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Rojiroti microfinance and child nutrition: a cluster randomised trial.

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ABSTRACT

Objective

To determine whether Rojiroti microfinance, for poor Indian women, improves child nutrition.

Design

Cluster randomised trial.

Setting

Tolas (village communities) in Bihar State.

Participants

Women and children under 5 years.

Interventions

In Rojiroti, women form self-help groups and save their money to provide loans to group members. After 6 months, they receive larger external loans. Tolas were randomised to receive Rojiroti immediately or after 18 months.

Outcome measures

The primary analysis compared the mean weight for height Z score (WHZ) of all children under 5 years in the intervention vs. control tolas, who attended for weight and height measurement 18 months after randomisation. Secondary outcomes were weight for age Z score (WAZ), height for age Z score (HAZ), mid-upper arm circumference (MUAC), wasting, underweight, and stunting.

Results

We randomised 28 tolas to each arm and collected data from 2469 children (1560 mothers) at baseline and 2064 children (1326 mothers) at follow-up. WHZ was calculated for 1718 children at baseline and 1377 at follow up. At 18 months, mean WHZ was

significantly higher for intervention (-1·02) vs. controls (-1·37; regression coefficient adjusted for clustering β=0·38, 95% CI 0·16-0·61, p=0·001). WHZ in controls deteriorated from baseline whilst the intervention arm showed little change. Significantly fewer children were wasted in the intervention group (122, 18%) vs. control (200, 29%; odds ratio=0·46, 95% CI 0·28-0·74, p=0·002). Mean WAZ was better in the intervention group (-2·13 vs. -2·37; β=0·27, 95% CI 0·11-0·43, p=0·001) as was MUAC (13·6cm vs. 13·4cm; β=0·22, 95% CI 0·03-0·40, p=0·02).

Conclusion

In marginalised communities in rural India, child nutrition was better in those who received Rojiroti microfinance, compared to controls.

Trial registration. ClinicalTrials.gov NCT01845545

INTRODUCTION

Globally, 50 million children under five years suffer from acute malnutrition or wasting (weight for height Z score of below -2).[1] These children are at least three times more likely to die than their better-nourished peers.[2] Two thirds live in Asia.[1] Ending all forms of child malnutrition by 2030 is a Sustainable Development Goal.[3] In spite of programmes to address malnutrition in almost all low and middle income countries (LMICs), acute malnutrition remains highly prevalent.[4]

Child health follows a social gradient where wealthier means healthier.[5] Recent economic growth in India has not led to a reduction in childhood undernutrition.[6] Bihar (population 116 million) is one of the poorest and most deprived states in India (population 1.3 billion). Nearly 90% of the population is rural and has poor access to health-care and education. Of the 100 districts in India with the highest prevalence of malnutrition, 23 are in Bihar.[7] Rojiroti ("daily bread") microfinance has been operating in Bihar since 2001.[8] Participants are women and 62% are from scheduled castes (disadvantaged groups, recognised in the Indian Constitution).[8] It is delivered by the non-governmental organisation (NGO) the Centre for Promoting Sustainable Livelihood (CPSL). Women form self-help groups (SHGs) and contribute their own savings to a fund, from which they can request small loans. Later, women may become eligible for larger loans funded by CPSL (see panel).[9]

Our hypothesis was that Rojiroti microfinance would improve nutrition amongst children under five years. We tested this through a cluster randomised trial, based in rural tolas (village neighbourhoods of around 500 people of similar socio-economic status and caste).

METHODS

Study design

We conducted a matched pair, cluster randomised controlled trial (RCT) with a 1:1 allocation ratio. The protocol has been published[9] and the trial is registered (ClinicalTrials.gov, NCT01845545). Ethics approval was granted by the University of Nottingham's Medical School Research Ethics Committee (J18102012) and by the Patna Medical College Ethics Committee (15 August 2013). Approval was obtained from the Department of Health, Government of Bihar, India (SHSB/NRC/2008/01/Part III/2615). Our findings are reported in line with the CONSORT extension for cluster randomised trials.[10]

Participants were village women, mostly from scheduled castes in four administrative blocks in Patna District (Dulhin Bazar, Naubatpur, Masaurhi, and Bikram; figure 1) were chosen because of proximity to the teams from CPSL and Patna Medical College. We approached the next 60 tolas, due to be offered Rojiroti (on the basis of need). SHG membership was open to any woman in the tola. All children in the tola were invited for weighing and measuring, irrespective of whether their mother was an SHG member. There were no exclusion criteria.

Consent and Randomisation

We followed the CONSORT guidelines on consent for cluster randomised trials.[11] Only 46% of women in rural Bihar are literate[12] and so trial information was conveyed verbally (in Hindi). A CPSL volunteer explained that:

- The trial involved random allocation to immediate or delayed Rojiroti.
- In the delayed (control) group, participants could not implement Rojiroti for 18 months.
- Tolas declining the trial, could access Rojiroti through the normal procedure.
- In control tolas, women could join non-Rojiroti SHGs.

Women indicated if they agreed or declined to participate by show of hands. The discussion and vote were video recorded. Written informed consent was obtained from one literate representative of the women. Consent for the child to participate was confirmed verbally when the children were weighed and measured.

Panel. The principles of Rojiroti microfinance.

- Women are asked to form self-help groups (SHGs).
- They contribute small amounts of money to a communal fund (approximately Rs2·5, or 4 U.S. cents, per member per week).
- Women are expected to attend at least 4 SHG meetings (held weekly), before their savings entitle them to a loan.
- These loans are initially small (Rs50) and come from the SHG fund.
- After 6 months, women in the SHG are entitled to receive larger, external loans from CPSL of between Rs500 ($7) and Rs3,000 ($44), provided SHG credit is good.
- There are no restrictions on the use of loans.

Following consent, tolas of similar size were paired by researchers in Patna and given a tola ID by the research team in Nottingham. Tolas in each pair were randomly assigned to receive Rojiroti immediately (Intervention) or after the final 18 month measurements (Control) by the blinded researchers in Nottingham, using a computer-generated random number table. Intervention tolas were at least 15 km from any control tola to minimise "viral spread" of the intervention. CPSL then implemented Rojiroti in the intervention tolas, starting with establishing self-help groups. Data-analysts, but not field-workers, were blinded to allocation. The tola was the unit of randomisation and the child the unit of analysis.

Procedures

Phase one (feasibility) recruitment took place Aug-Sept 2013 (20 tolas). Once feasibility was established the pilot stage commenced, with phase two recruitment (30 tolas Feb-Mar 2014). Recruitment stopped during the monsoon and phase three recruitment (6 tolas) was in Sept 2014. At baseline, we collected data about each tola and demographic data for each mother and child. The age, sex, weight, length/height, and mid-upper arm circumference (MUAC) were recorded for all children under five years of age (and over 6 months for MUAC).[9] We used the following equipment for the age groups listed.

- **Length:** (<2 years) Seca 210 Measuring Mat. **Standing height:** (≥2 years) Seca 213 Portable Stadiometer (both Seca, Birmingham, UK).
- **Weight:** (<6 months) Docbel Baby Scales (Popular, Docbel Industries, New Delhi, India); (6 months - 2 years) hanging scales (Venus CHS, Ace, Rajasthan, India); (≥2 years) Libra Fitness Standing Scale (Edryl, Goa, India).
- **MUAC:** (>6 months) MUAC tapes (UNICEF Supply Division).

Equipment was calibrated, using standard measures, at the beginning of each visit. After setting the scales to zero, each child was weighed and measured three times and the middle value used.[13] Children were weighed and measured by CPSL workers, who were trained by staff from Patna Medical College, prior to the baseline and 18 month visits. Rojiroti then began in the tolas randomised to the intervention. CPSL staff met with women regularly to record how loans were used.

At 18 months, all children under five, present in the tola, were invited for weighing and measurement. Mothers and children who were also present at the baseline survey were identified by unique ID codes. Children aged 5.0 to 6½ years, who took part in initial data collection, were included to enable a longitudinal analysis of their growth. CPSL staff conducted one visit to each tola (to weigh and measure the children) at baseline and

follow up. Data were recorded on paper forms, entered electronically in Patna and transferred to Nottingham for analysis. In Nottingham a random 10% of the electronic data were checked against the paper records. Errors were found in <1% of those checked.

Statistical analysis

Data were checked for spurious age, height, and weight entries using the Emergency Nutrition Assessment (ENA) Tool and implausible data excluded.[14] Analysis was performed using Stata 14 (StataCorp, College Station, TX).

Outcome measures: In our feasibility phase, the primary outcome was mortality and this was registered in clinicaltrials.gov (NCT01845545) in April 2013. The feasibility phase began in August 2013 but it proved impossible to collect reliable data on mortality. The primary outcome was therefore changed to mean weight for height Z score (WHZ). This is recorded in our published protocol[9] in July 2014 and subsequently amended on clinicaltrials.gov. Data collection was completed in March 2016.

We assessed the following primary and secondary outcomes at 18 months.

Primary outcome: mean weight for height Z score (WHZ).

Secondary outcomes:

- Mean weight for age Z score (WAZ) and height for age Z score (HAZ).
- Prevalence of moderate to severe: wasting (WHZ below -2SD); undernutrition (WAZ below -2SD); stunting (HAZ below -2SD).
- Mean MUAC
- Prevalence of: moderate acute malnutrition (MUAC 12·5 to 11·5cm); severe malnutrition (MUAC <11·5cm)

WHZ, HAZ, and WAZ were calculated from the 2006 World Health Organisation growth standards,[15] using the 'zscore06' function in Stata. We calculated WAZ and HAZ (using

WHO AnthroPlus software) for children aged 5 to 6½ years at follow up and for whom we had baseline data, to enable the longitudinal analysis described below. We did not calculate WHZ for this age group because there are no reference values.

Sample size calculation: We used data from the feasibility phase on WHZ and the number of children per tola to determine the sample size and the number of tolas needed.[9] Previous work has suggested that, where programmes achieve an improvement in Z score of 0·1 to 0·5, this has a meaningful effect on the prevalence of malnutrition in young children.[16] There were on average 40 children under five in each of the first 20 tolas and the mean baseline WHZ score was -0·96 (SD 1·04). Baseline intracluster correlation coefficient was 0·082. We used the Stata function "clustersampsi" which implements the sample size calculation procedures detailed by Hayes and Bennett.[17] We calculated that, recruiting 60 tolas and allowing for 10% attrition, gave 80% power (alpha 0·05) to detect a difference in mean WHZ score of 0·26 standard deviations between groups. We therefore decided to continue the trial, with the aim of recruiting 60 tolas, as there would be sufficient statistical power to detect a meaningful difference (if present) in the primary outcome.

In cross-sectional analyses mean (SD) WHZ, HAZ, WAZ, MUAC, and the prevalence of binary outcomes, were calculated at 18 months. Linear or logistic regression models were used to quantify the difference in outcomes between children in intervention and control tolas at follow-up, using a multilevel model, with tola ID as a random effects variable, to account for clustering by tola. These models were not adjusted for baseline nutritional status, as many of the children were new to the tola at follow-up (babies born since baseline assessment and families who have moved to the tola). An interaction term was used to test whether the effect of the intervention varied between boys and girls.

We measured two potential harms of the programme in participating women at 18 months, using the Chi squared test.

- Freedom to travel without the permission of a male relative – usually the husband (travel might be restricted if Rojiroti participation causes domestic disputes).
- Forced asset sales (which might arise if Rojiroti increased indebtedness).

We performed two *post hoc* analyses which were not specified in our protocol (results in supplementary material).

1. A longitudinal analysis of participants who took part both at baseline and follow-up. This used a repeated measures generalised linear mixed model[18] and adjusted for potentially confounding variables (shown in Supplementary Figure 1A) as measured at baseline.
2. Whether the effects of the intervention varied according to mothers' SHG membership.

RESULTS

Between August 2013 and September 2014, 60 tolas were approached, 56 consented and 28 were randomised to each arm (figure 2). All 56 tolas provided data for the primary analysis. The final 18 month follow-up visit was in March 2016. Baseline characteristics of the tolas are in table 1. Baseline data were collected from 2469 children (1560 mothers) in 56 tolas (table 1). Baseline, demographic and nutritional data for the children in the intervention and control arms are shown in table 1. There was no difference between arms in WHZ at baseline (calculated in 1718 of 2469 children), although more children were wasted in the intervention arm (20%) vs. controls (15%). Conversely, in the control group, HAZ was worse (-2.14 *vs.* -2.00) and more children had MUAC <12.5cm (16% *vs.* 13%).

Cross-sectional analysis of effect of Rojiroti on undernutrition

At 18 months, data were collected from 2064 children under five (1326 mothers) – see figure 2. We excluded 687 children from the analysis of WHZ because their data were either missing or flagged as spurious by the ENA tool; 1377 children were included (anthropometric data shown in table 2).

The primary outcome (mean WHZ in children under five) at 18 months, was significantly higher in the intervention than control tolas (-1·02 vs. -1.37, regression coefficient, adjusted for clustering β=0·38, 95% CI 0·16 to 0·61, p=0·001). The WHZ in the control arm deteriorated, compared to baseline, whilst the intervention arm showed little change. The following secondary outcomes were also significantly better in the intervention tolas compared to controls: mean WAZ (-2·13 *vs.* -2·37), MUAC (13·6cm *vs.* 13·4cm), wasting prevalence (18% *vs.* 29%), underweight prevalence (53% *vs.* 63%), and prevalence of MUAC <12.5cm (13% *vs.* 18%) (table 2). There was no evidence for effect modification by child sex (all p-values from interaction terms >0·05, results not shown).

To look at the effects of Rojiroti on the same children measured at baseline and at 18 months, we performed a subgroup analysis (supplementary table 1 and supplementary figure 1). Of the 2469 children and 1560 mothers who were included at baseline, 1457 (59%) children and 894 (57%) mothers were included in this analysis at follow-up. There was a significant difference in the trajectories of change in favour of the intervention group for the outcomes of WHZ (p=0·006) and WAZ (p<0·001) in this analysis. When we compared the adjusted difference in intervention vs. control at follow-up for WHZ, HAZ, WAZ and MUAC in the longitudinal subgroup (supplementary table 1) we found that only the difference in WAZ was statistically significant 0.28 (95% CI 0.16 to 0.39, p<0·001). Nutritional outcomes were similar in children in intervention tolas whether or not their mothers were members of a Rojiroti SHG. There were no differences with non-Rojiroti SHG membership (supplementary table 2).

Outcomes for women

At 18 months, 33 (5%) women in the intervention group and 31 (5%) in the control group were free to travel without the permission of a male relative (p=0.5). Forced asset sales during the study period were similar in the two groups: intervention 16 women (2%) *vs.* control 15 (2%) (p=0·8). There were 1134 loans and the total borrowed was Rs2,499,532 ($36,858). The mean loan value was Rs2,204 ($32). Figure 3 shows the percentage of loans (A) and the amount borrowed (B) for each category of use.

DISCUSSION

Our cluster randomised trial showed better child nutrition in tolas which received Rojiroti microfinance. There was a difference of 0·35 in mean WHZ and only 18% of children in the intervention group were wasted vs. 29% of controls. There was no effect on HAZ which measures chronic undernutrition and can affect future cognitive development.[19] We believe this may be related to our short follow up period of 18 months. However, a recent trial has shown an improvement in HAZ over a shorter period than our study (6 and 12 months) with a cash transfer intervention.[20]

A recent, systematic review of the health impacts of group-based microfinance programmes found no randomised trial, with child health outcomes.[21] There has been little rigorous, evaluation of the impact of microfinance.[22,23] Our study is the first randomised controlled trial to evaluate the effects of microfinance on child nutrition. The only previous randomised study[24] did not consider child health outcomes. Of the non-randomised studies, with child health outcomes, some have suggested a benefit,[25-27] whilst others have shown either no benefit[28] or worse nutrition[29] in the children of microfinance participants.

In our cross-sectional and longitudinal analyses, nutritional indices did not improve in the intervention group but worsened in controls, suggesting that Rojiroti prevented deterioration in nutritional status. For phase one and three tolas, the 18 month follow-up occurred just before the Rabi harvest (wheat and lentils, March-April).[30] For phase two tolas, the final visit was two months before the Kharif harvest (rice and lentils, November-December).[30] The scarcity of staple foods at follow-up may explain the deterioration in the control group. Similar seasonal variations in children's growth have been observed in rural Africa.[31] Rojiroti microfinance may confer resilience on the community during periods of shortage.

This trial has limitations. The results may not be applicable outside Bihar. Our primary outcome was mean WHZ in the intervention and control tolas at 18 months. This outcome has the limitation that the same children we not measured at baseline and 18 months. Also, we do not know what proportion of the children in each village attended for weighing and measuring. However longitudinal data from the same children at baseline and follow up corroborate these findings for WHZ and WAZ (supplementary material). We included data from phase one (feasibility) in our final analysis, as the power calculation, based on phase one data, indicated this trial could reach a definitive conclusion. Data on length or height were missing in around 20% of children (mostly too young to stand). At baseline we excluded 751 of 2469 children, and at 18 months 687 of 2064 children, from WHZ analysis because of spurious or missing data (figure 2). In a future trial we will have increased quality assurance to reduce errors in measurement and recording. Rather than applying a correction for multiple hypothesis testing, we have presented full data, with 95% confidence intervals (CIs) and p-values, to allow the reader to judge the weight of evidence. The nutritional benefit in children was seen whether or not their mothers received the intervention. This may be attributable to a “trickle down” of wealth in the community but might also be due to the higher degree of landownership, literacy and schooling which occurred, by chance, in the women comprising the intervention group.

The defining characteristics of Rojiroti must be understood, if the approach is to be used elsewhere (see panel). The small sums and time-consuming meetings mean that Rojiroti is attractive only to the very poor. There are no restrictions on the use of loans and yet repayment rates are around 99%.[8] The price of defaulting on a loan is not loss of the borrower’s property but loss of access to affordable credit. Rojiroti is therefore distinct from women’s groups linked to cash transfer.[32]

Women only agreed to participate because they knew that tolas allocated to control would receive Rojiroti after 18 months. We do not know if benefits are seen beyond the 18 months. We have shown the percentage of loans and amounts borrowed in each category (figure 3). By

both criteria, the three most common uses are medical expenses, social and religious obligations and working capital for agriculture. Future research should evaluate effects on harms (such as domestic violence) and how access to credit for some mothers can benefit the children in the whole community. Our theory of change diagram (supplementary figure 2) shows how these factors may interact and postulates mechanisms for the Rojiroti effect.

Women participants were very poor (10% land ownership) and there were very low levels of decision making agency (only 5% could travel without permission). Less than 20% were literate vs. 46% literacy among most rural women in Bihar.[12] Children showed a higher prevalence of wasting, stunting, underweight and moderate malnutrition than reported in the National Family Health Survey 4.[12] The Rojiroti approach is designed for very poor communities and may not show the same benefits where poverty is less extreme.

Rojiroti has grown organically in Northern India over the last 15 years. There are now approximately 31,000 members in 3,100 SHGs in Bihar.[8] Scaling up the intervention can happen with modest funding and could deliver better health for children.

AUTHORS' CONTRIBUTION

Study design SO, LS, AF, SA and ARS. Organisation and conduct RS, GY, SC. Analysis LS, SO, AF, ARS. Manuscript written by SO and ARS and revised by all the authors.

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CONFLICT OF INTEREST STATEMENT

GY is a Trustee of Rojiroti UK. SC is CEO of the Centre for Promoting Sustainable Livelihood. The remaining authors have no conflicts of interest.

What is already known on this topic:

- Microfinance programmes have been implemented widely in poor communities in low and middle income countries (LMICs).
- Some microfinance programmes have brought economic benefits to female participants.
- Studies evaluating the impact of microfinance on child health and nutrition have not been rigorous and results have been conflicting.

What this study adds:

- In a cluster randomised trial, we found that several indices of child nutrition were better, at 18 months, in the groups randomised to Rojiroti microfinance.
- Weight for height Z score (primary outcome) was significantly better in the intervention group (-1·02) *vs.* controls (-1·37).
- In poor and marginalised communities in Bihar, Rojiroti microfinance appears to prevent a deterioration in nutritional indices, in children under five, at times of food insecurity.

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FIGURE LEGENDS

Figure 1. *The State of Bihar, showing Patna District, with the participating administrative blocks ("tehsils") of Dulhin Bazar, Naubatpur, Masurhi, and Bikram*

Figure 2. *CONSORT diagram for cluster randomised controlled trial of the Rojiroti microfinance programme, showing the number of children contributing to the primary outcome (WHZ) at 18 months.*

Figure 3. *Use of loans by women in the intervention tolas, showing % of loans granted (A) and total amount borrowed in each category (B).*

Participating tolas	Intervention (n = 28)	Control (n = 28)	p-value
Connected to a paved road (n, %)	28 (100)	27 (96)	0.3
Distance from main road (km) (median, interquartile range - IQR)	1 (0·3 to 4)	0·9 (0·45 to 3·5)	0.8
PDS* shop (n, %)	11 (39)	14 (50)	0.4
Government primary school (n, %)	28 (100)	27 (96)	0.3
Other school (n, %)	13 (46)	8 (29)	0.2
Primary health centre (n, %)	0 (0)	0 (0)	-
Presence of an ASHA worker (n, %)**	26 (93)	27 (96)	0.6
Presence of an ANM* (n, %)**	26 (93)	25 (89)	0.6
Presence of a water tap or pipeline (n, %)	0 (0)	0 (0)	-
Presence of electricity supply (n, %)	28 (100)	28 (100)	-

*PDS, public distribution system (a network of subsidised government stores)
**ASHA, Accredited Social Health Activists (local women, trained in health promotion)
***ANM, Auxiliary Nurse Midwife (village level maternal & child health worker)

Participating women	Intervention (n=756)	Control (n=804)	p-value
Number of women per tola (median, IQR)	25·5 (17·5 to 38)	27 (18·5 to 36·5)	0.9
Age in years (mean, SD)	27·6 (5·5)	27·6 (5·3)	0.9
Family owns land (n, %)	100 (13)	64 (8)	0.001
Able to travel outside of tola without permission from male relative (n, %)	61 (8)	27 (3)	<0.001
Able to read and write (n, %)	158 (21)	132 (16)	0.05
Attended school (n, %)	145 (19)	103 (13)	0.001
Participating children	**Intervention (n= 1175)**	**Control (n=1294)**	**p-value**
Median (IQR) no. children per tola	43 (27 to 57)	47 (28 to 59)	0.6
No. male, (%)	612 (52)	650 (50)	0.4
Mean (SD) age in months	30·9 (16·8)	31·2 (16·9)	0.6
Born at home (n, %)	356 (30)	359 (28)	0.2
Road to health† card (n, %)	1055 (90)	1166 (90)	0.8
Immunised†† (n, %)	1125 (96)	1257 (97)	0.06

†Road to health card is a summary of health & growth of the child in the first five years of life.
††Immunisation defined as maternal recall of any immunisation received by the child.

Baseline nutritional measures of participating children	Intervention	n Intervention‡	Control	n Control‡	p value‡‡
WHZ (mean, SD)	-1·00 (1·16)	808	-0·94 (1·00)	910	0·3
HAZ (mean, SD)	-2·00 (1·29)	808	-2·14 (1·33)	910	0·03
WAZ (mean, SD)	-1·89 (1·10)	985	-1·96 (1·10)	1170	0·2
MUAC (mean, SD)	13·6 (1·14)	933	13·6 (1·25)	1080	0.5
Wasted (n, %)	159 (20)	808	138 (15)	910	0·01
Stunted (n, %)	399 (49)	808	489 (54)	910	0·07
Underweight (n, %)	436 (44)	985	548 (47)	1170	0·2
MUAC <12·5cm (n, %)	122 (13)	933	176 (16)	1080	0·04
MUAC <11·5cm (n, %)	24 (3)	933	44 (4)	1080	0·06

‡The number of children contributing to each outcome measure is given in each row.
‡‡p values from t-test for continuous outcomes and chi-squared for binary outcomes

Table 1. Baseline characteristics of participating tolas, women and children. Intervention = immediate Rojiroti. Control = delayed Rojiroti.

	Intervention	n for each outcome (Intervention)	Control	n for each outcome (Control)	β/OR* (95% CI) for intervention vs. control at follow-up	ICC	p value
WHZ (mean, SD)	-1·02 (1·11)	674	-1·37 (1·10)	703	β = 0·38 (0·16 to 0·61)	0·108	0·001
HAZ (mean, SD)	-2·37 (1·29)	674	-2·53 (1·25)	703	β = 0·17 (-0·04 to 0·37)	0·053	0·1
WAZ (mean, SD)	-2·13 (1·03)	842	-2·37 (1·05)	871	β = 0·27 (0·11 to 0·43)	0·051	0·001
MUAC (mean, SD)	13·6 (1·10)	811	13·4 (1·12)	828	β = 0·22 (0·03 to 0·40)	0·063	0·02
Wasted (n, %)	122 (18)	674	200 (29)	703	OR = 0·46 (0·28 to 0·74)	0·134	0·002
Stunted (n, %)	421 (63)	674	465 (66)	703	OR = 0·82 (0·60 to 1·12)	0·044	0·2
Underweight (n, %)	446 (53)	842	545 (63)	871	OR = 0·63 (0·47 to 0·84)	0·042	0·002
MUAC <12.5cm (n, %)	102 (13)	811	152 (18)	828	OR = 0·65 (0·41 to 1·05)	0·116	0·08
MUAC <11.5cm (n, %)	24 (3)	811	37 (5)	828	OR = 0·70 (0·36 to 1·33)	0·097	0·3

Supine length or standing height was measured in 81% of children at baseline and 79% at follow-up.
Weight was measured in 99% of children at baseline and 99% at follow-up.
In children aged 6-59 months, **MUAC** was measured in 99% of children at baseline and 99% at follow-up.

*β is the regression coefficient for continuous outcomes and OR is the odds ratio, both adjusted for clustering. ICC is the intracluster correlation coefficient (proportion of the total variance of the outcome that can be explained by the variation between clusters).

Table 2. Cross-sectional analysis of the effects of the Rojiroti microfinance programme on nutritional status of children under five years of age at 18 month follow-up. Not all outcome measures could be recorded for each child and so the number of children contributing to each outcome is listed. Intervention = immediate Rojiroti. Control = delayed Rojiroti.

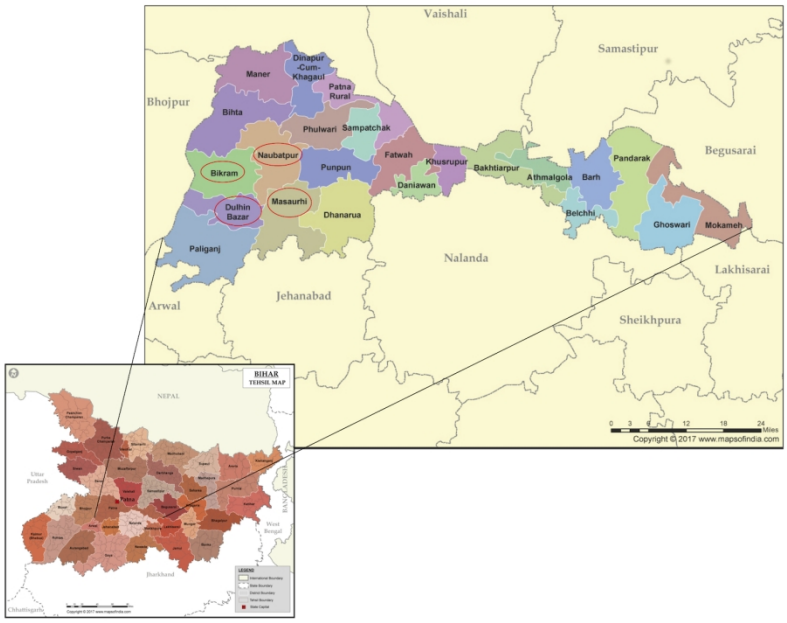

Figure 1. The State of Bihar, showing Patna District, with the participating administrative blocks ("tehsils") of Dulhin Bazar, Naubatpur, Masurhi, and Bikram

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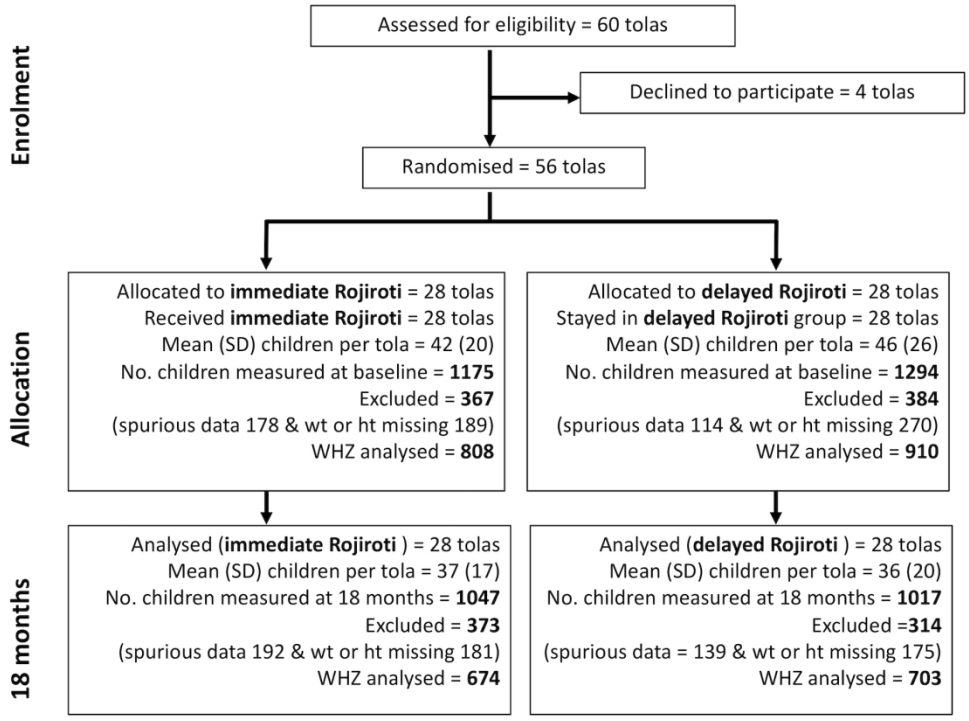

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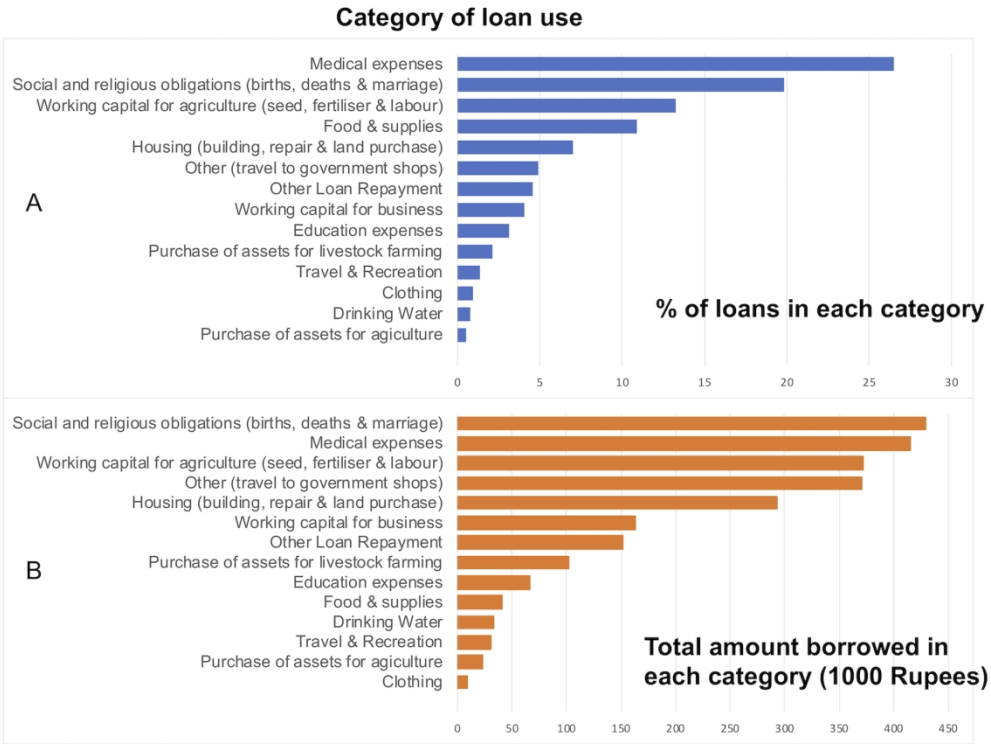

Figure 3. Use of loans by women in the intervention tolas, showing % of loans granted (A) and total amount borrowed in each category (B).

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SUPPLEMENTARY STATISTICAL ANALYSIS

Rojiroti microfinance & child nutrition: a cluster randomised trial.

Authors: Shalini Ojha, Lisa Szatkowski, Ranjeet Sinha, Gil Yaron, Andrew Fogarty, Stephen Allen, Sunil Choudhary, and Alan R Smyth

SUPPLEMENTARY METHODS

Growth trajectory over 18 months in children measured both at baseline and 18 months

In children with linked baseline and follow-up data we examined the trajectory of change in z-scores and MUAC between baseline and follow-up. Children aged over three and a half years at baseline were over five years at 18 month follow up and, for these, we used WHO AnthroPlus to calculate HAZ and WAZ.[1] There are no WHZ standards for children aged over five years and so analysis of this outcome includes only children who were under five at follow-up. Any child where the outcome variable was recorded as having changed by >3 standard deviations was excluded from the analysis[2]. We compared the trajectory of change in z-scores and MUAC, between baseline and follow-up, using a repeated measures, generalised linear mixed model. We examined the interaction between time point and group allocation to assess whether the trajectory of change varied between children in intervention and control tolas. In line with previous work,[2] potential tola, mother and child-level confounders were added to the models if at baseline they were univariably associated with group allocation or the outcome (based on a value of $p<0{\cdot}25$) or if they were considered *a priori* to be important factors in child growth (e.g. maternal education). The age and sex of the child and the number of children aged under five in the family were included *a priori* in all models. The tola ID was included as a random effects variable. A backward model fitting approach was used and variables kept in the model if $p<0{\cdot}1$. The confounders included in the model for each anthropometric measure are shown in Supplementary Figure 1A. We have also calculated the adjusted difference in intervention vs. control tolas (95% CI, p-value) in WHZ, WAZ, HAZ and MUAC.

Effects of mothers' SHG membership on nutritional outcomes in children under 5 years.

In order to examine whether any effects of the intervention varied according to mothers' SHG membership, linear and logistic regression analysis were repeated comparing all children measured at baseline in intervention and control tolas using a four level exposure variable:

- control and mother not a member of an SHG (reference category)
- control but mother a member of a non-Rojiroti SHG
- mother in intervention tola and member of a Rojiroti SHG
- mother in intervention tola but not a member of a Rojiroti SHG

SUPPLEMENTARY RESULTS

Growth trajectory over 18 months

Of those who were surveyed at baseline, 1457 (59%) children and 894 (57%) mothers also participated in the follow-up and could be included in the longitudinal analysis. Of the children who took part at baseline, 470 were aged over five years at follow up and were only included in the in the analysis of growth trajectory. There was no significant difference in follow-up rates between intervention and control tolas.

Supplementary Figure 1B shows the trajectory of change in z-scores and MUAC between baseline and follow-up, for those children included at both time points, with the p-values for the time*group interaction term. There was a significant difference in the trajectories of change in the intervention and control groups for the outcomes of WHZ (p=0·006) and WAZ (p<0·001); z scores worsened in all groups but more so in the control tolas. However, there was no significant difference in the trajectories of change in HAZ and

MUAC between intervention and control groups. The magnitude of change in the anthropometric parameters among this subgroup of children was similar to that in the cross-sectional analysis; however, due to the smaller sample size, the statistical power to detect differences was reduced.

Supplementary Table 1 shows the results for the subgroup of children who were present for measurement both at baseline and follow-up. In Supplementary Table 1, we show adjusted least square means with their standard errors for WHZ, HAZ, WAZ and MUAC in intervention and control tolas at baseline and follow-up for children with linked data, derived from a repeated measures generalised linear mixed model. The p-values for the time*group interaction term suggest there was a difference between intervention and control tolas in the pattern of change in WHZ (p=0·006) and WAZ (p<0·001) across the 18-month study period. WHZ and WAZ worsened in both groups over time, but less so in children in intervention tolas compared to children in control tolas. HAZ and MUAC both improved over time but there were no differences between groups.

Supplementary table 1 also shows the adjusted difference in intervention vs. control at baseline and follow-up for WHZ, HAZ, WAZ and MUAC. At follow up, in this analysis, only the difference in WAZ was statistically significant (0.28, 95% CI 0.16 to 0.39, p<0·001).

Effects of mothers' SHG membership

In the intervention group, 35% of women overall (median by tola 37%, interquartile range 8% - 59%) reported being members of a Rojiroti SHG. In control tolas, 29% of women overall (median by tola 24%, interquartile range 0% - 54%) reported being a member of a non-Rojiroti SHG. Comparisons of the mean z-scores and odds ratios for binary outcomes at follow-up in children in intervention and control tolas according to maternal SHG membership are given in Supplementary Table 2. The regression coefficients and odds

ratios were similar in children in intervention tolas in both the children of women who were members of a Rojiroti SHG and the children of women who were not members. There were no significant differences between children of women in control tolas who were members of a non-Rojiroti SHG and those who were not.

	Intervention group	Control group	p-value for time*group interaction	Adjusted difference in intervention vs. control (95% CI, p-value)
WHZ (n)	(257)	(291)		
Baseline	-1·01 ± 0·07	-0·90 ± 0·06	0·006	-0.11 (-0.29 to 0.07, p=0·2)
Follow-up	-1·22 ± 0·07	-1·39 ± 0·06		0.16 (-0.02 to 0.34, p=0·08)
HAZ (n)	(415)	(520)		
Baseline	-1·96 ± 0·06	-2·17 ± 0·05	0·09	0.20 (0.05 to 0.36, p=0·009)
Follow-up	-1·95 ± 0.06	-2·06 ± 0·05		0.11 (-0.04 to 0.27, p=0·1)
WAZ (n)	(530)	(669)		
Baseline	-1·90 ± 0·04	-1·96 ± 0·04	<0·001	0.06 (-0.05 to 0.18, p=0·3)
Follow-up	-2·04 ± 0·04	-2·32 ± 0·04		0.28 (0.16 to 0.39, p<0·001)
MUAC (n)	(332)	(379)		
Baseline	13·2 ± 0·06	13·2 ± 0·06	0·2	0.01 (-0.15 to 0.17, p=0·9)
Follow-up	14·0 ± 0·06	13·9 ± 0·06		0.13 (-0.03 to 0.29, p=0·1)

Supplementary Table 1. *Longitudinal analysis of the effects of the Rojiroti microfinance programme on nutritional status of children in the subgroup who were present both at baseline and follow-up. Adjusted least square mean ± standard error for interaction term (group x time point) from repeated measures generalised linear mixed model and adjusted difference in intervention vs. control at baseline and follow-up are presented.*

	Mean z-score (β, 95% CI for group vs. control)				p-value difference between groups
	Control non-SHG member	**Control SHG member**	**Intervention non-SHG member**	**Intervention SHG member**	
WHZ	-1·35 (ref)	-1·45 (-0·10, -0·31 to 0·11)	-1·02 (0·36, 0·11 to 0·61)	-0·99 (0·32, 0·06 to 0·59)	0·01
HAZ	-2·53 (ref)	-2·55 (0·00, -0·23 to 0·24)	-2·37 (0·15, -0·09 to 0·39)	-2·35 (0·21, -0·05 to 0·47)	0·4
WAZ	-2·35 (ref)	-2·44 (-0·08, -0·26 to 0·09)	-2·16 (0·22, 0·04 to 0·40)	-2·05 (0·29, 0·09 to 0·49)	0·007
MUAC (cm)	13·4 (ref)	13·4 (-0·03, -0·22 to 0·16)	13·6 (0·15, -0·06 to 0·36)	13·7 (0·25, 0·02 to 0·47)	0·1
	% (OR, 95% CI for group vs. control)				**p-value difference between groups**
Wasted	26 (ref)	33·5 (1·42, 0·91 to 2·22)	17·2 (0·48, 0·28 to 0·84)	19·1 (0·60, 0·33 to 1·09)	0·007
Stunted	66 (ref)	68·0 (1·05, 0·71 to 1·57)	63·4 (0·89, 0·62 to 1·28)	60·3 (0·73, 0·49 to 1·09)	0·4
Underweight	63 (ref)	62·9 (1·02, 0·72 to 1·45)	55·8 (0·71, 0·51 to 0·99)	46·6 (0·52, 0·36 to 0·75)	0·003
MUAC <12.5cm	17 (ref)	19·2 (1·18, 0·74 to 1·87)	13·9 (0·77, 0·45 to 1·30)	10·2 (0·65, 0·35 to 1·20)	0·4
MUAC <11.5cm	5 (ref)	3·4 (0·73, 0·31 to 1·74)	3·4 (0·78, 0·37 to 1·66)	2·2 (0·55, 0·20 to 1·51)	0.7

CI, confidence interval; OR, odds ratio; ref. reference group; WHZ, weight for height z-score; HAZ, height for age z-score; WAZ, weight for age z-score; MUAC, mid-upper arm circumference; wasted, WHZ <-2SD; stunted, HAZ<-2SD; underweight, WAZ<-2SD

Supplementary Table 2. *Comparison of mean z-scores and odds ratios at follow-up in children in intervention vs. control tolas according to mother's self-help group membership.*

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Supplementary Figure 1.

A. *Confounders included in the model for each anthropometric measure*

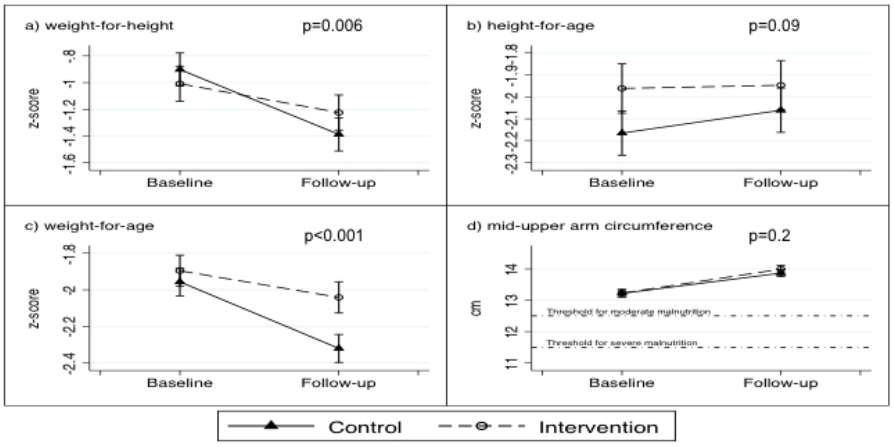
B. *Trajectories of change in anthropometric measures between baseline and follow-up in intervention and control tolas. Error bars represent 95% confidence intervals. P values are for the time*group interaction term from a repeated measures generalised linear mixed model.*

Supplementary Figure 2. Theory of change diagram of how Rojiroti may improve child nutrition. Intermediate & longer term outcomes are "assumptions" apart from those shaded which have been demonstrated in our field study.[3]

A.

Potential confounding factor	WHZ	HAZ	WAZ	MUAC
Child road to health card	✓	✓		
Family own land		✓	✓	
Mother can travel without permission of male relative		✓	✓	
Child immunised		✓		
Mother literate				✓
Family forced to sell assets in previous 18 months				✓
Age of child	✓	✓	✓	✓
Sex of child	✓	✓	✓	✓
Number of children <5y in family	✓	✓	✓	✓

B.



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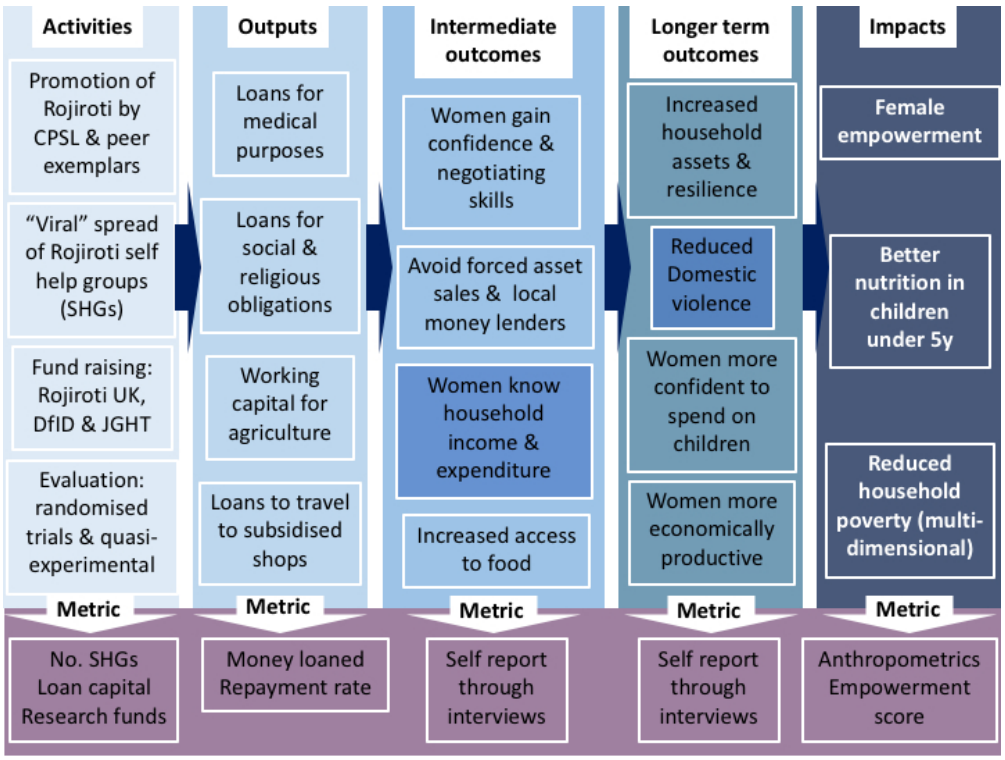

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