Impact of text message reminders on caregivers’ adherence to a home fortification program in rural western China: a cluster-randomized controlled trial
Abstract

Objective. To test whether text message reminders sent to caregivers will improve the effectiveness of a home micronutrient fortification program in western China.

Methods. A cluster-randomized controlled trial was carried out in 351 villages in Shaanxi province in 2013-14. We enrolled children aged 6-12 months in target villages. Each village/cluster was randomly assigned into one of three groups: Free Delivery Group (FDG; caregivers received free micronutrient packets); Text Messaging Group (TMG; FDG treatment plus daily text message); and Control Group. We collected information on compliance with treatments and hemoglobin concentrations from all children at baseline and 6-month follow-up. We estimated the intent-to-treat (ITT) effects on compliance and child anemia using a logistic regression model, controlling for infant, caregiver and household characteristics.

Results. There were 1393 eligible children. We found that assignment to TMG led to an increase full compliance (marginal effect = 0.10, 95% CI = 0.03, 0.16) and decrease in the rate of anemia at endline (marginal effect=-0.07, 95% CI= -0.12, -0.01).

Conclusions. Text messages improved compliance of caregivers to a home fortification program and children’s nutrition.
INTRODUCTION

Anemia is one of the most prevalent nutritional disorders among preschool-aged children in developing countries.\(^1\) Despite overall improvements in child health in China over the past three decades, the prevalence of anemia among children under 5 years old in rural areas is still serious.\(^2\)\(^-\)\(^4\) One national survey demonstrated that while the prevalence of anemia had decreased among infants aged 6-12 months from 35.0% in 2005 to 28.2% in 2010, the disease’s prevalence is still nontrivial.\(^4\)\(^-\)\(^5\) Other studies have found similarly high rates (e.g., 23% in Guangxi province; 58% in Gansu).\(^6\)\(^,\)\(^7\)

Although anemia is influenced by many factors, iron deficiency is the major cause of anemia, accounting for about half of the global incidence of anemia.\(^5\)\(^-\)\(^10\) The development of daily-use micronutrient packets containing microencapsulated iron offers a way to provide key micronutrients to iron-deficient children.\(^11\)

In China research shows that 90% of anemia in children stems from iron deficiency.\(^12\) Research on the effectiveness of micronutrient supplementation, however, is mostly limited to studies based on small, non-randomized samples.\(^13\)\(^-\)\(^18\)

While supplementation has potential if caregivers systematically comply with supplement programs, there are indications that compliance has been a barrier to the success internationally.\(^19\) Unfortunately, almost no research has been conducted on how either supplementation can best be delivered or how caregivers can be persuaded to regularly give their children micronutrient supplements. One study evaluated a micronutrient supplement distribution program on household compliance in Kenya.\(^20\) Another study in Bangladesh compared the effectiveness of programs that administered
micronutrient supplements to individuals using different approaches. Although both studies found low compliance, researchers concluded that the nature of the delivery strategy was associated with decreased rates of anemia in children. The authors of the both studies, however, suggest the relatively low rates of use of the micronutrient supplement are indicative of the generally poor project design and suggest that systematic research is needed to evaluate the impact of alternative delivery strategies on caregiver compliance and infant outcomes.

In this paper, 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 phones. An even larger percentage (>90%) of households in China—even in rural areas—have mobile phones.

Mobile technology is increasingly used as a way to promote health and prevent disease, although 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 have shown positive results. In China, a short message service (SMS) intervention was found to have promoted longer duration of exclusive breastfeeding for mothers. This study, however, did not follow an RCT design and was underpowered.

There are also examples of text messaging programs that do not work. In studies of these programs, the factors that were identified as those leading to the failure of the programs included limited phone access, privacy concerns, phone maintenance and text
A recent literature review of text messaging’s effect on health concluded that most studies were not carried out systematically. The goal of this paper is to test whether text message reminders sent to the mobile devices of caregivers will improve the effectiveness of a home micronutrient fortification program using a cluster-randomized controlled trial design. To meet this goal, we have three specific objectives. We examine caregiver compliance to a home fortification program. We evaluate the impact of adding a program that adds text message reminders on compliance. And, we examine whether text messaging had any impact on child nutrition, focusing on the prevalence of anemia.

METHODS

Sample Selection

Our research team carried out a cluster-RCT with villages as the clusters in rural China. Our study included three experimental groups: two treatment groups and a control group. We enrolled two cohorts of children aged 6-12 months. The intervention period lasted for 6 months for both cohorts. This trial is registered with ISRCTN (ISRCTN44149146).

Our baseline survey was conducted in two waves: one began in April 2013; one in October 2013. From 11 nationally-designated poverty counties in Southern Shaanxi, 174 townships were selected to participate in the study. All townships in each county were included except the one township/county that housed the county seat and those townships that did not have any villages with at least 800 people.

To meet the power requirements of an RCT, we required a minimum of five
infants per village (prior to attrition). We used official government data to compile a list of all villages in each township. 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 one village in each selected township. Therefore, our final sample consisted of 351 villages. 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 (6–12 months) were enrolled.

Sample villages were selected at the time of the initial wave (April 2013). At the time of each of the first home visits (April 2013 for wave 1; and October 2013 for wave 2), we sampled all children in the desired age range (6–12 months) living in the village. Overall, the baseline sample included 1818 children.

Once the sample selection was complete, villages were randomly assigned, by computer-generated random numbers by one of authors (R. Luo) into two treatment groups and a control group. Assignment was cluster-randomized, with 117 villages in each treatment group. A total of 619 children were randomly assigned to the Control group, 600 children were assigned to Treatment Group 1 and 599 children were assigned to Treatment Group 2. After assignment, the caregivers did not know that they were in an RCT or being evaluated. All participating caregivers gave their oral consent for their own and their infant’s involvement in the program.

**Interventions**

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 six-month supply of micronutrient supplement packets containing a home
fortification powder along with instructions on how to use the powder. This group served as our *Free Delivery Group* (FDG).

The caregivers of children in the Treatment Group 2 (*Text Messaging Group, TMG*) received the same treatment as the FDG. However, the TMG 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 TMG for 6 months. The messages are in Appendix Table 1.

In both the FDG and TMG 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 (Appendix Table 2). Approved by China’s government, NurtureMate is recommended for infants aged 6-36 months. It is recommended that caregivers give infants 5 packets per week or one packet per day. 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. Enumerators tallied unused and empty packets to assess compliance.

**Data Collection**

The research team conducted two rounds of surveys for each cohort: one at baseline and one at follow-up. For Cohort 1 (2) the baseline survey was conducted in April (October) 2013 and the follow-up survey was conducted in October 2013 (April 2014).

In each baseline survey nurses from Xi’an Jiaotong Medical School collected hemoglobin concentrations from all infants and caregivers. Hemoglobin concentrations
were measured using a HemoCue Hb 201+ finger prick system (Hemocue, Inc, Ängelholm, Sweden). Teams of enumerators collected socioeconomic data from study households. Each infant’s primary caregiver was identified and administered a survey on infant, parental and household characteristics, including each child’s gender, age and birth order, maternal age and education, and whether the family was receiving Minimum Living Standard Guarantee payments (a poverty indicator). The primary caregiver was identified by each family as the individual most responsible for the infant’s care (typically the child’s mother or grandmother). The primary caregiver was administered a survey on child feeding practices. The mobile phone number of each caregiver was recorded. All baseline tests and surveys were re-administered at the time of the endline.

Anemia status was determined by finger blood analysis for hemoglobin (Hb) concentrations. Following international standards for our sample age group, anemia was defined as Hb < 110 g/L.\textsuperscript{34,35}

To collect the information that was needed to assess compliance, survey enumerators counted the total number of opened (unopened) packets and divided this number by the number of days that elapsed between the passing out of the packets and the follow up survey—and then multiplied by seven. Careful records on the initial date that we distributed packets and the date that we counted packets were kept. We also asked households to self-report the number of packets used per week. Analysis of the differences among the three approaches is in Appendix Table 3. The three approaches give similar results, statistically. The paper uses opened packages as our main compliance variable. According to the manufacturer’s recommendation, if a caregiver gave her infant 5-7 packets per week, we counted the caregiver as being fully compliant.
Statistical Analysis

The sample size for our study was determined by power calculations performed before enrollment using Optimal Design, a software developed by University of Michigan. The power to detect a difference in anemia rates between the treatment and control groups in a cluster-RCT depends on 5 factors: a) number of children/village (n); b) number of villages (J); c) intra-cluster correlation in anemia prevalence (ICC); d) minimum effect size that we would expect to be able to detect, called minimum detectable effect (MDE); f) how anemia rates within villages correlate over time ($R^2$).

Based on previous studies, we assumed an ICC of 0.1 and an $R^2$ of 0.5. We then assumed 4 infants per village. Based on these parameters, we calculated that we required 112 villages/group to detect a standardized effect of 0.2 at 80% power given a significance level of 0.05. Five villages were added to each group to overpower the study as the budget allowed.

Statistical analyses were conducted using STATA 12.0 (StataCorp, College Station, TX, USA). P-values below 0.05 are considered statistically significant. 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 a histogram showing the frequency distribution of the fully compliant by intervention arms. Our primary outcome variable is compliance with the home fortification program, as measured by a caregiver being fully compliant (5-7 packets per week). Our secondary outcome variable is an infant nutritional indicator (anemia status).

We estimated the treatment effects on both caregiver compliance and anemia status of infants using an intent-to-treat (ITT) analysis. To estimate the ITT impacts, we
used a multivariate logistic regression model and controlled for observable baseline infant, caregiver and household characteristics (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 hemoglobin concentration, breastfeeding duration, formula feeding duration, complementary feeding after six months, infant iron supplementation, meat consumption) and fixed-effects at county and cohort levels. In all analyses, we account for clustering within villages using Huber-White cluster-adjusted standard errors.

In order to accommodate partial compliance (that is, because not all caregivers administered nutrient packets 5-7 days/week) and to measure the impact of full compliance on children’s anemia status, we estimated the Average Treatment Effect on the Treated (ATT) using a two-stage least squares (2sls) approach to instrument a variable indicating full compliance (this variable is 1 if nutrient packets were given 5-7 days/week; 0 otherwise) with variables indicating random assignment.

**RESULTS**

A total of 1818 infants aged 6-12 months in 351 villages were enrolled at baseline. Although we tracked each infant with valid contact information who was still living in the sample villages, we had an attrition rate of 23.4% between baseline and follow-up surveys. This attrition was due either to incomplete data (n=130) or to relocation of the household (infant with his/her mother) out of our sample areas (n=295). Incomplete data occurred for two reasons: caregivers refused permission for their infants to be given the
hemoglobin test (n=67); incomplete data on home fortification compliance (n=63). After accounting for attrition/incomplete data, we followed up with 1393 children (endline). No villages/clusters were lost (Figure 1). It is shown that attrited infants had individual and family characteristics that were statistically identical to tracked children (Appendix Table 4). We also compare attrition rates due to being lost to follow-up (variable 1); and those lost because the families were unwilling/unable to let their child take the Hb test (variable 2). These two sources of attrition are compared across 3 groups. We also compare the attrition rates due to not having information on taking nutrient packages (variable 3) across the 2 treatment groups. The analyses demonstrate that there are no statistical differences across the three groups (in the case of variables 1 and 2—$P = 0.38$, Appendix Table 5) nor are there any statistical differences between the two treatment groups (in the case of variable 3—($P = 0.20$, Appendix Table 6). According to our data, the study’s power reached 94.5% (MDE=0.24, ICC=0.058, $R^2=0.5$, $J=351$, $n=4$, group=3). The three groups were balanced at baseline across socioeconomic status, caregiver and mother characteristics, feeding practices and child nutritional indicators ($P$ values $> 0.05$—Table 1).

Among caregivers in the TMG, 92.4% (414/448) caregivers reported that they had regularly received our daily text messages and were reading them. Only 3.6% (16/448) caregivers changed their cell phone numbers.

The data presented in Table 1 also show that baseline anemia prevalence is just under 50 percent for each of the three groups. There are no differences in anemia rate among three groups ($P = 0.63$).
Overall, 42.7% of caregivers were fully compliant with the program (that is, on average, caregivers administered 5-7 NurtureMate packets/week). A higher relative frequency of children in the TMG consumed 5-7 packets/week (177/438=44.9%), compared with children in the FDG (201/448= 40.4%), although the difference is not statistically significant ($P = 0.09$). The share of all children that were anemic at baseline was balanced at the baseline across indicators for socioeconomic status, caregiver/mother characteristics and feeding practices ($P$ values > 0.05) (Appendix Table 7). However, there is a modestly higher proportion (45.3%) of caregivers with baseline-anemic children in the TMG administering 5-7 packets/week than in the FDG (36.7%—$P = 0.05$) (Appendix Table 8).

Using the ITT model, the impact of text message reminders on caregiver compliance (using full compliance as dependent variable) is shown in Table 2. After adjusting for other covariates, we see that assignment to the TMG led to an increase in the likelihood that caregivers had full compliance to program (marginal effect = 0.10; 95% CI=0.03, 0.16). Using our ITT model, we find no significant impact of the FDG on anemia status at endline relative to the Control Group ($P > 0.05$). We do, however, find that, relative to the Control Group, assignment to the TMG reduces anemia rates by 7 percentage points at endline (marginal effect = -0.07, 95% CI=- 0.12, - 0.01). Comparing the marginal effects of the FDG and TMG shows no difference ($P = 0.20$).

* The results are almost the same when adjusting for the clustering and the county and cohort fixed effects in the analysis. Appendix Table 9 shows the difference between the baseline and endline anemia rates for the different groups, giving similar results to those in Table 3.
Using the ATT model, we estimate that among fully compliant households in the intervention groups (FDG and TMG together), anemia rates fell by 13 percentage points (marginal effect = -0.13, 95% CI: -0.25, -0.002) relative to the Control Group (Appendix Table 10). Hence, micro-nutrient packets were effective in reducing anemia if administered 5-7 times/week.

DISCUSSION

We find that among families participating in a micronutrient fortification program for children aged 6-12 months, caregivers who received a daily text message reminder showed better compliance. The children in the Text Messaging treatment group also experienced lower levels of anemia at endline.

We have two main theories about the mechanism behind our 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 be 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 giving of the nutrient packages. 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, represented by a significantly higher proportion of caregivers of baseline-anemic children
in the TMG persisted in administering 5-7 packets/week than those in the FDG. We have two theories for why text message reminders were more effective among caregivers of anemic infants, both of which directly related to the two mechanisms discussed above. First, text messages may have had a larger effect on caregivers of anemic children through the first mechanism (raising salience) because these caregivers tended to be poorer and less educated than those of non-anemic children. Studies have shown that the poor tend to face more distractions/obstacles in their daily life. Because the amount of attention that individuals have to devote to different considerations is limited and the attention of the poor is more constrained, an intervention that raises the salience a given activity (such as text reminders) may have a larger effect on the behavior of the poor.

Second, text message reminders may have had more of an effect on caregivers of anemic children through the second mechanism: Because anemia is likely correlated with other illnesses—or, more specifically, the probability that an infant experiences an illness episode that disrupts the family’s routine—text message reminders may play a larger role in this group by serving as a reminder after a disruption.

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 TMG led to a fall in children’s anemia rate at endline. The result is consistent with the results from Western Kenya and Bangladesh in which the rates of anemia fell in children who were given nutrient packets. Text messages appear to be able to play a role in public programs that are trying to promote health.

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.43

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/bi-weekly visits from researchers to ensure high levels of compliance.44-47 This level of engagement is simply unrealistic in areas of the world where health resources are constrained and infrastructure is underdeveloped.

Several limitations should be recognized. First, the observed attrition rate was relatively high (23.4%), due either to incomplete data or to relocation of the household. From interviews with family members of the attrited, we know that this relocation was spurred by a search for job opportunities. Incomplete data occurred for several reasons. Even allowing for attrition, the statistical power of the study reached 95%. High rates of attrition also appear to be a common problem in other studies.48 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 hemoglobin our sole indicator of micronutrient deficiency. Hence, the study’s measured impact should be considered as a lower-bound estimate.

In conclusion, our findings show that daily text message reminders can lead to positive/sustained improvements in the compliance of caregivers to home fortification
programs. The increases in compliance are also associated with improvements in child nutrition. We therefore recommend that low-cost text-message reminders be used to complement existing program delivery strategies.
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Human Participant Protection

This study received ethical approval from the Stanford University Institutional Review Board (IRB) and from the Sichuan University Medical Ethical Review Board. All participating caregivers gave their oral consent for both their own and their infant’s involvement in the study.
References


45. Seth A, Anna L, Kenneth HB, Stanley Z, André B, Kathryn GD. 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. 2008;87:929 –38.
