on these parameters, we calculated that we required 112 villages/group to detect a standardized effect of 0.2 at 80 per cent power given a significance level of 0.05.

For compliance (number of home fortification packets fed) between the Free Distribution and Text Messaging Groups, on the basis of previous study, [52] the overall weighted mean effect size representing the impact of these interventions is about 0.3 SD. In the case of the MDI and PDI test scores, there is evidence that the effect size of iron supplementation intervention is more than 0.3 SD. [53] Based on this information, we assumed an ICC of 0.1, R2 of 0.5 and 4 infants per village after attrition again, and detectable effect of 0.3 SD (nutrition supplement packets fed and compliance, MDI and PDI scores); we can detect a standardized effect of 0.3 at more than 90 per cent power given a significance level of 0.05. Because of some uncertainty over the overall attrition rate in two years, we decided to overpower slightly. As a result, five villages were added to each group to overpower the study.

Statistical analyses were conducted using STATA 13.0 (StataCorp, College Station, TX, USA). P-values below 0.05 are considered statistically significant. Linear regression and logistic regression were used for multivariate analyses as appropriate. We included the following variables as potential confounders in the multivariate analysis: gender; age; whether the child was born prematurely; birth order; whether the child's mother was identified as the primary caregiver; maternal educational level and age; and whether the child's family received Minimum Living Standard Guarantee payments. All multiple linear regressions adjust for county fixed effects. Standard errors account for clustering at the village level. Lowess curves reflecting the relationship between Hb concentration and BSID score were estimated using the Lowess procedure in SAS. We used ANOVA and chi-square tests to test the balance of the control variables in the baseline. We examined caregiver compliance to the fortification program through the histogram showing the frequency distribution of the fully compliant by intervention arms.

We estimated the treatment effects of both the compliance of caregivers and the anemia status of infants using an intent-to-treat (ITT) analysis. To estimate the ITT impacts, we used a multivariate regression model and controlled for observable variables (child age; gender; low birth weight; premature birth; birth order; baseline anemia status of child; whether the family received social security support; relationship of primary caregiver to child; maternal education; maternal micronutrient supplementation during pregnancy; maternal Hb concentration; breastfeeding duration; formula feeding duration; complementary feeding after six months; infant iron supplementation; meat consumption) and fixed-effects (county and cohort) at the cluster level. We corrected for clustering of standard errors at the village level.

In order to accommodate partial compliance (that is, because not all caregivers were fully compliant) and measure the impact of the actual treatment on children's anemia status, we produced an estimate using the Average Treatment Effect on the Treated (ATT). [54] We estimated our ATT estimate by using the random assignment as the instrumental variable (IV) for compliance (number of home fortification packets fed).

5.6 Ethical issues

This study received ethical approval from the Stanford University Institutional Review Board (IRB) (Protocol ID 25734) and from the Sichuan University Ethical Review Board (Protocol ID 2013005-01). All participating caregivers gave their oral consent for both their own and their infant's involvement in the study. Two children who were found to have severe anemia were referred to the local hospital for treatment and excluded from the analysis.

The trial was registered with the ISRCTN Registry in April 2013 (trial number: ISRCTN44149146) prior to the start of study activities.

6. Impact analysis and key results

6.1 Participants

A total of 1,834 children aged 6–11 months in 351 villages were enrolled at baseline. We excluded 32 children due to serious illnesses. Although we were able to track each sampled child with valid contact information who was still living in the sample villages, we had an attrition rate of about 15 per cent between baseline and each follow-up survey. Of the 1,802 children, 1,592 (88%) remained in the sample at 12–17 months of age, 1,585 (88%) remained in the sample at 18–23 months of age, and 1,490 (82%) remained in the sample at 23–29 months of age. No villages (clusters) were lost (Figure 4). Based on the multiple logistic estimates of the propensity to be attrited, after controlling for potential confounding variables (infant and family characteristics), we find that attrition rates did not vary significantly across the experimental arms (Table 3). Table 4 shows that attrited children had individual and family characteristics that were statistically nearly identical to the tracked children (Table 4).

Table 3: Comparison across Free Group, Text Group and Control Group of attrition status

	Lost to follow-up at least once (yes = 1, no = 0)[1]	
Trial arms compared	Coefficient (95% CI)	p-value
Free MNP vs control	0.21 (-0.08; 0.49)	0.161
Text vs control	0.02 (-0.28; 0.30)	0.936
R-squared	0.07	
Observations	1,802	

[1] Regression estimates from multiple logistic model adjusted for age, gender, premature birth, birth order, families received social security support, whether primary caregiver is mother, maternal education, ever breastfeeding and breastfeeding period, food supplement feeding after six months, period of taking formula in baseline, as well as county fixed effect and cohort fixed effect. Clustering is at the village level.

Table 4: Baseline characteristics of sample children by attrition

Characteristics	Never lost (n = 1,291)	Lost to follow-up at least once (n = 511)	p[1]
Social economic status			
Age (month) [2]	9.48±1.82	9.48±1.91	0.88
Girls (%)	48.0 (620)	45.6 (233)	0.29
Low birth weight (%)	5.1 (66)	3.3 (17)	0.12
First birth (%)	60.1 (776)	68.7 (351)	< 0.01
Families received social security support (%)	23.0 (297)	25.1 (128)	0.75
Caregiver and mother characteristic			
Mother is primary caregiver (%)	81.0 (1045)	80.8 (413)	0.66
Maternal education above 9 years (%)	82.9 (1070)	76.1 (389)	< 0.01
Maternal age above 25 years (%)	51.3 (662)	47.2 (241)	0.21
Infant feeding practice			
Ever breastfed (%)	88.9 (1417)	88.5 (452)	0.80
Exclusive or predominant breastfeeding < 6 Months (%)	38.0 (490)	37.4 (191)	0.55
Ever formula-fed (%)	65.9 (851)	64.2 (328)	0.84
Still breastfed ≥ 12 Months (%)	44.9 (579)	20.4 (104)	< 0.01
Supplementary feeding after six months (%)	65.8 (850)	64.6 (330)	0.82
Infant nutrition status			
Hemoglobin concentration (g/L) [3]	109.0±12.7	109.5±12.4	0.80
Anemia prevalence (%)[3]	49.1 (630)	47.7 (240)	0.80
Infant development status			
MDI test score[4]	96.5±17.0	97.6±16.7	0.60
PDI test score[5]	89.7±17.5	91.1±16.2	0.42

Data are presented as mean ± SD or % (n) for categorical variables.

[1] Testing null hypothesis of no difference between free MNP and control groups, adjusted for cohort, county fixed effect and cluster randomization. [2] Data missing for 4 children in the free MNP group. [3] Data missing for 7 children in control group and 10 in the free MNP group. [4] Data missing

for 1 child in control group and 4 in the free MNP group.[5] Data missing for 2 children in control group and 5 in the free MNP group.

There were incomplete data for some sample children at both baseline and follow-up. Incomplete data occurred for several reasons: caregivers refused permission for their infants to be given the Hb test; infants or the caregivers refused to take some of the BSID test items; and we could not get information on home fortification behavior, etc. In summary, Hb data were missing for 349 children, MDI data were missing for 214 children, PDI data were missing for 233 children and feeding behavior data were missing for a total of 206 children across all rounds of surveying.

The three groups were balanced at baseline for a range of indicators including socioeconomic status, caregiver and mother characteristics, feeding practices, and child nutritional and development indicators (p-values > 0.05—Table 5). Average characteristics of interviewees from our sample areas are depicted in Table A1. In general, the basic characteristics of interviewees are similar to that of sample child in the three groups.

The data presented in Table 5 also show that the anemia prevalence is just under 50 percent for each of the three groups. There are no significant differences in anemia rate among the three groups (p = 0.88).

Table 5: Baseline characteristics by treatment groups in rural Shaanxi province

Characteristics	Control Group (n = 610)	Free Group (n = 597)	Text Group (n = 595)	p[1]
Social economic status				
Age (month) [2]	9.46±1.90[b]	9.53±1.88	9.48±1.80	0.75
Girls (%)	49.0 (299)	46.7 (279)	46.2 (275)	0.26
Low birth weight (%)	4.4 (27)	4.7 (28)	4.7 (28)	0.80
First birth (%)	62.3 (380)	62.3 (372)	63.0 (375)	0.88
Families received social security support (%)	24.4 (149)	24.3 (145)	22.0 (131)	0.44
Caregiver and mother characteristic				
Mother is primary caregiver (%)	79.2 (483)	81.4 (486)	82.2 (489)	0.31
Maternal education below or equal to 9 years (%)	78.4 (478)	81.7 (488)	82.9 (493)	0.07
Maternal age above 25 years (%)	51.2 (312)	50.6 (302)	48.6 (289)	0.61
Infant feeding practice				
Ever breastfed (%)	87.7 (535)	88.1 (526)	90.4 (538)	0.36
Exclusive or predominant breastfeeding < 6 Months (%)	37.7 (230)	37.9 (226)	37.8 (225)	0.97
Still breastfed ≥ 12 Months (%)	39.2 (239)	35.2 (210)	39.3 (234)	0.14
Ever formula-fed (%)	63.4 (387)	68.7 (410)	64.2 (382)	0.07

Characteristics	Control Group (n = 610)	Free Group (n = 597)	Text Group (n = 595)	p[1]
Supplementary feeding after six months (%)	65.9 (402)	66.5 (397)	64.0 (381)	0.87
Infant parenting practice				
Played with baby yesterday with toys (%)	49.8 (304)	45.2 (270)	48.2 (287)	0.13
Sang song to baby yesterday (%)	29.0 (177)	27.5 (16.4)	29.9 (178)	0.78
Infant nutrition status				
Hemoglobin concentration (g/L)[3]	109.3±13.0	109.1±12.6	108.9±12.8	0.70
Anemia prevalence (%)[3]	49.3 (297)	48.0 (284)	49.2 (291)	0.88
Infant development status				
MDI test score[4]	97.2±17.0	95.9±17.2	97.4±16.6	0.88
PDI test score[5]	90.1±18.0	90.6±16.8	89.5±16.6	0.86

Data are presented as mean ± SD or % (*n*) for categorical variables.

[1] Testing null hypothesis of no difference between free, text and control groups, adjusted for cohort, county fixed effect and cluster randomization. [2] Data missing for 2 children in the Free Group and 2 in Text Group. [3] Data missing for 7 children in Control Group and 7 in the Free Group and 3 in Text Group. [4] Data missing for 1 child in Control Group and 2 in the Free Group and 2 in Text Group. [5] Data missing for 2 children in Control Group and 3 in the Free Group and 2 in Text Group.

Table 6 shows the demographic characteristics of the sample. Slightly over half of the sample infants were male (53.2%). Around 4.6% of sample infants were premature and 62.6% were first-order births; the mother was the primary caregiver for 79.6% of the infants in the sample. The majority of the mothers (81.1%) had completed fewer than 9 years of schooling; 49.9% were aged over 25 years. About one-quarter (24.3%) of sample families reported receiving Minimum Living Standard Guarantee payments, a form of government welfare for the lowest-income families nationwide.

Table 6: Basic characteristics of sample infants in rural Shaanxi province

Characteristics	Frequency (n)	Percentage (%)
Gender		
Male	961	53.2
Female	847	46.8
Infant age		
6 months	184	10.2
7 months	301	16.6
8 months	280	15.5
9 months	276	15.3
10 months	301	16.6
11 months	466	25.8
Is the infant premature?		
No	1,724	95.4
Yes	84	4.6

Characteristics	Frequency (n)	Percentage (%)
Birth order of infant		
First	1,132	62.6
Second or higher	676	37.4
Mother is primary caregiver		
No	368	20.4
Yes	1,440	79.6
Maternal educational level		
< = 9 years	1,467	81.1
> 9 years	341	18.9
Maternal age		
Age < = 25	906	50.1
Age > 25	902	49.9
Family receives Minimum Living Standard Guarantee		
No	1,369	75.7
Yes	439	24.3

Data are presented as frequency and percent for all infants.

6.2 Hemoglobin concentration, anemia and physical development among rural Chinese infants

Hb concentrations were normally distributed with a mean of 109.1 g/L (Table 7). In our sample, 48.8 per cent of infants had Hb concentrations below 110 g/L, indicating anemia. A total of 363 infants (19.4%) had Hb concentrations below 100 g/L, classifying them as moderately or severely anemic. There was considerable variation in anemia prevalence across the sample counties, ranging from 33.3 per cent to 69.7 per cent.

Table 7 further shows indicators of the infants' physical development, as measured by LAZ, WAZ and WLZ scores. The data show that 3.7% of infants in our sample are stunted, 1.2% are underweight and 1.6% are wasted.

Table 7: Hemoglobin concentration, anemia prevalence and physical development of sample infants in rural Shaanxi province

	Mean/Percent	CI (95%)
Hb concentration, g/L	109.1 ± 12.7	[108.5; 109.7]
Anemia status		
Total percent anemic (Hb < 110 g/L)	48.8 (882)	[46.5; 51.1]
Severe anemia (Hb < 70 g/L)	0.7 (12)	[0.3; 1.0]
Moderate anemia (70 g/L ≤ Hb < 100 g/L)	19.4 (351)	[17.6; 21.2]
Mild anemia (100 g/L ≤ Hb < 110 g/L)	28.7 (519)	[26.6; 30.8]
Stunting (LAZ < -2)	3.7 (68)	[2.9; 4.6]
Underweight (WAZ < -2)	1.2 (22)	[0.7; 1.7]
Wasting (WLZ < -2)	1.6 (30)	[1.1; 2.2]

Data are presented as mean ± SD or % (n) for categorical variables. CI = confidence interval.

Table 8 presents the associations between Hb concentrations, anemia prevalence, and infant and household characteristics. There were no differences in Hb concentrations or anemia prevalence either by gender or between pre-term and normal infants. The child's birth order was not associated with Hb concentration but was significantly correlated with anemia prevalence. When the child's mother was identified as the primary caregiver, Hb concentrations were lower and anemia prevalence was higher ($p < 0.05$). Hb concentrations were higher among children whose mothers had 10 or more years of schooling ($p < 0.05$); however, neither the mother's age nor household economic status (as measured by whether the family received Social Security Support) were associated with Hb concentrations or anemia prevalence.

Table 8: Adjusted association of nutritional status (hemoglobin concentration and anemia) and infant, maternal and household characteristics

	Hemoglobin concentration[1]		Anemia status (Yes = 1)[1]	
	Coefficient (95% CI)	p-value	Coefficient (95% CI)	p-value
Infant sex (Female = 1)	-0.02 (-1.13; 1.08)	0.04	-0.003 (-0.05; 0.04)	0.89
Infant age (6 months is base)				
7 months	-1.00 (-3.23; 1.02)	0.38	0.001 (-0.09; 0.09)	0.99
8 months	-3.00 (-5.37; 0.64)	0.01	0.02 (-0.07; 0.12)	0.65
9 months	-0.69 (-2.77; 1.39)	0.52	0.01 (-0.08; 0.10)	0.81
10 months	-0.86 (-3.09; 1.38)	0.45	-0.01 (-0.10; 0.08)	0.85
11 months	0.14 (-1.99; 2.17)	0.90	-0.06 (-0.14; 0.03)	0.19
Is the infant premature? (Yes = 1)	0.55 (-2.73; 3.83)	0.74	-0.07 (-0.18; 0.04)	0.19
Birth order of infant (second or higher = 1)	-1.21 (-2.66; 0.13)	0.10	0.07 (0.01; 0.13)	0.03
Mother is primary caregiver (Yes = 1)	-2.23 (-3.67; -0.97)	<0.01	0.08 (0.02; 0.14)	0.01
Maternal educational level (more than 9 years = 1)	1.77 (0.33; 3.20)	0.02	-0.05 (-0.11; 0.01)	0.10
Maternal age (more than 25 years = 1)	0.94 (-0.37; 2.24)	0.16	-0.03 (-0.09; 0.02)	0.23
Family receives Minimum Living Standard Guarantee (Yes = 1)	0.34 (-1.10; 1.78)	0.64	-0.002 (-0.06; 0.05)	0.94

[1] In addition to the covariates presented, the multiple linear regressions also adjust for county fixed effects. Standard errors account for clustering at the village level

6.3 Mental Development Index and the Psychomotor Development Index among rural Chinese infants

BSID measures were available for sample infants; 2 per cent of the sample infants failed to achieve the minimum score (50) on the MDI and were assigned a score of 49. No infants scored below 50 on the PDI. Table 9 shows the MDI scores for all sample infants. The mean MDI score for the sample was 96.7, significantly lower than the expected mean of 100 ($p < 0.001$). The SD was 17.0. The BSID test results show that 6.9 per cent had an MDI score below 70, thereby classifying them as moderately or severely impaired in their cognitive development. Around 13.1 per cent of infants had an MDI score between 70 and 85, which indicates mild cognitive impairment. In total, 20.0 per cent had MDI scores lower than 85.

Table 9 also shows the PDI score for sample infants. The mean PDI score for the sample was 90.0, significantly lower than both the observed MDI score and the expected mean PDI score of 100 ($p < 0.001$). The SD was 17.2. The data show that 13.1 per cent of sample infants were moderately or severely impaired in their psychomotor development (PDI < 70) and 19.2 percent were mildly impaired (70 ≤ PDI < 85).

Table 9: Cognitive and psychomotor development of sample infants in rural Shaanxi province

	Mean/Percent	CI (95%)
MDI score	96.7 ± 17.0	[96.0; 97.5]
Cognitive impairment		
Moderate or severe (MDI < 70)	6.9 (125)	[5.7; 8.1]
Mild (70 ≤ MDI < 85)	13.1 (237)	[11.6; 14.7]
Any (MDI < 85)	20.0 (362)	[18.2; 21.9]
PDI score	90.0 ± 17.2	[89.2; 90.8]
Psychomotor impairment		
Moderate or severe (PDI < 70)	13.1 (236)	[11.5; 14.6]
Mild (70 ≤ PDI < 85)	19.2 (348)	[17.4; 21.1]
Any (PDI < 85)	32.3 (584)	[30.1; 34.5]

Data are presented as mean ± SD or % (n) for categorical variables. CI = confidence interval.

6.4 Correlational analysis between hemoglobin concentration and child development

The multivariate analyses show a significant positive association between Hb concentrations and both MDI and PDI scores after controlling for potential confounding variables (Table 10). More precisely, our analysis shows that a 10 g/L rise in infant Hb concentration is associated with a 0.9-point rise in the MDI score and a 1.0-point rise in the PDI score. Logistic analyses using three commonly used BSID score cutoffs are largely consistent with this result for both MDI and PDI (Table 11).

Figure 5 shows a Lowess plot of the relationship between Hb concentrations and BSID scores. Both panels show a positive relationship between Hb concentrations and both MDI and PDI scores. This positive relationship is approximately linear and evident both below and above the WHO cutoff for anemia (110 g/L).

Table 10: Association between hemoglobin concentration and BSID scores

	MDI score[1]		PDI score	
	Coefficient (95% CI)	P value	Coefficient (95% CI)	p-value
Hb concentration (g/L)	0.09 (0.03; 0.15)	<0.01	0.10 (0.04; 0.16)	<0.01
Sex (Female = 1)	1.31 (-0.16;2.78)	0.08	0.44 (-1.05; 1.93)	0.56
Infant age (6 months is base)				
7 months	9.05 (5.56; 12.53)	<0.01	6.20 (3.30; 9.10)	<0.01
8 months	7.79 (4.38; 11.20)	<0.01	4.06 (1.09; 7.03)	<0.01
9 months	6.69 (3.17; 10.21)	<0.01	-0.65 (-3.89; 2.58)	0.69
10 months	5.92 (2.34; 9.49)	<0.01	-7.69 (-11.0; -4.35)	<0.01
11 months	4.78 (1.45; 8.12)	<0.01	-2.04 (-5.36; 1.28)	0.23
Is the infant premature? (Yes = 1)	-1.70 (-6.10; 2.69)	0.45	0.76 (-2.71; 4.23)	0.67
Birth order of infant (second or higher = 1)	-0.83 (-2.79; 1.14)	0.41	-1.37 (-3.41; 0.67)	0.19
Mother is primary caregiver (Yes = 1)	0.55 (-1.49; 2.59)	0.60	1.40 (-0.85; 3.65)	0.22
Maternal educational level (more than 9 years = 1)	0.96 (-0.93; 2.85)	0.32	2.41 (0.51; 4.30)	0.01
Maternal age (more than 25 years = 1)	-1.19 (-3.12;0.73)	0.22	-0.94 (-2.86; 0.98)	0.34
Family receives Minimum Living Standard Guarantee (Yes = 1)	-0.42 (-2.16; 1.32)	0.64	-0.71 (-2.58; 1.17)	0.46

[1] In addition to the covariates presented, the multiple linear regressions also adjust for county fixed effects. Standard errors account for clustering at the village level.

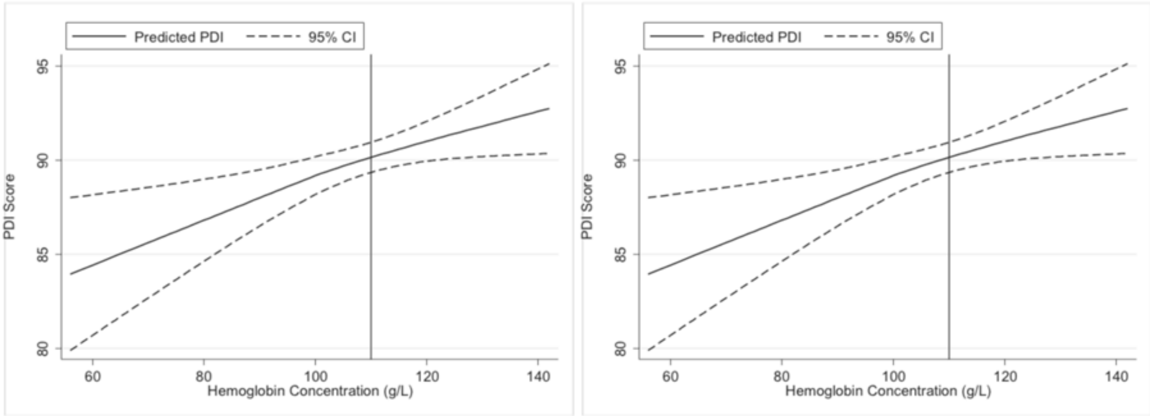
Table 11: Association between hemoglobin concentration and BSID scores, using three commonly used score cutoffs[1]

	MDI < 100 (Yes = 1)		MDI < 85 (Yes = 1)		MDI <80 (Yes = 1)		PDI < 100 (Yes = 1)		PDI < 85 (Yes = 1)		PDI <80 (Yes = 1)	
	Marginal effects (95% CI)	p = value	Marginal effects (95% CI)	p = value	Marginal effects (95% CI)	p = value	Marginal effects (95% CI)	p = value	Marginal effects (95% CI)	p = value	Marginal effects (95% CI)	p = value
Hb concentration (g/L)	-0.002 (-0.00; 0.00)	0.02	-0.00 (-0.00; 0.00)	0.47	-0.00 (-0.00; 0.00)	0.29	-0.00 (-0.00; -0.00)	<0.01	-0.002 (-0.00; -0.00)	0.03	-0.00 (-0.00; 0.00)	0.29
Sex (Female = 1)	-0.03 (-0.07; 0.01)	0.18	-0.03 (-0.06; 0.01)	0.12	-0.01 (-0.05; 0.02)	0.44	-0.03 (-0.07; 0.02)	0.23	-0.00 (-0.04; 0.04)	0.90	-0.01 (-0.04; 0.02)	0.44
Infant age												
7 months	-0.18 (-0.27; -0.09)	<0.01	-0.18 (-0.26; -0.10)	<0.01	-0.14 (-0.21; -0.08)	<0.01	-0.06 (-0.14; 0.03)	0.17	-0.21 (-0.29; -0.12)	<0.01	-0.14 (-0.21; -0.08)	<0.01
8 months	-0.15 (-0.25; -0.06)	<0.01	-0.15 (-0.23; -0.08)	<0.01	-0.12 (-0.18; -0.05)	<0.01	-0.03 (-0.12; 0.06)	0.54	-0.19 (-0.28; -0.11)	<0.01	-0.12 (-0.18; -0.05)	<0.01
9 months	-0.07 (-0.12; 0.02)	0.12	-0.09 (-0.17; -0.01)	0.04	-0.09 (-0.16; -0.02)	0.01	0.07 (-0.02; 0.15)	0.11	0.03 (-0.06; 0.12)	0.58	-0.09 (-0.16; -0.02)	0.01
10 months	-0.08 (-0.17; 0.01)	0.10	-0.08 (-0.16; 0.00)	0.06	-0.08 (-0.14; 0.01)	0.02	0.15 (0.06; 0.23)	<0.01	0.21 (0.12; 0.30)	<0.01	-0.08 (0.14; 0.01)	0.02
11 months	-0.08 (-0.17; -0.00)	0.05	-0.03 (-0.11; 0.05)	0.44	-0.02 (-0.09; 0.04)	0.50	0.04 (-0.04; 0.12)	0.33	0.06 (-0.03; 0.15)	0.17	-0.02 (-0.09; 0.04)	0.50

	MDI < 100 (Yes = 1)		MDI < 85 (Yes = 1)		MDI <80 (Yes = 1)		PDI < 100 (Yes = 1)		PDI < 85 (Yes = 1)		PDI <80 (Yes = 1)	
	Marginal effects (95% CI)	p = value	Marginal effects (95% CI)	p = value	Marginal effects (95% CI)	p = value	Marginal effects (95% CI)	p = value	Marginal effects (95% CI)	p = value	Marginal effects (95% CI)	p = value
Is the infant premature? (Yes = 1)	0.00 (-0.10; 0.11)	0.08	0.08 (-0.00; 0.17)	0.05	0.04 (-0.03; 0.11)	0.26	-0.04 (-0.14; 0.06)	0.40	-0.07 (-0.17; 0.03)	0.17	0.04 (-0.03; 0.11)	0.26
Birth order of infant (Second or higher = 1)	0.06 (0.00; 0.12)	0.04	0.04 (-0.01; 0.09)	0.15	0.01 (-0.03; 0.05)	0.63	0.02 (-0.04; 0.07)	0.57	0.00 (-0.05; 0.06)	0.87	0.01 (-0.03; 0.05)	0.63
Mother is primary caregiver (Yes = 1)	-0.04 (-0.10; 0.02)	0.17	0.01 (-0.03; 0.06)	0.56	0.03 (-0.01; 0.07)	0.15	-0.01 (-0.06; 0.05)	0.82	-0.03 (-0.09; 0.02)	0.23	0.03 (-0.01; 0.07)	0.15
Maternal educational level (more than 9 years = 1)	-0.02 (-0.08; 0.03)	0.43	0.01 (-0.04; 0.05)	0.72	0.01 (-0.05; 0.03)	0.67	-0.06 (-0.11; -0.01)	0.03	-0.06 (-0.11; 0.00)	0.06	-0.01 (-0.05; 0.03)	0.67
Maternal age (more than 25 years = 1)	0.01 (-0.04; 0.07)	0.46	-0.00 (-0.05; 0.04)	0.96	-0.01 (-0.03; 0.05)	0.53	0.01 (-0.04; 0.06)	0.68	0.06 (0.01; 0.11)	0.03	0.01 (-0.03; 0.05)	0.53
Family receives Minimum Living Standard Guarantee (Yes = 1)	0.04 (-0.01; 0.09)	0.13	-0.01 (-0.05; 0.04)	0.80	-0.01 (-0.05; 0.03)	0.66	0.02 (-0.03; 0.08)	0.34	0.03 (-0.02; 0.07)	0.30	-0.01 (-0.05; 0.03)	0.66

[1] In addition to the covariates presented, the multiple logistic regressions also adjust for county fixed effects. Standard errors account for clustering at the village level. Marginal effects show the change in probability when the independent variable increases by one unit.

Figure 5: A Lowess plot of the relationship between hemoglobin concentrations and BSID scores

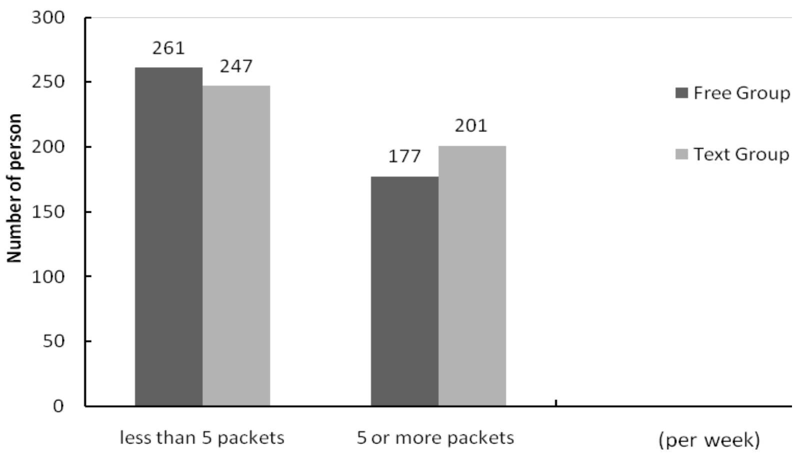


6.5 Impact on compliance

We found that all sample children had at least one primary caregiver with a mobile phone that could receive text messages. About 80 per cent of caregivers knew how to read or send text messages.

Figure 6 shows the frequency of full compliance of caregivers by treatment groups six months after the start of the intervention. Overall, 42.7 per cent were fully compliant with the program (that is, on average, caregivers administered five or more NurtureMate packets per week). A higher relative frequency of children in the Text Messaging Group consumed five or more packets per week (44.9%), compared with children in the Free Delivery Group (40.4%), although the difference is not statistically significant (p = 0.09).

Figure 6: Frequency of full compliance by treatment groups in rural Shaanxi province



Relying on the coefficient estimated using the ITT model, the impact of text message reminders on caregiver compliance (using the fully compliant variable as the dependent variable) is shown in Table 12. After adjusting for other covariates, we see that assignment to the Text Messaging Group led to a positive increase in the likelihood that caregivers had full compliance with the program six months after the start of the intervention (marginal effect = 0.25; 95% CI=0.20, 0.31).

Table 12: Intent-to-treat analysis of the impact of treatment condition on caregiver compliance in rural Shaanxi province

	Caregivers administered 5 or more packets per week (Yes = 1, no = 0)[1]		
	Coefficient	95% CI	P
Treatment (Text Group = 1, Free Group = 0)	0.25	0.20 0.31	< 0.001

[1] Regression estimates from multiple logistic model adjusted for age, gender, low birth weight, premature birth, birth order, families received social security support, whether primary caregiver is mother, maternal education, maternal micronutrient supplement during pregnancy, maternal hemoglobin concentration, period of breastfeeding, food supplement feeding after six months, infant iron supplement, taking meat, period of taking formula and infant hemoglobin concentration in baseline, as well as county fixed effect and cohort fixed effect. Clustering is at the village level.

We also explored the heterogeneous impact of the text message on the consumption of nutritional supplement packets by child characteristics (age, gender), caregiver characteristics (whether mother was the primary caregiver; whether mother had primary school education) and text-messaging practices (whether the primary caregiver knew how to read text messages; whether the primary caregiver knew how to send text messages). Panel A of Table 13 reports the coefficient of each interaction term significant at 0.05. It suggests that the text message was more likely to increase consumption of the home fortification powder if the primary caregiver was the child's mother (marginal effect = 12.19; 95% CI = 0.69, 23.68). If the primary caregiver knew how to read text messages, he or she was also more likely to respond to the message (marginal effect = 9.72; 95% CI = 0.20, 19.25). The same holds for primary caregivers who knew how to send text messages (marginal effect = 14.68; 95% CI = 5.37, 23.98). In fact, as suggested by Panel B of Table 13, receiving the text message significantly increased the likelihood of full compliance when the primary caregiver either knew how to read (odds ratio = 2.93; 95% CI = 1.34, 6.40) or send (odds ratio = 3.26; 95% CI = 1.53, 6.97) text messages.

Table 13: Heterogeneous impact of daily text messages on nutrition supplement compliance in rural Shaanxi province

Panel A

Number of nutrition supplement packets fed	Marginal effect (95% CI)	p
Text group and mom was primary caregiver[1]	12.19 (0.69; 23.68)	0.038
Text group and primary caregiver could read messages[1]	9.72(0.20; 19.25)	0.046
Text group and primary caregiver could send messages[1]	14.68(5.37; 23.98)	0.002

Panel B

Full compliance	Odds ratio (95% CI)	p
Text group and primary caregiver could read messages[1, 2]	2.93(1.34; 6.40)	0.007
Text group and primary caregiver could send messages[1, 2]	3.26(1.53; 6.97)	0.002

[1] Adjusted for treatment assignment, infant's age, gender, mother as the infant's primary caregiver, mother finished primary school education, households received social security support, primary caregiver could read text messages, primary caregiver could send text messages, as well as county fixed effects. Clustering is at the village level. Control group = 0, and Text Group = 1 in this model. [2] Caregiver compliance was measured by administration to child 5–7 nutritional supplement packets per week (yes = 1, no = 0).

6.6 Impact of nutrition supplement on child nutrition, health and development

6.6.1 The impact of nutrition supplement on child nutrition and health

Table 14 summarizes the effects of the treatment condition on child anemia status six months after the start of the intervention. Using the ITT model, after controlling for confounding variables, we find no significant impact of the Free Delivery Group on Hb concentration and children's anemia status six months after the start of the intervention relative to the Control Group (p > 0.05). In the ITT analysis, there is no significant impact of the Text Messaging Group on Hb concentration either. However, we do find that, relative to the Control Group, assignment to the Text Messaging Group has a significantly lower children's anemia rate by 6 per cent after six months of intervention (coefficient=- 0.06; 95% CI = -0.12, -0.01). Testing between the coefficients of the Free Delivery and Text Messaging Groups, we find no difference (p = 0.23).

Table 14: Intent-to-treat and average treatment effect on the treated analysis of the impact of treatment condition on hemoglobin concentration and anemia status of children after six months of intervention in rural Shaanxi province

Treatment	Hb concentration (g/L)		Anemia Prevalence (Hb < 110 g/L)	
	Coefficient (95% CI)	p = value	Coefficient (95% CI)	p = value
ITT analysis[1, 2]				
Free Group (yes = 1, no = 0)	1.80(-0.09; 0.04)	0.09	-0.03(-0.09; 0.04)	0.41
Text Group (yes = 1, no = 0)	1.83(-0.12; -0.01)	0.08	-0.06 (-0.12; -0.01)	0.03
ATT analysis[1, 2, 3]				
Free Group (yes = 1, no = 0)	6.37 (-0.14; 12.89)	0.06	-0.07 (-0.13; -0.01)	0.021
Text Group (yes = 1, no = 0)	4.83 (-0.88; 10.55)	0.10	-0.16 (-0.27; -0.06)	0.003

[1] Regression estimates from multiple logistic model adjusted for age, gender, low birth weight, premature birth, birth order, families received social security support, whether primary caregiver is mother, maternal education, maternal micronutrient supplement during pregnancy, maternal hemoglobin concentration, period of breastfeeding, food supplement feeding after six months, infant iron supplement, taking meat, period of taking formula and infant hemoglobin concentration in baseline, as well as county fixed effect and cohort fixed effect. Clustering is at the village level.
[2] The coefficients are measuring impact of the treatments relative to the Control Group.
[3] The average treatment effect on the treated was estimated by using the random assignment as an instrument variable (IV) for the actual treatment. The IV is if infant was assigned to the Free Group, and if infant was assigned to the Text Group. The actual treatment (endogenous variable) is if child caregiver was fully compliant (administered 5 or more nutrient packets per week).

The impact of the actual treatment condition on child anemia status six months after the start of the intervention by ATT analysis is presented in Table 14. Similar to the finding of ITT analysis, there are no significant differences on Hb concentration among the three experimental arms. We find that, considering the caregiver's compliance, assignment to the Free Delivery Group significantly lowered children's anemia rates by 7 per cent after six months of intervention (coefficient = -0.07, 95% CI: -0.23, -0.06). At the same time, assignment to the Text Messaging Group lowered children's anemia rates by 16 per cent after six months of intervention (coefficient = -0.16, 95% CI: -0.37, -0.06). When accounting for compliance using the ATT model, the analysis shows that there is a significant difference between the coefficients in the Free Delivery and the Text Messaging Groups (p = 0.04).

At the start of the project, we signed an agreement with partners at China Mobile that allowed us to use specialized China Mobile software to send out mass blasts of text messages to all households in the Text Messaging Group. Unfortunately, after six months of intervention, China Mobile announced an update to this software that would not allow us to send out text messages to individuals with competing cell phone service providers. (We reported this problem during our regular interim reporting to 3ie.) As a result, we cannot analyze the effect of Free Delivery and Text Messaging Group respectively, so after six months of nutrition supplement intervention we pooled the Free Delivery and Text Messaging Groups (Free Micronutrient Powders Group or Free MNP Group) and analyzed the effect of the Free Delivery intervention only.

Figure 7 (Panels A and B) shows the average Hb concentration and anemia prevalence (with 95% confidence intervals) over the four survey rounds separately for the Free MNP and Control Group. Overall, there is a rapid increase in Hb levels (decrease in anemia rates) over the course of the study in both groups. In the Control Group, average Hb rose from 109 g/L on average when children were 6–11 months old to 118 g/L when children were 24–29 months old. Corresponding anemia rates dropped by more than half, but remained high (22%).

Figure 7: Measured hemoglobin concentration (g/L) and anemia prevalence (%) of sample child in Control and Free MNP Groups at baseline and each follow-up

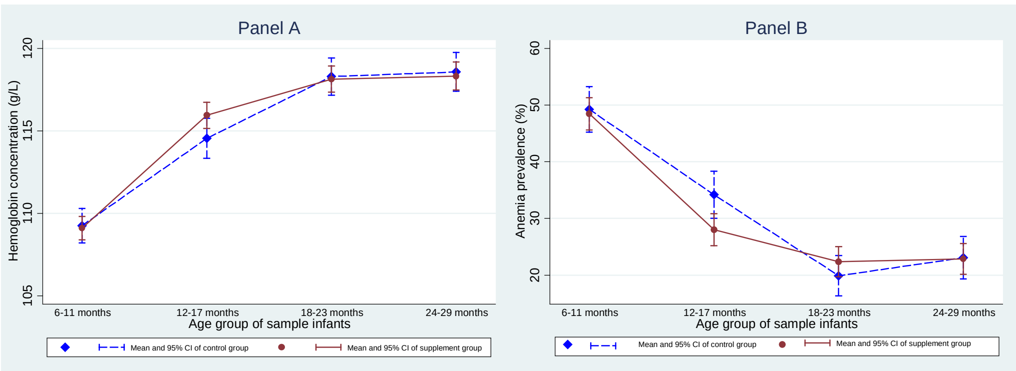


Table 15 shows the estimated treatment effects of the MNP intervention on Hb concentration and anemia status based on ITT analysis. For each outcome, we report impact estimates at 12 and 18 months after the start of the intervention, along with its 95% confidence interval and p-value. Unlike the finding at six months after the start of the intervention, the estimated effects of the Free MNP intervention on average Hb concentration and anemia prevalence were not statistically different from zero.

Table 15: ITT and ATT analysis of impact of Free MNP on hemoglobin concentration, anemia prevalence after 12 and 18 months of intervention among children in rural China

	Hb concentration (g/L)[1]		Anemia prevalence (Hb <110 g/L)[1]		Hb concentration (g/L)[2]		Anemia prevalence (Hb <110 g/L)[2]	
	Marginal effect (95% CI)	p = value	Marginal effect (95% CI)	p = value	Marginal effect (95% CI)	p = value	Marginal effect (95% CI)	p = value
Effect of MNP distribution after 12 months (children 18–23 months of age)	-0.115 (-2.189–1.959)	0.913	0.034 (-0.039–0.107)	0.357	-0.002 (-0.026–0.022)	0.883	0.0003 (-0.0005–0.001)	0.427
Effect of MNP distribution after 18 months (children 24–29 months of age)	0.127 (-1.850–2.105)	0.899	-0.001 (-0.071–0.070)	0.982	0.002 (-0.022–0.027)	0.861	-0.00001 (-0.001–0.001)	0.977
R-squared	0.14		0.10		0.14		0.10	
Observations	6092		6092		6003		6003	

[1] Intention to treat analysis, and regression estimates from multiple linear models adjusted for gender, age, the Hb test machine and county fixed effect. Clustering is at the village level. Hb data missing for 349 observations (17 in baseline, 115, 144 and 73 in 6-month, 12-month and 18-month follow-up).

[2] Average treatment effect on the treated analysis, using the treatment assignment instrument variables for the total number of sachets used every six months; regression estimates from multiple linear models adjusted for gender, age, the Hb test machine and county fixed effect. Clustering is at the village level. Hb data missing for 349 children (17 in baseline, 115, 144 and 73 in 6-month, 12-month and 18-month follow-up) and feeding behavior data missing for 206 children (74, 91 and 41 in 6-month, 12-month and 18-month follow-up).

Table 15 also reports the effects of Free MNP consumption estimated using instrumental variables (ATT analysis) in order to account for imperfect compliance. Similar to the ITT estimates, however, we do not find a significant effect of MNP on Hb concentrations at 12 or 18 months after the start of the intervention even after adjusting for compliance. Nor do we find any significant effects on anemia prevalence in the ITT and ATT analysis at 12 or 18 months after the start of the intervention.

Table 16 presents the consumption of the home fortification powder. The average number of sachets consumed each month in the Free MNP Group over the course of the study was 14 (SD 11.6). The average number of sachets consumed declined slightly from 15.7 to 12.9 across the survey waves. We also found that there was no significant difference between Free MNP Group and Control Group according to the scores of minimum dietary diversity, minimum meal frequency and minimum acceptable diet (Table 17).

Table 16: The average number sachets consumed monthly in MNP Group

Intervention time	Free MNP Group	
	n	Number of sachets consumed monthly
After 6 months intervention	978	15.73 ± 12.1
Between month 7 and 12 of intervention	948	14.1 ± 11.0
Between month 13 and 18 of intervention	934	12.9 ± 11.6
Total	2860	14.3 ± 11.6

Data are presented as mean ± SD; MNP = micronutrient powder

Table 17: Feeding behavior of child aged 6–24 months between Free MNP and Control Groups in rural Shaanxi Province

Feeding behavior indicators	Control group (%)	Free MNP group (%)	p-value
Minimum dietary diversity			
Child aged 6–11 months	38.60	37.36	0.73
Child aged 12–17 months	65.69	69.11	0.18
Child aged 18–23 months	80.87	78.88	0.37
Minimum meal frequency			
Child aged 6–11 months	68.44	66.97	0.67
Child aged 12–17 months	71.91	69.49	0.33
Child aged 18–23 months	66.74	62.01	0.09
Minimum acceptable diet			
Child aged 6–11 months	14.78	14.55	0.92
Child aged 12–17 months	32.16	33.40	0.63
Child aged 18–23 months	31.05	31.20	0.95

6.6.2 The impact of nutrition supplement on child development

Figure 8 (Panels A and B) presents the average BSID MDI and PDI indices (with 95% confidence intervals) over the four survey rounds separately for the Free MNP and

Control Groups. Over the course of the study there was a marked decline in average MDI scores from 97 to 81. The number of children considered to have cognitive delays (MDI < 85) increased from 20 per cent at 6–11 months of age to 56 per cent at 24–29 months of age. In contrast to MDI, we find that average scores on the PDI increased over time rising, from 90 to 102.

Figure 8: Measured MDI and PDI scores of sample children in the Control and Free MNP Groups at baseline and each follow-up

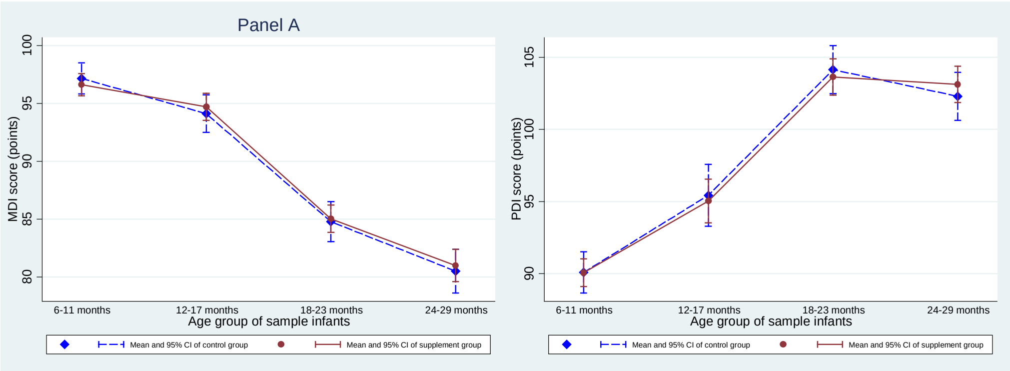


Table 18 shows the estimated treatment effects of the MNP intervention on the two BSID sub-indices based on the ITT analysis. For each outcome, we report impact estimates at 6, 12, and 18 months after the start of the intervention, along with its 95 per cent confidence interval and p-value. The effect of the MNP intervention on cognition (MDI) shows a pattern similar to the effect on Hb concentration and anemia prevalence. After six months of supplementation, the effect of free MNP on the MDI sub-index was 2.23 points (p = 0.044; 95%; CI 0.061—4.399), equal to 0.13 SD of the baseline distribution in the Control Group. These effects did not persist, however. At 12 and 18 months after the start of the intervention estimated effects on MDI scores are not statistically different from zero. Nor do we find significant effects on PDI scores in the ITT analysis after 6, 12 and 18 months of intervention.

Table 18 also reports the effects of free MNP consumption estimated using instrumental variables (IV) or ATT analysis in order to account for imperfect compliance. For MDI, the IV analysis suggests that each additional sachet consumed increased MDI by 0.028 points (p = 0.034; 95% CI 0.002—0.054) six months after the start of the intervention. The implied effect of full compliance is therefore 5.04 points (0.29 SD). By 12 months after the start of the intervention, however, this effect also subsided. The ATT analysis also did not detect any effects on MDI after 12 and 18 months of intervention, nor could we detect any significant effect on PDI scores at 6, 12 and 18 months after the start of intervention.

Table 18: ITT and ATT analysis of impact of Free MNP on Bayley MDI and PDI scores

	Bayley MDI (points)[1]		Bayley PDI (points)[1]		Bayley MDI (points)[2]		Bayley PDI (points)[2]	
	Marginal effect (95% CI)	p = value	Marginal effect (95% CI)	p = value	Marginal effect (95% CI)	p = value	Marginal effect (95% CI)	p = value
Effect of MNP distribution after 6 months (children 12–17 months of age)	2.230 (0.061–4.399)	0.044	-0.266 (-3.328–2.796)	0.864	0.028 (0.002–0.054)	0.034	-0.001 (-0.038–0.035)	0.943
Effect of MNP distribution after 12 months (children 18–23 months of age)	0.487 (-2.071–3.046)	0.708	-0.461 (-2.938–2.016)	0.715	0.007 (-0.022–0.035)	0.640	-0.004 (-0.031–0.023)	0.774
Effect of MNP distribution after 18 months (children 24–29 months of age)	0.828 (-1.787–3.444)	0.534	0.084 (-2.277–2.445)	0.944	0.015 (-0.016–0.047)	0.346	0.003 (-0.026–0.031)	0.843
R-squared	0.27		0.21		0.26		0.21	
Observations	6204		6186		6113		6096	

[1] Intention to treat analysis and regression estimates from multiple linear models adjusted for gender, age, played with baby yesterday with toys, sang song to baby yesterday, BSID testers and county fixed effect. Clustering is at the village level. MDI data missing for 214 observations (5 in baseline, 101, 88 and 20 in 6-month, 12-month and 18-month follow-up); and PDI data missing for 233 children (7 in baseline, 102, 98 and 26 in 6-month, 12-month and 18-month follow-up).

[2] Average treatment effect on the treated analysis, using the treatment assignment instrument variables for the total number of sachets used every six months. Regression estimates from multiple linear models adjusted for gender, age, played with baby yesterday with toys, sang song to baby yesterday, BSID testers and county fixed effect. Clustering is at the village level. MDI data missing for 214 children (5 in baseline, 101, 88 and 20 in 6-month, 12-month and 18-month follow-up); PDI data missing for 233 children (7 in baseline, 102, 98 and 26 in 6-month, 12-month and 18-month follow-up); and feeding behavior data missing for 206 children (74, 91 and 41 in 6-month, 12-month and 18-month follow-up).

6.6.3 Heterogeneous impacts of nutrition supplements on child nutrition, health and development

We also explored the heterogeneous impact of the free MNP on Hb concentration and anemia prevalence by child characteristics (age and gender) and caregiver characteristics (whether the mother was the primary caregiver). Table 19 reports the coefficient of each interaction term. It suggests that the free MNP would be more likely to increase the Hb concentration (marginal effect = 0.31; 95% CI = 0.05, 0.57) and decrease the anemia prevalence (marginal effect = -0.01; 95% CI = -0.02, -0.004) of older children. The results also show that children in the Free MNP Group whose primary caregiver is not their mother are more likely to experience reductions in anemia rates in comparison to children whose primary caregiver is their mother.

Table 19 also reports the heterogeneous impact of the free MNP on child development. The results show that the impact of the free MNP intervention on MDI and PDI scores among children at different ages is either similar or not significantly different. The impact of the free MNP intervention on MDI and PDI scores is not significantly different between children whose caregiver is their mother and children whose caregiver is not their mother. The free MNP is more likely to lead to increases in MDI score (marginal effect = 3.07; 95% CI =1.62; 4.52) and PDI score (marginal effect = 1.67; 95% CI = 0.18, 3.16) if the child is female.

Table 19: Heterogeneous Impact of Free MNP on nutrition, health and development in rural Shaanxi province

Treatment	Hb concentration (g/L)		Anemia prevalence (Hb < 110 g/L)		Bayley MDI (points)		Bayley PDI (points	
	Coefficient (95% CI)	p = value	Coefficient (95% CI)	p = value	Coefficient (95% CI)	p = value	Coefficient (95% CI)	p = value
ITT analysis[1]								
Free MNP (yes = 1, no = 0)* Age of child in months	0.31 (0.05; 0.57)	0.02	-0.01 (-0.02; -0.004)	< 0.01	-0.32 (-0.68; 0.05)	0.09	-0.15 (-0.56; 0.26)	0.47
Free MNP (yes = 1, no = 0)* Gender of child (female = 1, male = 0)	-0.80 (-1.70; 0.09)	0.08	0.03 (-0.01; 0.06)	0.11	3.07 (1.62; 4.52)	< 0.01	1.67 (0.18; 3.16)	0.03
Free MNP (yes = 1, no = 0)* Care giver is mother	-0.57 (-1.49; 0.35)	0.22	0.03 (0.002; 0.07)	0.04	1.51 (-0.10; 3.13)	0.07	0.25 (-1.51; 2.01)	0.78

[1] Intention to treat analysis, and regression estimates from multiple linear models adjusted for treatment assignment, gender, age, survey rounds, cohort, BSID testers and county fixed effect. Clustering is at the village level. MDI data missing for 214 observations (5 in baseline, 101, 88 and 20 in 6-month, 12-month and 18-month follow-up), and PDI data missing for 233 children (7 in baseline, 102, 98 and 26 in 6-month, 12-month and 18-month follow-up).

6.7 Qualitative analysis

In our interviews, caregivers consistently responded that cost is not a primary issue when it comes to providing for their children. Many caregivers added that they would do whatever is necessary to ensure that their children get all that they need.

> *Money is not an obstacle for taking care of my baby. She's still so young that she doesn't have many needs. [2.7 Mother]*

> *I buy what the baby likes to eat. Cost is not a major concern. [2.1 Grandma]*

> *I can afford to take care of the baby. It's not even a choice. If the baby needs something of course you have to find a way to get it for him. I would do anything for the baby. [2.2 Grandma]*

Luo et al. (2014) found that nearly one-fourth of the families in the study received Social Security Support (payments from China's Minimum Living Standard Guarantee system); receipt of such support was used as a household-specific indicator of poverty.[55] Interview responses from caregivers in these households indicated that, although some of these families struggle to provide for their children, they nevertheless make sure to do what they believe to be required to satisfy their child's nutritional needs.

> *Sometimes costs are a barrier to taking good care of my baby. We don't get very much money from my husband's income. But if the baby really needed something, if I thought she really needed something, I would get it for her. [2.5 Mother]*

The interview questions related to costs repeatedly drew responses from the caregivers indicating that their child feeding practices and decisions are not resulting from their poverty status. Thus, we sought to determine what other structural factors are in place that may contribute to the high rate of child anemia.

6.7.1 Lack of knowledge

Malnutrition and iron-deficient anemia

Interviews with parents and grandparents revealed that, while poverty was not a problem, there was a general lack of knowledge and understanding regarding child nutrition. When asked to describe their understanding of malnutrition and, specifically, anemia, many caregivers were at a complete loss, and denied any comprehension of the terms.[1] Others ascribed inaccurate meanings to the terms.

> *I don't know what malnutrition is. [1.5 Mother]*

> *Malnutrition is bad digestion. [1.2 Mother]*

> *Malnutrition is when you don't absorb the food you're eating so you'll grow slowly. [1.4 Mother]*

---

[1] When interviewing caregivers we used the Chinese term *yingyang buliang*, the commonly used term for malnutrition, which literally translates to "nutrition not good", and *pinxie*, the term for anemia, which literally translates to "weak blood".

I've never heard of anemia. [3.1 Grandma]

Anemia? … Doesn't that mean you don't have enough blood? [1.2 Mother]

I think you have anemia when you have low blood pressure and are a little dizzy. [3.08 Mother]

We also asked caregivers if they knew what caused child malnutrition. Some caregivers guessed as to the causes, but many of their assumptions and understandings were not correct.

It might be genes that cause malnutrition. [1.7 Mother]

Don't you get malnutrition when you're a picky eater? [1.3 Mother]

Malnutrition is when you get bad digestion from getting too many colds. It's the result of catching colds easily. [2.3 Grandma]

Further, while some caregivers demonstrated a general understanding that malnutrition can lead to disease, they did not have an accurate perception of the actual causes and consequences of malnutrition. Caregivers cited visible physical signs as indicators of malnutrition. However, micronutrient deficiencies do not lend themselves to detection by observation of physical characteristics. Some caregivers suggested remedies for malnutrition, but none of these included an improved diet that is higher in micronutrients.

You'll know if your skin turns white and pale and you become really thirsty. Also, your hair would turn lighter. So dark skin is healthy [1.7 Mother]

I don't know what the effects of malnutrition are. But you can resolve it by curing the [common] cold: making the baby put on more clothes and sleep more. [2.3 Grandma]

My child has anemia. I've heard others say that all small children have anemia. When he is bigger it won't be a problem. [3.22 Mother]

Malnutrition is when you have trouble digesting certain foods, like maybe noodles so you have to eat rice instead or something else that's easier to digest. If you have malnutrition, then you get diarrhea. If you get malnutrition you can cure it with medicine to promote better digestion. [2.5 Mother]

Similarly, many caregivers are unaware of the causes, symptoms and treatments for child anemia. When asked to identify the causes of anemia, many caregivers' responses were loosely related to food consumption and nutrition; however, they did not demonstrate an understanding of the importance of micronutrients and a diverse supplemental diet.

[Anemia] is caused by not eating enough. [1.9 Mother]

Anemia is bad nutrition. [2.6 Mother]

Several caregivers made guesses as to how to identify the signs and symptoms of anemia. In some cases, caregivers knew that it was necessary to treat anemia; however, they believed anemia to be prevalent only in adults and, therefore, thought that treatments are available only for adults. Many caregivers did not realize that it is possible for even a baby to have anemia.

If you're lightheaded and sweating a lot, you're anemic. [1.7 Mother]

Before we found out [the baby] was anemic I'd never heard of anemia. Now I know that people with anemia have sallow, yellowish faces. [2.4 Grandma]

My grandmother has anemia. She's been taking medicine, but I don't think they can cure it. I never thought of it as a big problem. I think people don't really care about anemia. [1.4 Mother]

I've only heard of adults having anemia, not kids. [1.6 Mother]

We asked caregivers to identify treatments for anemia and consequences that may arise if anemia is not identified and treated in young children. We found that even when caregivers had an understanding of the terms "malnutrition" and "anemia", they often did not know how to treat anemia. In addition, many caregivers did not consider it necessary to treat child malnutrition or anemia, while others believed the only cure for anemia to be medicine. This latter misconception is troubling, since it is coupled with a belief on the part of many caregivers that babies that are too young to walk should not be treated with medicine.

I don't know how to treat anemia. [3.08 Mother]

I'm pretty sure there's no other way to cure anemia besides medicine. [2.7 Mother]

Some caregivers suggested remedies that would, in fact, be detrimental. We observed a belief common to many households that anemia is related to difficulty digesting foods. As a result, caregivers recommended eliminating or decreasing foods that are "difficult to digest" which, could potentially lead to removing iron-rich foods from the diet. Not one mother referred to increasing iron in the diet through supplemental feeding practices. Some mothers did recommend increased consumption of formula, which has been correlated with lower rates of anemia and higher Hb concentrations (these analyses do not control for confounding). [55] However, our interview respondents suggested feeding more formula *in lieu of* other foods (i.e. while decreasing supplemental feeding).

Malnutrition is when a child gets uncomfortable and bloated after they eat and can't digest well. Maybe they only poop every several days. I'm not sure what causes malnutrition. You can cure it by feeding the baby less solid food. Give the baby more formula instead. You can't let the baby eat so much. [2.7 Mother]

You can treat it by not eating things you can't digest. [1.2 Mother]

My baby's a little bit anemic. I know because some people came before and tested him for that. I'm anemic too. Sometimes when I stand up I feel light-headed. I'm not sure what causes it. I took some medicine for my anemia. But I didn't worry about it when I found out the baby was anemic. He's so young that

> *we can't tell if he's uncomfortable or light-headed, so we didn't do anything for it. [2.6 Mother]*

Again and again, caregivers gave responses that demonstrated that they were not equipped with the appropriate knowledge and information about how to identify and treat child malnutrition and anemia.

Growth and development

We asked caregivers if there is a connection between diet and their child's growth and development. Beyond a basic understanding of these terms, most rural mothers and caregivers simply did not believe there is a connection between diet and their child's growth. We discovered that they share a common belief that all food is nutritious, and, therefore, as long as a baby eats until he or she is full, the baby will get adequate nutrition. This finding is supported by Luo et al. (2014), who found high rates of anemia accompanied by extremely low rates of child wasting and stunting, a pattern that can occur when children have sufficient caloric intake, but insufficient micronutrient intake. [55] Many caregivers believe—mistakenly—that their children are, in fact, getting adequate nutrition.

> *It doesn't matter what he eats. That doesn't impact his development at all. [2.6 Mother]*

> *Now I usually give him milk, I think whatever a child can eat is good for development. [3.17 Mother]*

> *Different foods don't affect the baby differently. All food has nutrition. As long as he eats his fill of course he will be healthy. [2.8 Grandma]*

> *I don't think there's a big impact of nutrition on health. Formula and porridge are good enough for my baby. [1.2 Mother]*

Some caregivers acknowledged a connection between child nutrition and healthy development. However, these same caregivers suggested a diet consisting of starches, such as rice and porridge, as one that would stimulate physical and cognitive development. Interviews revealed a shared belief that dietary staples of formula and rice porridge provide adequate nutrition as long as the child has enough of it. No parents mentioned the need to supplement this diet with other foods that are high in micronutrients, such as meats and vegetables. In fact, most parents believed that consuming such foods at this young age (6–18 months) actually affects development adversely and results in delayed growth and unhealthy outcomes, such as diarrhea. However, rates of diarrhea may not be as high as caregivers indicated. Luo et al. (2014) found that roughly one-third of their sample recorded having diarrhea within the one month prior to the time of the survey. [55] Globally, children aged 6–11 months have been found to have 4.5 incidents of diarrhea per year. [56]

> *Some foods have impacts [on my baby's health]. Others don't. Soft, clean foods are good for my baby. Hard foods are not healthy. [1.8 Mother]*

I don't think about the effect of different kinds of foods on my baby. As long as she can eat her fill, I think that's enough. If a certain food gives her diarrhea, then you shouldn't give her that anymore. [2.7 Mother]

Yes, I have [thought that food choice will affect my baby's cognitive development] ...A good way to make him smarter is to feed him starches and rice. You can't feed him hard food. You should feed him fewer vegetables. The effect of these foods is that he can grow taller. [1.8 Mother]

Furthermore, most caregivers were content to let their child's taste preferences dictate their diets, even to the point that children's diets lack foods that caregivers believe are good for children. If a baby refuses a food, the caregiver simply allows the child to eat what he or she wants. Several caregivers had stopped trying to feed their children vegetables, since the children did not seem to like them. We found that caregivers continued to feed staple foods that the children would accept readily.

I just give her what she wants to eat. I don't think different types of foods have different impacts on her development or growth. And I don't make her eat what she doesn't like. Even if I think something's good for her. There's no way to do it. If she doesn't like something what can you do? [2.5 Mother]

If my baby doesn't like the taste of the food, I won't give it to her. She basically feeds herself. [1.1 Mother]

If he doesn't like a food, he spits it out. Trying to feed it to him again is hopeless. So I don't. [1.9 Mother]

The baby doesn't like to eat vegetables, so we don't give them to him anymore. [2.2 Grandma]

Vitamins and supplements

Finally, we asked mothers whether they gave their children vitamins or micronutrient supplements. We found that most caregivers had little knowledge of vitamins and micronutrient supplements and many were unwilling to provide them. When asked if micronutrient supplements could improve physical and cognitive development, most caregivers answered in the negative. Almost all of the caregivers stated that they were not willing to feed products they are unfamiliar with to their children, despite the potential nutritional benefits.

We don't dare give the baby anything to eat that we're not familiar with. Even if people say it's good for him. [2.6 Mother]

We don't give the baby any supplements. We don't even give him the yingyangbao.[2] The baby's mother says it's bad. They gave it to us to deceive us. So, she doesn't give it to him. [2.9 Grandma]

[2] Some of the families we interviewed had access to a free supply of government-approved micronutrient packets (*yingyangbao*) aimed at children aged 6–36 months.

The baby only needs vitamin supplements at two stages. First, when she's learning to walk you have to give her supplements. Second, when she's old enough to start school you should get her tested to see if she is deficient in any nutrients and maybe then give her some supplements. Apart from those two stages you shouldn't give the baby any supplements. [2.7 Mother]

6.7.2 Unreliable sources of information

Given this pervasive ignorance regarding child nutrition, we concluded that caregivers are in need of accurate information about nutrition. Unfortunately, our results show that most caregivers obtain information about good feeding practices from unreliable sources. Further, even if caregivers were eager to improve their knowledge of nutrition, they do not have access to knowledgeable sources.

Family and friends

We found that most mothers relied on a combination of their own experience and the experience of friends and family members. This reliance on the child-rearing experience of others can (in some cases) be detrimental to child development, since other caregivers in the community may not have any better sources of information. Interviews with caregivers revealed that nearly all villagers lack even a general understanding of basic principles of healthy nutrition for children. Therefore, this system of shared knowledge perpetuates the community's ignorance of sound child feeding practices.

I get tips for what to feed my baby from my mom and other family members. I have seen some stuff on TV and read some books. I trust everyone because most of it is consistent, or I just rely on personal experience. [1.6 Mother]

I get advice from friends and relatives, but I trust my own advice the most. I see how [my baby] is doing and decide whom I trust. [1.8 Mother]

I get information on taking care of my baby from other older people in the village. There's no need to study. I know how to do it. Everyone says similar things. I do what I know how to do. [2.5 Mother]

I'm not really worried about the baby's health. I am learning as I go. She's my first child. If I ever don't know what to do I just ask my friends. [2.7 Mother]

We found that grandmothers frequently did not turn to any outside sources of information when it came to childcare and child nutrition. Many grandmothers claimed that, since they had already raised children and knew how to raise a healthy child, it was unnecessary to study or learn about baby development.

We don't need any nutrition or child care information. Everyone knows how to take care of babies. Just give the baby what she likes to eat, what she's willing to eat. That's all you have to do. [2.3 Grandma]

I raised my own children. I know what I'm doing! [2.8 Grandma]

Some caregivers did not know what to do when it came to caring for their children and described a feeling of futility about improving their knowledge. These caregivers turned to many different sources regarding child care and nutrition. However, they received inconsistent information from these sources, leaving them confused as to which sources of information were credible and which were not. We also found that caregivers relied on television commercials and advertisements to inform their nutrition choices.

> *I don't think I have enough good information to take care of the baby. I don't talk to other people about the baby. And I see ads about babies on TV sometimes but I don't understand them. [2.10 Grandma]*

> *I get lots of advice from my family, but they all say something different. I usually listen to whomever I disagree with least. [1.2 Mother]*

> *I'm blindly buying the stuff companies tell us to buy, but I really don't know anything or have any sources of information. No one ever told me how to feed my baby. I have no idea. I would read pamphlets in the hospital. Only then would I get information. But on an average day I don't know anything. [1.4 Mother]*

Health professionals and misinformation

Interviews revealed that many caregivers rarely interact with health professionals, who might be able to give them better nutritional information or advice. Those caregivers who do take their children to the doctor reported either that they did not receive nutritional information at all or that they were given misleading or inaccurate advice. As a result, many caregivers are often unwilling to rely on their local health care provider. While better information might be available from health professionals in the county seat, many families live too far away for this to be a realistic option for obtaining health care or information. Only half of the caregivers participating in the larger quantitative study reported taking their children in for their free health check-ups. At most, caregivers rely on local village doctors for basic healthcare needs. However, many caregivers are unwilling to trust these clinicians or doctors for child-feeding advice.

> *I've never taken the baby to the doctor. For a routine check-up or anything else. We live very far away from the county seat. It's not convenient to go there. [2.5 Mother]*

> *This baby has never been to the doctor and has never had a checkup. The doctors around here [in our village] are no good. They can't even treat the cold or diarrhea. We don't usually take kids to the doctor here in the village. Instead we go to the county seat. But from here to the county seat it's more than three hours. [2.9 Grandma]*

> *I can get good information on taking care of the baby from TV. I don't go to the doctors here. They are no good. [2.9 Grandma]*

> *He was found to be a little bit anemic...the doctor never said anything helpful to help me understand my child. He just told me to buy some rice powder and medicine. [1.5 Mother]*

> *We've taken the baby to the village clinic before when he had a cold. But he's never gone to the doctor or to get a health checkup. Doctors here don't give nutrition advice, they just cure small problems. [2.10 Grandma]*

Formula vendors
Interviews revealed that another popular source of information is the local formula vendor. Interviews revealed that information provided by these formula vendors is often viewed as reliable, even though the advice they gave was incorrect. Surprisingly, caregivers often were more willing to heed advice from formula vendors regarding child feeding practice than from other sources. However, these formula vendors are not much more educated than the mothers regarding child nutrition, and they almost certainly have external incentives and motivations to maximize revenue.

> *I read the booklets at the formula store for information. [1.7 Mother]*

> *The person selling formula gives me tips about food, vitamins and supplements for my baby. [1.3 Mother]*

> *His favorite thing to eat is a supplement. It's basically a protein powder. It says on the box that the supplement is not suitable for babies under one year, but the formula vendor said it was okay, so I feed it to him anyway. [1.4 Mother][3]*

6.7.3 Poor feeding practices
Our results show that lack of information on child health and nutrition available to caregivers contributes to the poor feeding practices that are likely the primary cause of child undernutrition. Caregivers receive conflicting parenting and nutritional advice from multiple sources and are often left with an incomplete picture of what should be included in an appropriate diet for their growing child.

6.7.4 Supplementary feeding practices
During our interviews we found that most parents do not follow the international recommendations for feeding infants. WHO and UNICEF recommendations for feeding infants are as follows: exclusive breastfeeding for infants 0–6 months old; from 6–7 months of age, infants should be introduced to safe and nutritionally rich complementary foods, such as soft vegetables and fruit; from 7–12 months of age, infants should be introduced to soft, small pieces of meat and eggs; and for children aged 12 months and older, solid foods should make up at least half of the baby's diet, supplemented with breast milk. [57] Quantitative data collected by Luo et al. (2014) revealed that only 23.7 per cent of the children/infants aged 6-11 months old included in the study had consumed meat in the past week.[55] Further, caregivers reported that only 54.6 per cent of children had consumed vegetables in the past week.

Our interviews revealed that children's diets consisted primarily of breast milk and formula, followed primarily by staple foods. Some families gave their babies small portions of fruit. Few children were fed vegetables and even fewer had meat in their diet. We asked caregivers when children should start getting supplemental food. The most common responses from caregivers recommended breastfeeding and formula exclusively until the child was one year old. Caregivers indicated that, after one year, staple foods and fruit should be introduced. Caregiver responses regarding when meat

---

[3] The child in this case was under one year of age.

should be introduced into the diet varied from 15 to 24 months of age, all well above the international recommendations.

> *I started giving her meat when she was one and a half years old. Before that she wasn't used to meat and would just get sick." [1.1 Mother]*

> *From 0 to 10 months you should give the baby breast milk. After 10 months you shouldn't give any more breast milk. Then we switched to formula. And after five months you can start giving the baby a little bit of other solid foods. But we waited until about eight months. Then we gave simple starches and a little bit of fruit. He doesn't like vegetables, so we don't make him eat those. And we don't give him any meat. I'm afraid that if we give him meat he will get diarrhea. I think we will wait until the baby is two years old to start giving him any meat. [2.2 Grandma]*

> *Now the baby eats whatever the grownups eat. We don't give her formula anymore. She's almost two years old. We just give her some of what we are eating. Except for meat. We wouldn't dare give such a young child any meat. [2.3 Grandma]*

> *How would he eat vegetables? He's too young. I'll give him more vegetables when he is a little older[4] [3.03 Mother]*

The confidence with which caregivers responded to our questions regarding supplemental feeding practices is a concern, as it demonstrates the caregivers' firm belief that they were feeding their children a diet that was sufficient to meet health and development needs. However, the caregivers' responses revealed that poor complementary feeding practices are likely contributing to the high rates of iron-deficiency anemia among rural children.

One-year myth

Interviews with caregivers revealed a pervasive belief that there is a change in children's digestive systems at the one-year mark, mandating that a change in diet should occur no earlier than at this point. Caregivers referred to this one-year mark repeatedly, in relation to everything from breast milk and formula to supplemental feeding practices and vitamin supplements. Many caregivers believed that a child should not receive any solid foods at all before he or she reaches one year of age and can walk.

> *A baby can usually walk at one year, and that means he can digest food better. Instead of the baby being held all day, now he can walk around and therefore digest the food better. [1.6 Mother]*

> *The baby has always been formula fed. He never had breast milk. We don't give him many starches. Some porridge. He won't eat other kinds of starches. We only started giving him porridge after he was one year old. And even now we have never given him fruit or veggies or meat. Mostly we just give him formula. About 150 ml three times per day. We will give him other kinds of food once he is willing to eat them. [2.10 Grandma]*

[4] The child in this case was a 14-month-old boy.

The baby only had breast milk and formula until he was one year old. Then we started to give him some starchy foods and fruits and veggies. We didn't dare give the baby any solid food before he was one year. Then it's bad for him. Even if he had been willing to eat it at that age we wouldn't have given it to him. And we waited a little longer to give meat. When the baby was about 1 year and three months we started giving him a little meat. [2.1 Grandma]

Caregivers also reported following the "one-year" rule as to breast feeding. Some mothers expressed a belief that after one year they could no longer produce enough breast milk to keep their baby full. They also indicated a belief that breast milk is less nutritious after one year. As to vitamin supplements, caregivers again gave responses tied to the one-year mark, stating that it was not healthy to continue giving a baby supplements after they reach that age.

When the baby was less than one year old I gave him some vitamin supplements but after that I stopped. After 1 year old the kid doesn't need supplements. As soon as she can walk she doesn't need them. Otherwise they can adversely impact her growth. [2.7 Mother]

I am planning to end breastfeeding when she is one year old, and then start feeding her formula. I am going to switch at one year because there is not enough breast milk at that time. Also, at one year my baby can adapt to drinking formula. [1.10 Mother]

At one year I will start giving him formula because that's when the milk stops. It was the same with his sister. After that there is not enough breast milk, but formula is unlimited. Also, there aren't enough nutrients left in the breast milk for it to be good at that time. [1.5 Mother]

These in-depth interviews suggest that rural caregivers do not have sufficient knowledge of nutrition principles to guide them toward feeding their child a healthy diet. Many children subsist on a diet of staple foods and formula that lacks the micronutrients that are essential for healthy physical and cognitive development.

7. Discussion

We observed that 48.8 per cent of infants aged 6-11 months in low-income areas of rural China are anemic. This is nearly twice as high as the 2011 average for East and Southeast Asia. [58] Nearly 20 per cent of the sample suffers from moderate or severe anemia. Stunting, underweight and wasting, however, are much less prevalent in this population, ranging from only 1.2 per cent to 3.7 per cent. Such low rates are indicative of a population with virtually no linear growth failure, a notable finding for China, especially given that as recently as 2012, stunting prevalence among children under five years of age in rural areas was observed to be around 20 per cent. [3] This contrast suggests that it is now the quality of infant diets, rather than the quantity of food, that is lacking in rural China today.

Our data further show that the high prevalence of anemia that we observe is significantly correlated with high rates of cognitive and psychomotor delays, as measured by infant performance on the BSID. Around 20 per cent of the sample suffered from some degree of cognitive delay, while nearly one-third (32.3%) of the sample suffered from some degree of psychomotor delay. In total, 39.2 per cent of the sample suffered from one or both types of developmental delay. These numbers are quite a bit higher than what would be expected in a normal population. In the urban Chinese population against which the BSID-I scores were normalized, only 11.7 per cent of children would be expected to have cognitive delays, and only 11.0 per cent would be expected to have psychomotor delays. Moreover, children with lower Hb counts were significantly more likely to suffer from either type of delay.

The graph of the relationship between Hb concentrations and BSID scores demonstrates that the association between nutrition and child development exists both below and above the 110 g/L mark, the traditional cutoff point used to identify an infant as having anemia. In other words, even for infants that WHO considers to be non-anemic, higher Hb levels are associated with better cognitive and psychomotor development. While our data cannot prove causality, these results merit careful consideration, since they point to a link between Hb and child development even for children traditionally considered to be "healthy".

We note that our results are not sensitive to our treatment of infants failing to reach the minimum MDI score. As described in the Results section, in our sample, 31 infants, or 2 per cent of the sample infants, failed to achieve the minimum score (50) on the MDI and were assigned a score of 49. We included these measures in the analyses, reasoning that their inclusion helps contribute to better overall explanatory power. [59, 60]. Because some researchers prefer to exclude "failing" observations from the analyses, [61, 62] we also ran all of our analyses with these 31 failing observations excluded from the analysis (not shown), and the results were not statistically different from the results shown.

While our study highlights the important link between infant nutrition and early child development, we point out that other factors may also be at play. For example, studies elsewhere have indicated the importance of parental stimulation as a contributing factor to child development. [63] Maternal mental health and the home environment may also play a role. [64, 65]

Our results also show that caregivers who received a daily text message reminder showed better compliance. Primary caregivers who were mothers, and primary caregivers who could either read or send text messages, also had better compliance. When primary caregivers could either read or send text messages, receiving the text messages would increase the likelihood of full compliance. The results also show that children in the Text Messaging Group experienced lower levels of anemia six months after the start of the intervention.

We have two main theories about the mechanism behind these results. First, we believe that the text messages may have raised the salience of (i.e. impressed on caregivers the importance of) providing nutrition through the intervention. Second, we believe that the text messages may be addressing caregiver forgetfulness. The reminder function may have been especially important when caregivers encountered a "challenge" to their regular compliance, such as when their child came down with an illness. When children became sick, there was often a disruption in the household's daily routine, including the administration of the home fortification powder. Text message reminders may be improving overall compliance by reminding caregivers to return to their pre-challenge routine.

Another finding is that text messages helped more caregivers who were raising anemic children persist in being fully compliant with the home fortification program. Our data show a higher proportion (45.3%) of caregivers of baseline-anemic children in the Text Messaging Group persisted in administering five or more packets per week than those in the Free Distribution Group (36.7%, p =0.05; Table 20). This difference occurred even though the share of all children that were anemic at baseline were balanced at the baseline for a range of indicators including socioeconomic status, caregiver and mother characteristics and feeding practices (p-values > 0.05; Table 21).

Table 20: Compliance with daily home fortification for anemia children at baseline by treatment group

Treatment group	n	Children taking 5 or more packets per week		
		n	%	p[1]
Free Delivery Group	202	74	36.7	0.05
Text Messaging Group	223	101	45.3	
Total	425	175	41.2	–

[1] Chi-square test for proportion comparison.

Table 21: Baseline characteristics of anemia infants among three groups in rural Shaanxi Province

Characteristics	Control Group Mean/ percent	Free Group Mean/ percent	Text Group Mean/ percent	p
Social economic status				
Age (month)	8.98±1.87	9.06±1.83	8.77±1.71	0.22
Girls (%)	48.56(118)	50.50 (102)	43.95 (98)	0.38
Premature birth (%)	8.64 (21)	12.87 (26)	9.42(31)	0.31
Low birth weight (%)	4.53 (11)	3.47 (7)	4.93 (11)	0.75
First birth (%)	58.02 (141)	62.87 (127)	58.74 (131)	0.86
Families received social security support (%)	21.39 (52)	21.28 (43)	24.66 (55)	0.73
Caregiver and mother characteristic				
Mother is primary caregiver (%)	87.65 (213)	84.16 (170)	89.69 (200)	0.23
Maternal education above 9 years (%)	76.13 (185)	76.73 (155)	80.27 (179)	0.52
Maternal micronutrient supplement during pregnancy (%)	87.24 (212)	76.73(155)	74.89 (167)	0.01
Mother anemia rate in the baseline (%)	21.81 (53)	26.73 (54)	27.35 (61)	0.32
Infant feeding practice				
Period of breastfeeding (month)	7.47±3.25	7.19±3.44	7.59±3.06	0.44
Supplementary feeding after six months (%)	67.08 (163)	66.83 (135)	65.92(147)	0.96
Iron supplement for infants (%)	11.93 (29)	16.83 (34)	12.95 (29)	0.30
Infant took meat yesterday	36.21 (88)	38.12 (77)	32.47 (73)	0.50
Period of taking formula (month)	3.47±3.80	3.44±3.69	3.16±3.61	0.62

An objective of this study was to examine the impact of texting on the anemia rate of sample children. Our findings confirmed that assignment to the Text Messaging Group led to a fall in children's anemia rate six months after the start of intervention. The result is consistent with the results from Western Kenya [18] and Bangladesh, [19] in which the rates of anemia fell children were given nutrient packets. Text messages appear to play a role in public programs that are trying to promote health.

We found that the effect of Free MNP on Hb concentrations and anemia prevalence were not significantly different from that of the Control Group after 12 months of supplementation (when children were 18-23 months of age) or after 18 months of supplementation (when children were 24–29 months of age). During this period from 6 to 30 months of age, a time in which children's diets are in transition, Hb concentrations in the Control Group increased rapidly (although anemia levels remained high). The Free MNP intervention hastened this improvement during the first six months; however, these positive effects subsided thereafter as Control Group Hb levels increased at a faster rate as children aged from 12–17 months to 18–23 months of age.

The effects of the intervention on cognition (as measured by Bayley MDI scores) followed a similar pattern of effects over time to those on Hb concentration and anemia prevalence. We found a significant improvement on the Bayley MDI score at six months after the start of intervention. However, although it would be reasonable to hypothesize a sustained effect on cognitive development even after the effect of MNP on Hb subsided, cognitive scores were also not significantly higher than the control group after 12 and 18 months of supplementation. MNP had no detectable effect on psychomotor development at any point during the trial.

Using an IV analysis to adjust for partial compliance, we find a similar pattern of results. Although the average number sachets consumed each month in the MNP group over the course of the study declined across the survey waves (Table 16), the finding of ATT analysis suggest that the lack of effects in later rounds was not due to reduced consumption of the MNP sachets. Moreover, nil effects after the six-month mark were unlikely due to low power. The study retained power to detect small effects throughout the trial as evidenced by relatively tight confidence intervals on impact estimates for later rounds.

Although it is difficult to say what led to this lack of effects, we note that our results are strikingly similar to those of a recent trial testing MNP in Columbia. [66, 67] An analysis of that trial by the authors suggested that nil effects in that study may have been due to the changing nature of the causes of low Hb and rapidly decreasing anemia rates over time as children age. As with our study, they find that Hb concentrations in the control group increased substantially as children aged from 12–30 months. This is in contrast to less rapid increases in Hb concentration (that occur without intervention) in other regions where trials of MNPs have been successful. Although the authors of the study in Columbia hypothesized that their intervention, which began when children were 12 months of age, was initiated too late to be effective, our intervention began when children were 6 months of age but still had no effect after 18 months.

Another possibility is that the amount of iron in the sachets used in this study (6 mg) was simply too low. Most previous trials used sachets that contained 12.5 mg of iron. [67, 68]

The amount of iron in the sachets was set at 6 mg in order to comply with regulations in China. [69] Sachets with similar iron content have been suggested for use a national program distributing sachets through local health centers.

Field interviews with mothers and grandmothers reveal insight into the root causes of child anemia in rural Shaanxi province, China. We found that three structural factors contribute to the high rates of iron-deficiency anemia in rural children: lack of knowledge, unreliable sources of nutritional information and poor feeding practices.

A lack of knowledge, especially knowledge about malnutrition and child anemia, was ubiquitous. This is consistent with quantitative work that shows high child anemia and low child Hb concentrations to be significantly correlated with low levels of maternal education [56]. Over the past few decades, studies have revealed that, among populations that have a basic level of economic resources, increased maternal education has a positive effect on child growth and health outcomes. [70-72]

Research has found maternal knowledge to be a positive function of maternal education, which has a positive effect on child micronutrient status. [73] It appears that low maternal education among our study population contributes to a low level of nutrition knowledge and to poor health outcomes among rural children. A bigger concern is that grandparents are likely to have even less education than mothers and therefore know even less about health and nutrition. [74] As more and more parents migrate to cities to find work, grandparents are raising the children left behind in rural villages. Therefore, addressing their nutrition literacy is essential to improving the overall health and development of millions of rural children.

A second structural factor contributing to child anemia is that caregivers do not have access to reliable sources of nutritional information. Caregivers cannot get informative advice from health advisors. In general, in rural China these are village doctors. It often resulted in a general consensus among all caregivers that village doctors were “no good” and were not able to provide appropriate nutritional information. Recent studies conducted in rural Shaanxi province support this belief. One study, using standardized patients to measure quality of care, found that village clinicians provided unnecessary or harmful medications to patients 64 per cent of the time. [75] These clinicians are more likely to harm the patient than provide effective treatments. Therefore, it is no surprise to find a warranted distrust of rural physicians among rural caregivers.

As a result, caregivers were more likely to turn to family members, friends and infant formula salespeople for their nutritional information than to health professionals. The dangers of relying on infant formula salespeople are obvious. When caregivers rely on the advice of their own experience, their family and friends, old—often inaccurate—myths are easily perpetuated. However, there is almost no option if reliable nutrition guidance from health professionals is not forthcoming.

Finally, we found that the caregivers’ underlying deficiency in nutrition literacy, which is perpetuated by their lack of access to knowledgeable sources of nutrition information and their resulting reliance on inaccurate advice from others, leads to poor feeding practices that have a detrimental effect on a child’s physical and cognitive development. Caregivers’ complementary feeding practices are not in accord with international recommendations; instead, they feed children a diet that consists primarily of formula and staple foods with little, if any, meat and vegetables.

It is also important to note that our results indicate that poverty is *not* a major obstacle to parents' attempts to provide appropriate nutrition for their babies. Caregivers frequently stated that financial constraints are not an issue when attempting to provide for their children. Instead, results indicated that caregivers do not know the best way to spend their resources to provide adequate nutrition. When caregivers' general lack of knowledge prompts them to seek information regarding child care and feeding practices, they turn to unreliable sources of information. This lack of accurate information hampers caregivers' efforts to provide adequate nutrition to their children, and ultimately results in caregivers' failure to supply an age-appropriate, micronutrient-rich supplemental diet that can stimulate children's physical and cognitive development.

Our study makes important contributions. First, our trial is the largest cluster-RCT to evaluate the impact of alternative delivery strategies on the adherence of caregivers to a home micronutrient fortification program. Previous studies only had limited sample sizes, did not include a control group and/or only measured impacts on outcomes after (at most) two months. [19] Other researchers have relied on cross-sectional data [76] or have used non-randomized comparisons. [18]

Another strength of this study is its policy relevance. To our knowledge, no other study has attempted to measure the impact of a home fortification study outside of a tightly controlled researcher-implemented environment. In our study, households were left alone to resume their regular routines for *six months*, during which time they had zero contact with any researcher. Most studies of home fortification programs employed weekly or bi-weekly visits from researchers to ensure high levels of compliance. [77–80] This level of engagement is simply unrealistic in areas of the world where health resources are constrained and infrastructure is underdeveloped. We believe our study design is scalable and could be adopted by policymakers.

Several limitations should be recognized. First, the observed attrition rate was relatively high (15%). All study attrition was due either to incomplete data or to relocation of the household (caregiver and child) out of our sample areas. From our interviews of family members and neighbors of attrited households, we know that this relocation was largely spurred by a search for job opportunities and/or modern environment in urban areas. Fortunately, in the multiple logistic analyses, the propensity to attrite, after controlling for potential confounding variables (child and family characteristics) did not vary significantly across the experimental arms (Table 3). We also show that attrited children had individual and family characteristics that were statistically nearly identical to the tracked children (Table 4). Even allowing for attrition, the statistical power of the study reached 95 per cent. High rates of attrition also appear to be a common problem in other studies. In one study on the effect of provision of daily zinc, iron or other micronutrients to children in Pakistan, of 2,746 children, the attrition rate reached 28 per cent. [81] Hence, we do not believe that the missing data invalidates our findings.

We also were unable to conduct full blood panel testing for nutritional deficiencies and consider Hb our sole indicator of micronutrient deficiency. A more nuanced measure may have been able to pick up on additional changes in levels of micronutrient deficiencies, such as zinc, folate, or Vitamin A deficiencies. The observed impact of the home fortification program on Hb should therefore be considered as a lower-bound estimate of the impacts on child health and nutrition.

In conclusion, our findings show that daily text message reminders can lead to positive improvements in the compliance of caregivers in the context of home fortification programs within six months of intervention. Our results also show that Free MNP did not improve anemia or cognitive outcomes of infants after 18 months of age. Although anemia rates appear to fall quickly as children age, they remained high at two years of age. Such results suggest that the government might consider raising the level of iron that is allowed in Free MNP supplements.

More alarming is the high level of cognitive delay among two-year-old children. Given that the national program to distribute MNPs is unlikely to address high levels of cognitive delay among infants, there is an urgent need for effective strategies to promote the development of young children in China’s rural areas. Without effective interventions, a large fraction of China’s children will be prevented from reaching their full potential.

Appendix

Table A1: Characteristics of interviewees from in-depth interview

	Percent
Maternal age	
Age <= 25	48.5
Age > 25	51.5
Maternal educational level	
<= 9 years	83.0
> 9 years	17.0
Family receives Minimum Living Standard Guarantee	
No	76.1
Yes	23.9
Infant gender	
Male	48.0
Female	52.0
Infant age	
6–12 months	58.0
13–18 months	42.0
Mother is primary caregiver	
Yes	72.0
No	28.0

Source: Authors' own data

References

McLean E, Cogswell, M, Egli, I, Wojdyla, D, and de Benoist, B, 2009. Worldwide prevalence of anaemia, WHO Vitamin and Mineral Nutrition Information System, 1993–2005. *Public Health Nutr*, 12, pp.444–54.

De Benoist B, McLean E, Egli I, Cogswell M (eds), 2008. Worldwide prevalence of anaemia 1993–2005: WHO global database on anaemia [online]. Available at: <http://apps.who.int/iris/bitstream/10665/43894/1/9789241596657_eng.pdf> [Accessed October 19, 2015].

News Office of the Ministry of Health, 2012. Report on the Nutritional Development of China's Children Aged 0–6 Years [in Chinese]. Beijing: Ministry of Health of the People's Republic of China.

Zhang, X, Li, H, Song, D, et al., 2009. Research on the anemia situation among poor, rural children in seven counties in Xinjiang [in Chinese]. *Chinese Journal of Child Health Care*, 006, pp.621–23.

Dong, CX, Ge, PF, Zhang, CJ, et al., 2013. Effects of different feeding practices at 0–6 months and living economic conditions on anemia prevalence of infants and young children [in Chinese]. *Journal of Hygiene Research*, 42(4): pp.596–99.

Li, Q, Yan, H, Zeng, L, Cheng, Y, Liang, W, Dang, S, et al., 2009. Effects of maternal micronutrient supplementation on the mental development of infants in rural western China: Follow-up evaluation of a double-blind, randomized, controlled trial. *Pediatrics*, 123, e685.

Balarajan, Y, Ramakrishnan, U, Öaltin, E, Shankar, AH, Subramanian, SV, 2011. Anaemia in low-income and middle-income countries. *Lancet*, 378, pp.2123–35.

Stoltzfus, RJ, Mullany, L, and Black, RE, 2005. Iron deficiency anaemia. Comparative Quantification of Health Risks: Global and Regional Burden of Disease Attributable to Selected Major Risk Factors. Geneva: World Health Organization, pp.163–209.

Black, RE, Victora, CG, Walker, SP, Bhutta, ZA, Christian, P, de Onis, M, Ezzati, M, Grantham-McGregor, S, Katz, J, Martorell, R, et al., 2013. Maternal and child undernutrition and overweight in low-income and middle-income countries. *Lancet*, 382, pp.427–51.

WHO, 2011. Guideline: use of multiple micronutrient powders for home fortification of foods consumed by infants and children 6–23 months of age. Geneva: World Health Organization.

Lin, LM, Song, XF, Liu, YL, Ma, GF, Tan, CW, Jiang, JX, Liu, M, Liu, CY, Wang, L, 2003. Relationship between vitamin A deficiency and anemia for Chinese children [In Chinese]. *Chin J Child Health Care*, 11, pp.242–44.

Xu, ZK, Wang, LJ, Chang, F, Fu, P, Zhang, J, Zhang, HP, and Li, JL, 2012. Effectiveness of nutrition interventions about infants aged 6–24 months in Ningqiang county affected by Wenchuan earthquake [In Chinese]. *Chin J Child Health Care*, 20(8), pp.728–30.

Wang, LJ, Huo, JS, Sun, J, Li, WX, Huang, J, Huang, CY, Hu, JF, Lin, L, and Zhou, YP. Nutrition effectiveness of infants and young children aged 6 to 23 months by Yingyangbao in Lixian County affected by Wenchuan earthquake in Sichuan Province [In Chinese]. *Journal of Hygiene Research*, 40(1), pp.61–64.

Wang, YY, Chen, CM, Jia, M, Fang, JP, and Wang, FZ, 2004. Effect of complementary food supplements on anemia in infant and young children [In Chinese]. *Journal of Hygiene Research*, 3(3), pp.334–36.

Sun, J, Dai, YH, Zhang, SM, Huang, J, Yang, ZY, Huo, JS, and Chen, CM, 2011. Implementation of a programme to market a complementary food supplement (Ying Yang Bao) and impacts on anaemia and feeding practices in Shanxi, China [In Chinese]. *Maternal and Child Nutrition*, Supplement 3, pp.96–111.

Deng, HY, and Zhu, SH, 2014. Effects of Heinz nutrition package complementary food supplement on hemoglobin levels for infants and young children [In Chinese]. *Medical Journal of Chinese People's Health*, 26(8), pp.26–27.

Xu, YQ, Wang, HS, Gong, LM, Hong, M, Zhao, J, and Huang, XN, 2011. Effect of complementary food supplements on incidence of anemia among children in rural areas of China [In Chinese]. *Chinese Journal of Woman and Child Health Research*, 22(2), pp.128–31.

Suchdev, PS, Ruth, LJ, Woodruff, BA, et al., 2012. Selling sprinkles micronutrient powder reduces anemia, iron deficiency, and vitamin A deficiency in young children in Western Kenya: a cluster-randomized controlled trial. *Am J Clin Nutr*, 95, pp.1223–30.

Ip, H, Hyder, SMZ, Haseen, F, Rahman, M, and Zlotkin, SH, 2009. Improved adherence and anaemia cure rates with flexible administration of micronutrient Sprinkles: a new public health approach to anaemia control. *Eur J Clin Nutr*, 63, pp.165–72.

IT Union, 2010. *The World in 2010: ICT facts and figures*. International Telecommunication Union.

China Internet Network Information Center, 2012. Survey report on the development of China's mobile network [In Chinese, online]. Available at: <http://www.cnnic.net.cn/ research/bgxz/ydhlwbg/201203/ P0201203294 16039769203.pdf> [Accessed July 6, 2014].

Krishna, S, Boren, SA, and Balas EA, 2009. Healthcare via cell phones: a systematic review. *Telemed J E Health*, 15, pp.231–40.

Cole-Lewis, H, and Kershaw, T, 2010. Text messaging as a tool for behavior changer in disease prevention and management. *Epidemiol Rev*, 32 pp.56–69.

Rodgers, A, Corbett, T, Riddell, T, Wills, M, Lin, R, and Jones, M, 2006. Do u smoke after txt? Results of a randomized trial of smoking cessation using mobile phone text messaging. *Tob Control*, 14, pp.255–61.

Joo, N, and Kim, B, 2007. Mobile phone short message service messaging for behavior modification in a community-based weight control programme in Korea. *J Telemedicine Telecare*, 13, pp.416–20.

Franklin, V, Waller, A, Pagliari, C, and Greene, S, 2006. A randomized controlled trial of SweetTalk, a text-messaging system to support young people with diabetes. *Diabet Med*, 23, pp.1332–38.

Jiang, H, Li, M, Wen, LM, Hu, QZ, Yang, DL, He, GS, Baur, LA, Dibley, MJ, and Qian, X, 2014. Effect of Short Message Service on Infant Feeding Practice: Findings from a Community-Based Study in Shanghai, China. *JAMA Pediatrics*, 168(5), pp.471–78.

Chong, A, Karlan, DS, Shapiro, J, et al., 2013. (Ineffective) messages to encourage recycling: evidence from a randomized evaluation in Peru. Social Science Electronic Publishing, lht022.

Jamison, J, Karlan, DS, and Raffler, P, 2013. Mixed Method Evaluation of a Passive mHealth Sexual Information Texting Service in Uganda. Information technologies and international development, 9(3), pp.1544–7529.

Bruxvoort, K, Festo, C, Kalolella, A, Cairns, M, Lyaruu, P, Kenani, M, Kachur, SP, Goodman, C, and Schellenberg, D, 2014. Cluster randomized trial of text message reminders to retail staff in Tanzanian drug shops dispensing artemether-lumefantrine: effect on dispenser knowledge and patient adherence. *Am J Trop Med Hyg*, 9(4), pp.844–53.

Kannisto, KA, Koivunen, MH, and Välimäki, MA, 2014. Use of mobile phone text message reminders in health care services: a narrative literature review. *J Med Internet Res*, 16(10), e222.

De Onis, M, Onyango, AW, Van den Broeck, J, Chumlea, WC, and Martorell, R, 2004. Measurement and standardization protocols for anthropometry used in the construction of a new international growth reference. Food and Nutrition Bulletin, 25, S27–S36.

Bayley, N, 1974. *The Bayley Scales of Infant Development: The Mental Scale*. New York, NY: Psychological Corporation.

American Psychiatric Association, 2000. *Diagnostic and Statistical Manual of Mental Disorders*. 4th ed., text revision. Washington, DC: American Psychiatric Association.

Yi, S, Luo, X, Yang, Z, and Wan, G, 1993. The revising of Bayley Scales of Infant Development (BSID) in China [in Chinese]. *Chinese Journal of Clinical Psychology*, 1, pp.71–75.

Huang, H, Tao, SD, Zhang, YW, et al., 1993. Standardization of Bayley Scales of Infant Development in Shanghai. *Chin J Child Health*, 1(3), pp.158–60.

Chang, S, Zeng, L, Brouwer, ID, Kok, FJ, and Yan, H, 2013. Effect of iron deficiency anemia in pregnancy on child mental development in rural China. *Pediatrics*, 131(3), e755–e763.

Wu, W, Sheng, D, Shao, J, and Zhao, Z, 2011. Mental and motor development and psychosocial adjustment of Chinese children with phenylketonuria. *Journal of Paediatrics and Child Health*, 47(7), pp.441–47.

Yi, S, 1995. *Manual of Bayley Scales of Infant Development*. Chinese revision. Changsha, China: Xiangya School of Medicine, Central South University.

Bayley, N, 1969. *Bayley Scales of Infant Development*. New York, NY: Psychological Corporation.

Centers for Disease Control and Prevention, 1998. Recommendations to prevent and control iron deficiency in the United States. Morbidity and Mortality Weekly Report, 47, pp.1–29.

Life Sciences Research Office, 1984. Assessment of the iron nutrition status of the US population based on data collected in the second national health and nutrition survey, 1976–1980. Bethesda, MD: Federation of American Societies for Experimental Biology.

WHO Multicentre Growth Reference Study Group, 2006. WHO Child Growth Standards: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: Methods and development. Geneva: World Health Organization.

De Onis, M, and Blossner, M, 1997. WHO Global Database on Child Growth and Malnutrition. Geneva: World Health Organization.

Moore, T, Johnson, S, Haider, S, Hennessy, E, and Marlow, N, 2012. Relationship between Test Scores Using the Second and Third Editions of the Bayley Scales in Extremely Preterm Children. *Journal of Pediatrics*, 160, pp.553–58.

Spybrook, J, Raudenbush, S, Liu, XF, and Congdon, R, 2008. Optimal Design for Longitudinal and Multilevel Research: Documentation for the Optimal Design Software. University of Michigan.

Li, Q, Yan, H, Zeng, L, et al., 2009. Effects of maternal micronutrient supplementation on the mental development of infants in rural western China: follow-up evaluation of a double-blind, randomized, controlled trial. *Pediatrics*, 123, e685.

Ermis, B, Demirel, F, Demircan, N, and Gurel, A, 2002. Effect of three different iron supplementations in term health infants after 5 months of life. *J Trop Pediatr*, 48(5), pp.280–84.

Berger, J, Ninh, NX, Khan, NC, et al., 2006. Efficacy of combined iron and zinc supplementation on micronutrient status and growth in Vietnamese infants. *Eur J Clin Nutr*, 60(4), pp.443–54.

Pasricha, S, Hayes, E, Kalumba, K, and Biggs, B, 2013. Effect of daily iron supplementation on health in children aged 4–23 months: a systematic review and meta-analysis of randomised controlled trials. *Lancet Glob Health*, 1(2), e77–e86.

Luo, R, Shi, Y, Zhang, L, et al., 2012. Nutrition and educational performance in rural China's elementary schools: results of a randomized control trial in Shaanxi Province. *Econ Dev Cult Change*, 60(1), pp.735–72.

Head, KJ, Noar, SM, Iannarino, NT, and Harrington, NG, 2013. Efficacy of text messaging-based interventions for health promotion: A meta-analysis. *Social Science & Medicine*, 97 (November), pp.41–48, [online]. Available at: <http://dx.doi.org/10.1016/j.socscimed.2013.08.003>.

Williams, J, Wolff, A, Daly, A, MacDonald, A, Aukett, A, and Booth, IW, 1999. Iron supplemented formula milk related to reduction in psychomotor decline in infants from inner city areas: randomised study. *BMJ*, 318, pp.693–98.

Duflo, E, Glennerster, R, and Kremer, M, 2007. Using randomization in development economics research: A toolkit. *Handbook of Development Economics*, Amsterdam: North-Holland, 4, pp.3895–962.

Luo, R, Shi, Y, Zhou, H, Yue, A, Zhang, L, et al., 2014. Anemia and Feeding Practices among Infants in Rural Shaanxi Province in China. *Nutrients*, 6, pp.5975–91.

Fischer Walker, CL, Perin, J, Aryee, MJ, Boschi-Pinto, C, and Black, RE, 2012. Diarrhea incidence in low-and middle-income countries in 1990 and 2010: a systematic review. *BMC Public Health*.

WHO, 2002. Infant and young child nutrition: Global strategy on infant and young child feeding. Fifty-Fifth World Health Assembly. World Health Organization.

Stevens, GA, Finucane, MM, De-Regil, LM, et al., 2013. Global, regional, and national trends in haemoglobin concentration and prevalence of total and severe anaemia in children and pregnant and non-pregnant women for 1995–2011: a systematic analysis of population-representative data. *Lancet Global Health*, 1: e16–25.

Hack, M, Taylor, HG, Drotar, D, et al., 2005. Poor predictive validity of the Bayley Scales of Infant Development for cognitive function of extremely low birth weight children at school age. *Pediatrics*, 116, pp.333–41.

Gay, CL, Armstrong, FD, Cohen, D, et al., 1995. The effects of HIV on cognitive and motor development in children born to HIV-seropositive women with no reported drug use: Birth to 24 months. *Pediatrics*, 96, pp.1078–82.

McCathren, RB, Yoder, PJ, and Warren, SF, 2000. Testing Predictive Validity of the Communication Composite of the Communication and Symbolic Behavior Scales. *Journal of Early Intervention*, 23, pp.36–46.

Hamadani, JD, Fuchs, GJ, Osendarp, SJM, Khatun, F, Huda, SN, and Grantham-McGregor, SM, 2001. Randomized controlled trial of the effect of zinc supplementation on the mental development of Bangladeshi infants. *American Journal of Clinical Nutrition*, 74, pp.381–86.

Attanasio, OP, Fernández, C, FitzsimonsEmla, OA, Grantham-McGregor, SM, Meghir C, Rubio-Codina, M, et al., 2014. Using the infrastructure of a conditional cash transfer program to deliver a scalable integrated early child development program in Colombia: cluster randomized controlled trial, *BMJ*, 349, g5785.

Patel, V, Rahman, A, Jacob, KS, and Hughes, M, 2004. Effect of maternal health on infant growth in low income countries: new evidence from South Asia, *BMJ*, 328(7443), pp.820–23.

Rodriguez, ET, and Tamis-LeMonda, CS, 2011. Trajectories of the home learning environment across the first 5 years: Associations with children's vocabulary and literacy skills at prekindergarten. *Child Development*, 82(4), pp.1058–75.

Andrew, A, Attanasio, O, Fitzsimons, E, and Rubio-Codina, M, 2016. Why is multiple micronutrient powder ineffective at reducing anaemia among 12–24 month olds in Colombia? Evidence from a randomised controlled trial. *SSM–Popul Health*, 2, pp.95–104, doi:10.1016/j.ssmph.2016.02.004.

Attanasio, OP, Fernández, C, Fitzsimons, EOA, Grantham-McGregor, SM, Meghir, C, Rubio-Codina, M, 2014. Using the infrastructure of a conditional cash transfer program to deliver a scalable integrated early child development program in Colombia: cluster randomized controlled trial. *BMJ*, 349:g5785, doi:10.1136/bmj.g5785.

De-Regil, LM, Suchdev, PS, Vist, GE, Walleser, S, and Peña-Rosas, JP, 2013. Home fortification of foods with multiple micronutrient powders for health and nutrition in children under two years of age (Review). *Evid-Based Child Health Cochrane Rev J*, 8(1), pp.112–201, doi:10.1002/ebch.1895.

Ministry of Health and Standardization Administration of the People's Republic of China, 2008, General standard for complementary food supplement (GB-T 22570-2008).

Pelto, GH, Levitt, E, and Thairu, L 2003. Improving feeding practices: Current patterns, common constraints, and the design of interventions. *Food and Nutrition Bulletin*, 24, pp.45–82.

Desai S, and Alva, S, 1998. Maternal Education and Child Health: Is there a Strong Causal Relationship? *Demography*, 35, pp.71–81.

Cleland, JG, and Van Ginneken, JK, 1998. Maternal education and child survival in developing countries: the search for pathways of influence. *Soc Sci Med* 27(12), pp.1357–58.

Block, S, 2007). Maternal Nutrition Knowledge versus Schooling as Determinants of Child Micronutrient Status. *Oxford Economic Papers, New Series* 59(2), pp.330–53.

Wu, KB, Young, ME, and Cai, J, 2012. Early Child Development in China: Breaking the Cycle of Poverty and Improving Future Competitiveness. Washington, DC: World Bank.

Sylvia, S, Shi, Y, Xue, H, Tian, X, Wang, H, et al., 2014. Survey using Incognito Standardized Patients Shows Poor Quality Care in China's Rural Clinics. Working Paper.

Jack, SJ, Ou, K, Chea, M, et al, 2012. Effect of micronutrient sprinkles on reducing anemia: a cluster-randomized effectiveness trial. *Arch Pediatr Adolesc Med*, 16, pp.1–9.

Stanley, Z, Paul, A, Claudia, S, Kojo, YA, George, Y, and Ana, P, 2003. Home-Fortification with Iron and Zinc Sprinkles or Iron Sprinkles Alone Successfully Treats Anemia in Infants and Young Children, *J Nutr*, 133, pp.1075–80.

Seth, A, Anna, L, Kenneth, HB, Stanley, Z, André, B, Kathryn, GD, 2008. Home fortification of complementary foods with micronutrient supplements is well accepted and has positive effects on infant iron status in Ghana. *Am J Clin Nutr*, 87, pp.929–38.

Sengchanh, K, Toshihiko, S, Nicholas, M, Masahiro, H, Junko, O, Kazuhiko, M, Boungnong, B, Taro, Y, 2011. Effect of daily versus weekly home fortification with multiple micronutrient powder on haemoglobin concentration of young children in a rural area, Lao People's Democratic Republic: a randomised trial. *J Nutr*, 10, p.129.

Purnima, M, Marie, TR, Cornelia, U, Loech, Mary, A, Jean-Pierre, H, Gretel, P, Lesly, M, 2007, Micronutrient Sprinkles Reduce Anemia among 9- to 24-Mo-Old Children When Delivered through an Integrated Health and Nutrition Program in Rural Haiti, *J Nutr*, 137, pp.1023–30.

Soofi, S, Cousens, S, Iqbal, SP, Akhund, T, Khan, J, Ahmed, I, Zaidi, AKM, and Bhutt, ZQA, 2013. Effect of provision of daily zinc and iron with several micronutrients on growth and morbidity among young children in Pakistan: a cluster-randomised trial. *Lancet*, 382, pp.29–40.

Other publications in the 3ie Impact Evaluation Report Series

The following reports are available from http://www.3ieimpact.org/evidence-hub/impact-evaluation-repository

Impacts of the World Food Programme's interventions to treat malnutrition in Niger. 3ie Impact Evaluation Report 80. Brück, T, Ferguson, NTN, Ouédraogo, J and Ziegelhöfer, Z, 2018.

Impact evaluation of the World Food Programme's moderate acute malnutrition treatment and prevention programmes in Sudan. 3ie Impact Evaluation Report 79. Guevarra, E, Mandalazi, E, Balegamire, S, Albrektsen, K, Sadler, K, Abdelsalam, K, Urrea, G and Alawad, S, 2018.

Impact evaluation of WFP's programs targeting moderate acute malnutrition in humanitarian situations in Chad. 3ie Impact Evaluation Report 78. Saboya, M, Rudiger, J, Frize, J, Ruegenberg, D, Rodríguez Seco, A and McMillon, C, 2018.

Improving midday meal delivery and encouraging micronutrient fortification among children in India, 3ie Impact Evaluation Report 77. Shastry, GK, Berry, J, Mukherjee, P, Mehta, S and Ruebeck, H, 2018.

Evaluation of infant development centres: an early years intervention in Colombia, 3ie Impact Evaluation Report 76. Andrew, A, Attanasio, O, Bernal, R, Cordona, L, Krutikova, S, Heredia, DM, Medina, C, Peña, X, Rubio-Codina, M and Vera-Hernandez, M, 2018.

Can the wounds of war be healed? Experimental evidence on reconciliation in Sierra Leone. 3ie Impact Evaluation Report 75. Cilliers, J, Dube, O and Siddiqi, B, 2018.

Impact evaluation of the Menabe and Melaky development programme in Madagascar, 3ie Impact Evaluation Report 74. Ring, H, Morey, M, Kavanagh, E, Kamto, K, McCarthy, N, Brubaker, J and Rakotondrafara, C, 2018.

Impact evaluation of the Smallholder Dairy Commercialization Programme in Kenya, 3ie Impact Evaluation Report 73. Bonilla, J, McCarthy, N, Mugatha, S, Rai, N, Coombes, A and Brubaker, J, 2018.

Impact and adoption of risk-reducing drought-tolerant rice in India, 3ie Impact Evaluation Report 72. Yamano, T, Dar, MH, Panda, A, Gupta, I, Malabayabas, ML and Kelly, E, 2018.

Poverty and empowerment impacts of the Bihar Rural Livelihoods Project in India, 3ie Impact Evaluation Report 71. Hoffmann, V, Rao, V, Datta, U, Sanyal, P, Surendra, V and Majumdar, S 2018.

How should Tanzania use its natural gas? Citizens' views from a nationwide Deliberative Poll, 3ie Impact Evaluation Report 70. Birdsall, N, Fishkin, J, Haqqi, F, Kinyondo, A, Moyo, M, Richmond, J and Sandefur, J, 2018.

Impact evaluation of the conditional cash transfer program for secondary school attendance in Macedonia, 3ie Impact Evaluation Report 69. Armand, A and Carneiro, P, 2018.

Age at marriage, women's education, and mother and child outcomes in Bangladesh, 3ie Impact Evaluation Report 68. Field, E, Glennerster, R, Nazneen, S, Pimkina, S, Sen, I and Buchmann, N, 2018.

Evaluating agricultural information dissemination in western Kenya, *3ie Impact Evaluation Report 67.* Fabregas, R, Kremer, M, Robinson, J and Schilbach, F, 2017.

General equilibrium impact assessment of the Productive Safety Net Program in Ethiopia, 3ie Impact Evaluation Report 66. Filipski, M, Taylor, JE, Abegaz, GA, Ferede, T, Taffesse, AS and Diao, X, 2017.

Impact of the Uddeepan programme on child health and nutrition in India, 3ie Impact Evaluation Report 65. Kochar, A, Sharma, A and Sharma, A, 2017.

Evaluating oral HIV self-testing to increase HIV testing uptake among truck drivers in Kenya, 3ie Impact Evaluation Report 64. Kelvin, EA, Mwai, E, Romo, ML, George, G, Govender, K, Mantell, JE, Strauss, M, Nyaga, EN and Odhiambo, JO, 2017.

Integration of EPI and paediatric HIV services for improved ART initiation in Zimbabwe, *3ie Impact Evaluation Report 63.* Prescott, M, Boeke, C, Gotora, T, Mafaune, HW, Motsi, W, Graves, J, Mangwiro, A and McCarthy, E, 2017.

Increasing male partner HIV testing using self-test kits in Kenya, 3ie Impact Evaluation Report 62. Gichangi, A, Korte, JE, Wambua, J, Vrana, C and Stevens, D, 2017.

Evaluating the impact of community health worker integration into prevention of mother-to-child transmission of HIV services in Tanzania, 3ie Impact Evaluation Report 61. Nance, N, McCoy, S, Ngilangwa, D, Masanja, J, Njau, P and Noronha, R, 2017.

Using HIV self-testing to promote male partner and couples testing in Kenya, 3ie Impact Evaluation Report 60. Thirumurthy, H, Omanga, E, Obonyo, B, Masters, S and Agot, K, 2017.

Increasing male partner HIV self-testing at antenatal care clinics in Kenya, 3ie Impact Evaluation Report 59. Gichangi, A, Korte, JE, Wambua, J, Vrana, C and Stevens, D, 2017.

Impact of free availability of public childcare on labour supply and child development in Brazil, *3ie Impact Evaluation Report 58*. Attanasio, O, Paes de Barros, R, Carneiro, P, Evans, D, Lima, L, Olinto, P and Schady, N, 2017.

Estimating the effects of a low-cost early stimulation and parenting education programme in Mexico, 3ie Impact Evaluation Report 57. Cardenas, S, Evans, D and Holland, P, 2017.

The Better Obstetrics in Rural Nigeria study: an impact evaluation of the Nigerian Midwives Service Scheme, 3ie Impact Evaluation Report 56. Okeke, E, Glick, P, Abubakar, IS, Chari, AV, Pitchforth, E, Exley, J, Bashir, U, Setodji, C, Gu, K and Onwujekwe, O, 2017.

The Productive Safety Net Programme in Ethiopia: impacts on children's schooling, labour and nutritional status, 3ie Impact Evaluation Report 55. Berhane, G, Hoddinott, J, Kumar, N and Margolies, A, 2016.

The impact of youth skills training on the financial behaviour, employability and educational choice in Morocco, 3ie Impact Evaluation Report 54. Bausch, J, Dyer, P, Gardiner, D, Kluve, J and Mizrokhi, E, 2016.

Using advertisements to create demand for voluntary medical male circumcision in South Africa, 3ie Impact Evaluation Report 53. Frade, S, Friedman, W, Rech, D and Wilson, N, 2016.

The use of peer referral incentives to increase demand for voluntary medical male circumcision in Zambia, 3ie Impact Evaluation Report 52. Zanolini, A, Bolton, C, Lyabola, LL, Phiri, G, Samona, A, Kaonga, A and Harsha Thirumurthy, H, 2016.

Using smartphone raffles to increase demand for voluntary medical male circumcision in Tanzania, 3ie Impact Evaluation Report 51. Mahler, H and Bazant, E, 2016.

Voluntary medical male circumcision uptake through soccer in Zimbabwe, 3ie Impact Evaluation Report 50. DeCelles, J, Kaufman, Z, Bhauti, K, Hershow, R, Weiss, H, Chaibva, C, Moyo, N, Braunschweig, E, Mantula, F, Hatzold, K and Ross, D, 2016.

Measuring the impact of SMS-based interventions on uptake of voluntary medical male circumcision in Zambia, 3ie Impact Evaluation Report 49. Leiby, K, Connor, A, Tsague, L, Sapele, C, Koanga, A, Kakaire, J and Wang, P, 2016.

Assessing the impact of delivering messages through intimate partners to create demand for voluntary medical male circumcision in Uganda, 3ie Impact Evaluation Report 48. Semeere, AS, Bbaale, DS, Castelnuovo, B, Kiragga, A, Kigozi, J, Muganzi, A, Kambugu, A and Coutinho, AG, 2016.

Optimising the use of economic interventions to increase demand for voluntary medical male circumcision in Kenya, 3ie Impact Evaluation Report 47. Thirumurthy, H, Omanga, E, Rao, SO, Murray, K, Masters, S and Agot, K, 2016.

The impact of earned and windfall cash transfers on livelihoods and conservation in Sierra Leone, 3ie Impact Evaluation Report 46. Bulte, E, Conteh, B, Kontoleon, A, List, J, Mokuwa, E, Richards, P, Turley, T and Voors, M, 2016.

Property tax experiment in Pakistan: Incentivising tax collection and improving performance, 3ie Impact Evaluation Report 45. Khan, A, Khwaja, A and Olken, B, 2016.

Impact of mobile message reminders on tuberculosis treatment outcomes in Pakistan, 3ie Impact Evaluation Report 44. Mohammed, S, Glennerster, R and Khan, A, 2016.

Making networks work for policy: Evidence from agricultural technology adoption in Malawi, 3ie Impact Evaluation Report 43. Beaman, L, BenYishay, A, Fatch, P, Magruder, J and Mobarak, AM, 2016.

Estimating the impact and cost-effectiveness of expanding access to secondary education in Ghana, 3ie Impact Evaluation Report 42. Dupas, P, Duflo, E and Kremer, M, 2016.

Evaluating the effectiveness of computers as tutors in China, 3ie Impact Evaluation Report 41. Mo, D, Bai, Y, Boswell, M and Rozelle, S, 2016.

Micro entrepreneurship support programme in Chile, 3ie Impact Evaluation Report 40. Martínez, CA, Puentes, EE and Ruiz-Tagle, JV, 2016.

Thirty-five years later: evaluating the impacts of a child health and family planning programme in Bangladesh, 3ie Impact Evaluation Report 39. Barham, T, Kuhn, R, Menken, J and Razzaque, A, 2016.

Effectiveness of a rural sanitation programme on diarrhoea, soil-transmitted helminth infection and malnutrition in India, 3ie Impact Evaluation Report 38. Clasen, T, Boisson, S, Routray, P, Torondel, B, Bell, M, Cumming, O, Ensink, J, Freeman, M and Jenkins, M, 2016.

Evaluating the impact of vocational education vouchers on out-of-school youth in Kenya, 3ie Impact Evaluation Report 37. Hicks, JH, Kremer, M, Mbiti, I and Miguel, E, 2016.

Removing barriers to higher education in Chile: evaluation of peer effects and scholarships for test preparation, 3ie Impact Evaluation Report 36. Banerjee, A, Duflo E and Gallego, F, 2016.

Sustainability of impact: dimensions of decline and persistence in adopting a biofortified crop in Uganda, 3ie Impact Evaluation Report 35. McNiven, S, Gilligan, DO and Hotz, C 2016.

A triple win? The impact of Tanzania's Joint Forest Management programme on livelihoods, governance and forests, *3ie Impact Evaluation Report 34.* Persha, L and Meshack, C, 2016.

The effect of conditional transfers on intimate partner violence: evidence from Northern Ecuador, 3ie Impact Evaluation Report 33. Hidrobo, M, Peterman, A and Heise, L, 2016.

The effect of transfers and preschool on children's cognitive development in Uganda, 3*ie Impact Evaluation Report 32*. Gillian, DO and Roy, S, 2016.

Can egovernance reduce capture of public programmes? Experimental evidence from India's employment guarantee, 3ie Impact Evaluation Report 31. Banerjee, A, Duflo, E, Imbert, C, Mathew, S and Pande, R, 2015.

Improving maternal and child health in India: evaluating demand and supply strategies, 3ie Impact Evaluation Report 30. Mohanan, M, Miller, G, Forgia, GL, Shekhar, S and Singh, K, 2016.

Smallholder access to weather securities in India: demand and impact on production decisions, 3ie Impact Evaluation Report 28. Ceballos, F, Manuel, I, Robles, M and Butler, A, 2015.

What happens once the intervention ends? The medium-term impacts of a cash transfer programme in Malawi, 3ie Impact Evaluation Report 27. Baird, S, Chirwa, E, McIntosh, C and Özler, B, 2015.

Validation of hearing screening procedures in Ecuadorian schools, 3ie Impact Evaluation Report 26. Muñoz, K, White, K, Callow-Heusser, C and Ortiz, E, 2015.

Assessing the impact of farmer field schools on fertilizer use in China, 3ie Impact Evaluation Report 25. Burger, N, Fu, M, Gu, K, Jia, X, Kumar, KB and Mingliang, G, 2015.

The SASA! study: a cluster randomised trial to assess the impact of a violence and HIV prevention programme in Kampala, Uganda, *3ie Impact Evaluation Report 24.* Watts, C, Devries, K, Kiss, L, Abramsky, T, Kyegombe, N and Michau, L, 2014.

Enhancing food production and food security through improved inputs: an evaluation of Tanzania's National Agricultural Input Voucher Scheme with a focus on gender impacts, 3ie Impact Evaluation Report 23. Gine, X, Patel, S, Cuellar-Martinez, C, McCoy, S and Lauren, R, 2015.

A wide angle view of learning: evaluation of the CCE and LEP programmes in Haryana, 3ie Impact Evaluation Report 22. Duflo, E, Berry, J, Mukerji, S and Shotland, M, 2015.

Shelter from the storm: upgrading housing infrastructure in Latin American slums, *3ie Impact Evaluation Report 21.* Galiani, S, Gertler, P, Cooper, R, Martinez, S, Ross, A and Undurraga, R, 2015.

Environmental and socioeconomic impacts of Mexico's payments for ecosystem services programme, *3ie Impact Evaluation Report 20.* Alix-Garcia, J, Aronson, G, Radeloff, V, Ramirez-Reyes, C, Shapiro, E, Sims, K and Yañez-Pagans, P, 2015.

A randomised evaluation of the effects of an agricultural insurance programme on rural households' behaviour: evidence from China, 3ie Impact Evaluation Report 19. Cai, J, de Janvry, A and Sadoulet, E, 2014.

Impact of malaria control and enhanced literacy instruction on educational outcomes among school children in Kenya: a multi-sectoral, prospective, randomised evaluation, 3ie Impact Evaluation Report 18. Brooker, S and Halliday, K, 2015.

Assessing long-term impacts of conditional cash transfers on children and young adults in rural Nicaragua, *3ie Impact Evaluation Report 17.* Barham, T, Macours, K, Maluccio, JA, Regalia, F, Aguilera, V and Moncada, ME, 2014.

The impact of mother literacy and participation programmes on child learning: evidence from a randomised evaluation in India, 3ie Impact Evaluation Report 16. Banerji, R, Berry, J and Shortland, M, 2014.

A youth wage subsidy experiment for South Africa, 3ie Impact Evaluation Report 15. Levinsohn, J, Rankin, N, Roberts, G and Schöer, V, 2014.

Providing collateral and improving product market access for smallholder farmers: a randomised evaluation of inventory credit in Sierra Leone, 3ie Impact Evaluation Report 14. Casaburi, L, Glennerster, R, Suri, T and Kamara, S, 2014.

Scaling up male circumcision service provision: results from a randomised evaluation in Malawi, 3ie Impact Evaluation Report 13. Thornton, R, Chinkhumba, J, Godlonton, S and Pierotti, R, 2014.

Targeting the poor: evidence from a field experiment in Indonesia, 3ie Impact Evaluation Report 12. Atlas, V, Banerjee, A, Hanna, R, Olken, B, Wai-poi, M and Purnamasari, R, 2014.

An impact evaluation of information disclosure on elected representatives' performance: evidence from rural and urban India, 3ie Impact Evaluation Report 11. Banerjee, A, Duflo, E, Imbert, C, Pande, R, Walton, M and Mahapatra, B, 2014.

Truth-telling by third-party audits and the response of polluting firms: Experimental evidence from India, 3ie Impact Evaluation Report 10. Duflo, E, Greenstone, M, Pande, R and Ryan, N, 2013.

No margin, no mission? Evaluating the role of incentives in the distribution of public goods in Zambia, *3ie Impact Evaluation Report 9.* Ashraf, N, Bandiera, O and Jack, K, 2013.

Paying for performance in China's battle against anaemia, *3ie Impact Evaluation Report 8.* Zhang, L, Rozelle, S and Shi, Y, 2013.

Social and economic impacts of Tuungane: final report on the effects of a community-driven reconstruction programme in the Democratic Republic of Congo, *3ie Impact Evaluation Report 7*. Humphreys, M, Sanchez de la Sierra, R and van der Windt, P, 2013.

The impact of daycare on maternal labour supply and child development in Mexico, *3ie Impact Evaluation Report 6*. Angeles, G, Gadsden, P, Galiani, S, Gertler, P, Herrera, A, Kariger, P and Seira, E, 2014.

Impact evaluation of the non-contributory social pension programme 70 y más in Mexico, *3ie Impact Evaluation Report 5*. Rodríguez, A, Espinoza, B, Tamayo, K, Pereda, P, Góngora, V, Tagliaferro, G and Solís, M, 2014.

Does marginal cost pricing of electricity affect groundwater pumping behaviour of farmers? Evidence from India, 3ie Impact Evaluation Report 4. Meenakshi, JV, Banerji, A, Mukherji, A and Gupta, A, 2013.

The GoBifo project evaluation report: Assessing the impacts of community-driven development in Sierra Leone, *3ie Impact Evaluation Report 3*. Casey, K, Glennerster, R and Miguel, E, 2013.

A rapid assessment randomised-controlled trial of improved cookstoves in rural Ghana, *3ie Impact Evaluation Report 2.* Burwen, J and Levine, DI, 2012.

The promise of preschool in Africa: A randomised impact evaluation of early childhood development in rural Mozambique, *3ie Impact Evaluation Report 1.* Martinez, S, Naudeau, S and Pereira, V, 2012.

Previous research has indicated that quality nutrition during the first 2-3 years of life has large and significant effects on health and development throughout childhood and even into adulthood. However, a large proportion of infants in rural China are anaemic, and significantly delayed in their cognitive and psychomotor development. Luo and colleagues assessed the impact of providing children's caregivers various forms of assistance, including one-on-one health education training on nutrition and feeding practices, free micronutrient supplement packets, and daily text message reminders. The average treatment effects on the treated showed micronutrients, with or without text messages, reduced anaemia rates. However, almost all results disappeared 12 months after the intervention started.

Impact Evaluation Series

International Initiative for Impact Evaluation
202-203, Rectangle One
D-4, Saket District Centre
New Delhi – 110017
India

3ie@3ieimpact.org
Tel: +91 11 4989 4444
www.3ieimpact.org