Exploring the potential of community mobilisation with women's groups to improve child growth among underserved tribal communities of Eastern India

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Declaration

I, **Jennifer Saxton**, confirm that the work presented in this thesis is my own. Where information has been derived from other sources I confirm that I have indicated this in the thesis.

Signed ______________________________

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Abstract

Background: India is home to one-third of the world's undernourished children. Rural tribal areas are disproportionately affected. Community-based behaviour change interventions are central to addressing undernutrition. Most interventions have used didactic educational methods but have had a limited impact; fewer studies have tested participatory approaches. This thesis explores the potential of a participatory intervention to reduce child undernutrition in rural tribal communities of Eastern India.

Methods: We conducted a cross-sectional nutrition survey of 36 village-clusters in three districts of Jharkhand and Orissa: 18 clusters had been exposed to community mobilisation with women's groups to improve child health and nutrition; 18 control clusters matched the intervention areas on population and health-service characteristics. We also conducted focus groups with caregivers of young children.

Results: There were no group differences for child anthropometry. Levels of undernutrition were extremely high: 40% of children were experiencing global acute malnutrition, 60% were stunted, and 24% had mid-arm-circumference measurements in the moderate-severe malnutrition category. There were significant group differences for hand washing, water treatment, birth spacing, measles vaccination and awareness of child undernutrition that favoured the intervention group; there were no differences for child feeding practices, health-service uptake or child morbidity. The analyses identified a multitude of undernutrition determinants including strong protective effects of hand washing, and diarrhoea as a major risk factor. The focus groups revealed extreme food insecurity, problematic feeding and hygiene practices, and inadequate health services.

Conclusion: Community mobilisation with women's groups does not appear to have reduced child undernutrition in this context, but has the potential to improve important nutrition behaviours. There is scope to improve and combine this intervention with complementary strategies, but until the wider problems of food insecurity, poverty and poor health-services are addressed community mobilisation with women's groups, on its own, is unlikely to meaningfully impact on undernutrition.

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List of abbreviations

ANC	Antenatal care
ANM	Auxiliary Nurse Midwife
AOR	Adjusted Odds Ratio
ARI	Acute Respiratory Infection
ASHA	Accredited Social Health Activist
AWC	Anganwadi Centre
AWW	Anganwadi Worker
BMI	Body Mass Index
BPL	Below Poverty Line
CBT	Cognitive Behavioural Therapy
CHC	Community Health Centre
CHW	Community Health Worker
CMAM	Community Management of Acute Malnutrition
DFID	Department for International Development (UK)
DLHS	District-level Household and Facility Survey
DHS	Demographic and Health Survey
DWCD	Department for Women and Child Development
EBF	Exclusive Breastfeeding
FANTA	Food and Nutrition Technical Assistance
GAM	Global Acute Malnutrition
GEE	Generalised Estimating Equations
GoI	Government of India
HAZ	Height-for-age Z-score
ICDS	Integrated Child Development Services
IFPRI	International Food Policy Research Institute
IPC	Integrated Food Security Phase Classification
IYCF	Infant and Young Child Feeding
MDG	Millennium Development Goal
MoHFW	Ministry of Health and Family Welfare
MUAC	Mid to Upper Arm Circumference
NCHS	The National Center for Health Statistics
NFHS	National Family Health Survey
NGO	Non-governmental organisation
NRHM	National Rural Health Mission
OBC	Other Backward Class
ORS	Oral Rehydration Solution
PDS	Public Distribution System
PNC	Postnatal care
PRADAN	An Indian NGO involved in livelihood and micro-credit activities
PRI	Panchayati Raj Institution

Rs	Indian Rupees
SAM	Severe Acute Malnutrition
SC	Scheduled Caste
SD	Standard Deviation
ST	Scheduled Tribe
TBA	Traditional Birth Attendant
UN	United Nations
UNFPA	United Nations Population Fund
UNICEF	United Nations Children's Fund
VHC	Village Health Committee
VHSCs	Village Health and Sanitation Committees
WAZ	Weight-for-age Z-score
WHO	World Health Organisation
WHZ	Weight-for-height Z-score

Glossary of local terms

Adivasi	An umbrella term used to describe tribal groups in India, meaning 'original inhabitants'
Amul	A brand of milk and milk powder
Bidi	A handmade cigarette
Bigha	Approximately 0.5 acres of land
Benga saag	*Centella Asiatica*, a herb found in wet areas (near streams) and containing zinc and other micronutrients
Panchayat	Panchayati Raj Institutions include three levels of decentralised government: village, block, district-level; Panchayat refers to the village-level or to a group of connected villages
Dimri	A summer fruit
Gram sabha	Village council
Ho	A tribal group originating from Jharkhand
Juang	The Government of India has classified Juang communities as a 'particularly vulnerable' tribal group; the group originates from Orissa
Kendu	Kendu is a summer fruit, rich in vitamin A; its leaves are also used for making 'bidi' cigarettes
Kodhei	Summer fruits
Mahto	A tribal group
Muh-Juthi	A Mahto group festival held for infants at seven months to celebrate the child's consumption of food for the first time
Munda	A tribal group living in Jharkhand and Orissa
Paddy	Rice or rice field
Pita alu	A type of potato
Santhal	One of the largest tribal groups in India
Sarna	Ho tribal religion

Chapter 1

Background

1.1 Introduction

This chapter provides a general overview of child undernutrition, globally and in India. I begin with a brief summary of the global burden of undernutrition, its causal pathways, and the timing of growth faltering. I then describe recent international initiatives to address this issue and methods to monitor hunger and malnutrition. Finally I describe undernutrition in India, and the states of Jharkhand and Orissa. The chapter concludes with a discussion of the importance of community-based behaviour change interventions to improve child growth amongst those most at risk of undernutrition in rural India.

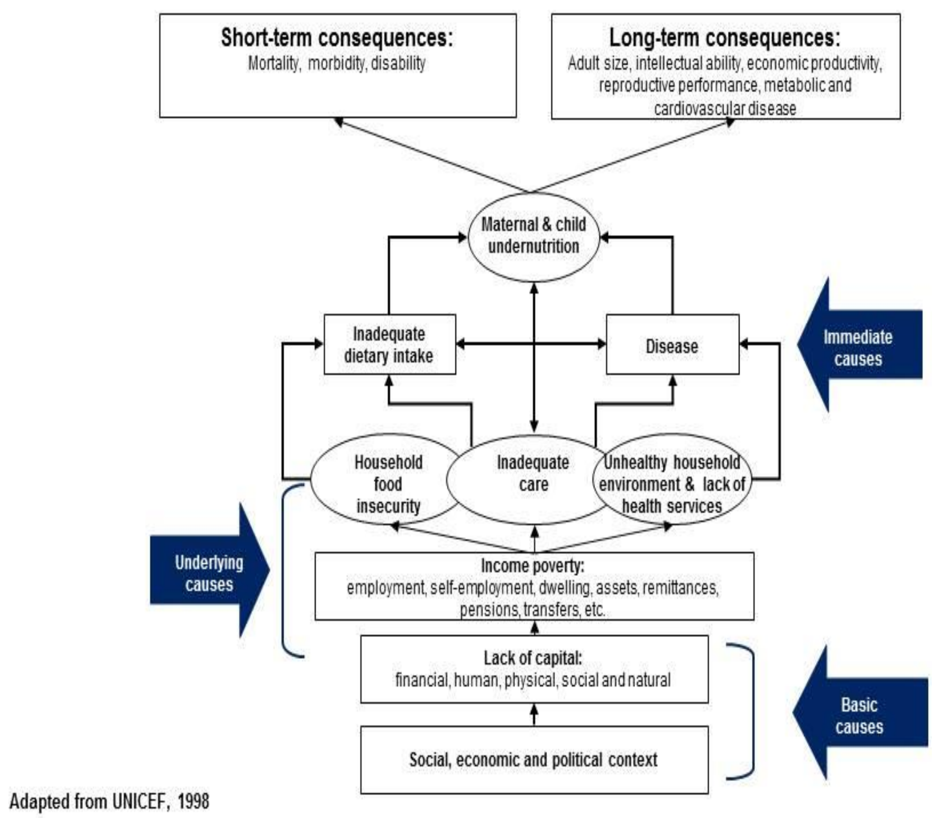
1.2 The global burden of undernutrition

Undernutrition contributes to 2.2 million under-five deaths annually, the vast majority occurring in twenty low and middle-income countries (Black et al. 2008;Gottlieb et al. 2009). Stunting (low height-for-age), wasting (low weight-for-height) and underweight (low weight-for-age) are significant independent risk factors for under-five mortality (Victora et al. 2008). Elevated mortality risks are not limited to severe cases: even mild-to-moderate weight-for-age deficits significantly increase vulnerability to a wide range of potentially fatal childhood diseases and all-cause mortality (Caulfield et al. 2004). Stunting and wasting can also impair cognitive development, and the combination of stunting, severe wasting and intra-uterine growth restriction (IUGR) has been estimated to account for 21% of disability adjusted life years among children under-five (Black et al. 2008). In the longer-term, child undernutrition increases adult susceptibility to a range of morbidities such as heart disease, high blood pressure and kidney damage (Kinra et al. 2008;Victora et al. 2008). There is also a strong association between stunting and lowered work productivity, which has been directly linked to diminished earning potential (Victora et al. 2008).

1.2 Causes of undernutrition: the UNICEF conceptual framework

The causes of undernutrition are multi-level, interwoven and nearly always underpinned by poverty and inequality. The UNICEF conceptual framework identifies three levels of causality: basic, underlying and immediate (UNICEF 1990;UNICEF 1998). An adapted version, extended by Black et al (2008) is shown in Figure 1.1.

Figure 1.1 The UNICEF Conceptual Framework



At the basic level is the social, economic and political context, which could include issues such as escalating food prices, lack of government spending on health, and absence of social security. The model also highlights the lack of five different forms of 'capital' as a basic cause; social capital refers to 'connections within and among social networks' and human capital to investment in education and training, which can have intrinsic value for health (OECD 2010). It is important to note that social capital is a complex construct and, depending on the context, does not necessarily result in improved health outcomes (Kunitz 2004). Kunitz argues that there are 'mixed and uncertain consequences of group membership' including the burden of expected reciprocal acts and coercion by the wider group to provide resources or to behave in a certain way. The chances of this are exacerbated where poverty levels are high, state provision of resources is low and community groups are expected to fill the gaps, often with little choice about who to work with to achieve these goals. At the kinship level, expectations may place a heavy burden on family members, and on some (such as women) more than others, which has the potential to erode life opportunities and be harmful for health. Whilst 'primary and secondary ties may bind us together…they may also imprison and divide us' (Kunitz 2004).

The next level in the framework illustrates underlying causes of undernutrition. This includes income poverty, which is in turn linked to three overlapping underlying risk factors: household food insecurity, unhealthy household environment and lack of health services, and inadequate care. Care refers to both women and children, and although it is given equal importance to the other domains in the framework, it may be the most neglected in practice in favour of food-focused activities (Engle 1999;Engle et al. 2000). A greater focus on the care of women may be particularly valuable in some South Asian societies, where women play a subservient role, their nutrition and education is of low priority, and they have limited control over their own lives, childcare practices and health-seeking behaviour (Bolam et al. 1998;Gillespie 1997). Given recent international attention on undernutrition, and an increasing awareness of intergenerational effects relating to the poor care and low status of women, this could result in 'care' receiving greater prominence in nutritional programmes (Black et al. 2008;Scaling Up Nutrition 2010).

The final level of the model specifies the immediate causes of undernutrition: poor dietary intake and disease. The World Health Organisation (WHO) has defined eight core infant and young child feeding indicators that represent optimal dietary intake: early initiation and exclusive breastfeeding under six-months, continued breastfeeding to one year, timely introduction of solid, semi-solid or soft foods (at 6-8 months), minimum dietary diversity (≥4 food groups per day for children 6-23 months), minimum meal frequency (which varies by age and breastfeeding status), minimum acceptable diet (a composite of the previous two indicators) and consumption of iron-rich foods (World Health Organisation 2009). The extent to which these recommendations can be followed varies. For example, flesh foods are iron-rich but may be too costly or culturally unacceptable for some households.

In terms of disease prevention, the WHO has developed immunisation schedules to prevent common childhood illnesses, such as measles. They also recommend routine deworming and vitamin A supplements in particular regions (World Health Organisation 2011b;World Health Organisation 2012). They further advocate for the use of Oral Rehydration Solution to manage diarrhoea, and in malarial zones families are advised to sleep under insecticide treated nets (Fischer Walker et al. 2009;World Health Organisation 2007). Common indicators of childhood infection (such as those measured in Demographic and Health Surveys) are fever, cough and diarrhoea and are all linked to an increased risk of undernutrition (DHS 2013).

The UNICEF framework was not intended as a universal model of undernutrition but as a guide to identify potential causes for consideration at the 'assessment and analysis' stage of programme planning. This then enables prioritising of the problems that are driving undernutrition and the creation of a context-specific plan of action (the 'triple A' approach) (UNICEF 1990;UNICEF 1998). It may be necessary to create different action plans for different nutritional indicators. One country-level analysis identified a negative correlation between stunting and wasting in Latin America, no correlation in Africa, and a strong positive correlation in Asia, indicating that stunting and wasting may have different determinants requiring different interventions (Victora et al. 2005).

Nutrition action plans should also involve consideration of the interaction and interdependency between different components of the framework. For example, an agricultural programme aimed at improving food security could negatively affect the 'care of women' if this resulted in an increase to already excessive workloads. Any health and nutrition programme would have the potential to change the dynamic between the different components of the framework, and ensuring that this does not have detrimental results requires good governance, inter-sectoral communication and commitment (Pelletier 2002;UNICEF 1990;UNICEF 1998). Overall, when applied correctly, the UNICEF model allows consideration of the full range of causes, contexts and pathways to undernutrition, which should avoid treating the manifestation of undernutrition alone without addressing distal causes that maintain these pathways (Pelletier 2002).

1.3 Timing of growth faltering

Epidemiological studies have identified the most vulnerable time-points for growth faltering, their associated risk factors and their proximal determinants. Evidence suggests that child undernutrition can begin in the womb: intra-uterine growth restriction (IUGR) from poor maternal nutrition during pregnancy may lead to linear growth deficits that are largely irreversible after two years (De Onis 2008). The linear growth potential of children may also be pre-set by maternal short stature, anaemia and young age at first pregnancy (<18 years): these factors increase the risk of low birth weight, which is in turn associated with stunting. Early pregnancy compounds the intergenerational transmission of undernutrition because it prematurely stops maternal growth, preventing women from reaching their full height potential (De Onis 2008).

A second critical time-point for growth is during the first two years of life. The WHO recommends early initiation of breastfeeding (within one hour of birth) and exclusive breastfeeding until six months of age (World Health Organisation 2011a). Early initiation is important because the colostrum in the first few days provides immune protection to the infant (Uruakpa et al. 2002). Late breastfeeding initiation may not only reflect colostrum discarding, but also pre-lacteal feeding, which increases infection risks and is a common cultural practice in parts of South Asia (Bamji 2003;Edmond et al. 2006;Fikree et al. 2005). Non-exclusive breastfeeding of infants under-six months in settings where it is difficult to hygienically prepare bottles and where formula milk is not affordable increases the likelihood of suboptimal feeding, infections and undernutrition (Weisstaub and Uauy 2012;World Health Organisation 2008a).

When children reach six months of age, solid, semi-solid and soft foods should be introduced into their diet (World Health Organisation 2009). If the timing of this transition is inappropriate, if feeding frequency is inadequate, or if the quality and diversity of foods are poor, this increases the risk of impaired physical growth and cognitive development (Arabi et al. 2012;Bhutta et al. 2008;Black et al. 2008). Poorer cognitive outcomes may be a direct result of brain damage from inadequate dietary quality, an extreme example being the development of cretinism due to an iodine-deficient diet (World Health Organisation 2001b). Poorer cognitive outcomes may also be an indirect result of children lacking the energy to explore their environments and demand social stimulation from adults (De Onis 2008).

1.4 International focus on undernutrition

The timing of growth faltering has recently captured international attention through the ‘1000 days’ concept. This emphasises the time period from day one of conception through to the age of two years as a critical window for child growth (1000 days 2011). The Scaling up Nutrition initiative (SUN) identifies 13 evidence-based direct interventions to reduce undernutrition, and further indirect governance-related activities required to coordinate effective action to tackle undernutrition; this built on the work of the Lancet maternal and child undernutrition series (Horton 2008;Scaling Up Nutrition 2010). Direct interventions refer to nutrition-specific interventions relating to the underlying and immediate determinants of undernutrition in the UNICEF framework. These include infant and young child feeding, hygiene and hand washing, micronutrients and deworming for mothers and children, food fortification with micronutrients, and therapeutic feeding for undernourished children. Indirect actions include tackling the basic causes of undernutrition (such as ensuring adequate incomes) and improving governance so nutrition can be integrated into other government sectors to allow a coordinated approach (Scaling Up Nutrition 2010).

The chances of achieving several of the Millennium Development Goals (MDGs) will hinge on improvements in nutrition. The 1000 days concept and the SUN initiative have made an important contribution by stimulating additional commitment and financial support from unilateral and bilateral organisations, Non-Governmental Organisations (NGOs) and governments of target countries (Department for International Development 2010). However, current data suggest that MDG 1 (eradicate extreme poverty and hunger) and MDG 4 (reduce under-five mortality by two-thirds between 1990-2015) are unlikely to be achieved by 2015 (Requejo et al. 2012). India and China, due to their large population sizes, play a key role in the overall attainment of MDGs 1 and 4. Whilst China is on track to meet both goals, in India achieving MDG 1 ‘will require interventions of great magnitude in disadvantaged states’, and there has been ‘insufficient progress’ on MDG 4 (Bhutta et al. 2010;UNICEF India 2010a).

The annual Global Hunger Index is one source of information used to monitor progress towards MDGs 1 and 4 (IFPRI 2006). This was developed by the International Food Policy Research Institute (IFPRI) who defines 'hunger' according to three measures: 1) undernourishment (the proportion of people consuming <1800 calories per day); 2) underweight in children under-five years (weight-for-age z-score <-2.00); and 3) under-five mortality. The index weights all three indicators equally and generates a score from 0 to 100, with lower values representing lower levels of hunger: <5=low, 5-9.9=moderate, 10-19.9=serious, 20-29.9=alarming, ≥30=extremely alarming. 120 developing countries have data available for all three measures, although several of them were excluded from the 2012 ranking because they scored very low. Of the remaining countries, Azerbaijan has the lowest ranking (i.e. the least hunger) and Burundi the worst ranking, in 79th place. India is also poorly ranked for hunger, placed 65th in 2012, and has shown little sign of improvement since 1996 and 2001 rankings, and no change since 2011. India ranked second worst for prevalence of child underweight in 2012 according to the Global Hunger Index (IFPRI 2012).

1.5 Hunger and undernutrition in India

It is surprising that India ranks so highly on the hunger index. It is the world's largest democracy and also one of the world's largest and fastest growing economies, with national growth for 2011/12 at 15.68% (Indian Planning Commission 2012). For the year 2011, India's Gross Domestic Product per capita was $1489 ($1055 in 2007) (The World Bank 2012). Increasing income tends to be matched by lowering levels of undernutrition, yet India is home to one third of the world's undernourished children (Haddad and Zeitlyn 2009). In absolute numbers this amounts to an estimated 61 million stunted and 25 million wasted children under-five (UNICEF India 2010b). Building on the Global Hunger Index from 2008, Menon and colleagues developed the India State Hunger Index (ISHI) to show the national distribution of 'hunger' (Menon et al. 2009). This is illustrated in Figure 1.2. It is evident that, although there is some variation, much of India has alarming levels of hunger, and Madhya Pradesh is the worst affected.

India's national nutrition survey, the National Family Health Survey (NFHS) provides separate estimates for stunting and wasting in children by state. The most recent NFHS-3 data from 2005/6 indicate substantial between-state differences (Ministry of Health and Family Welfare 2006;Paul et al. 2011). With the exception of Meghalaya in the North East and Gujarat in the

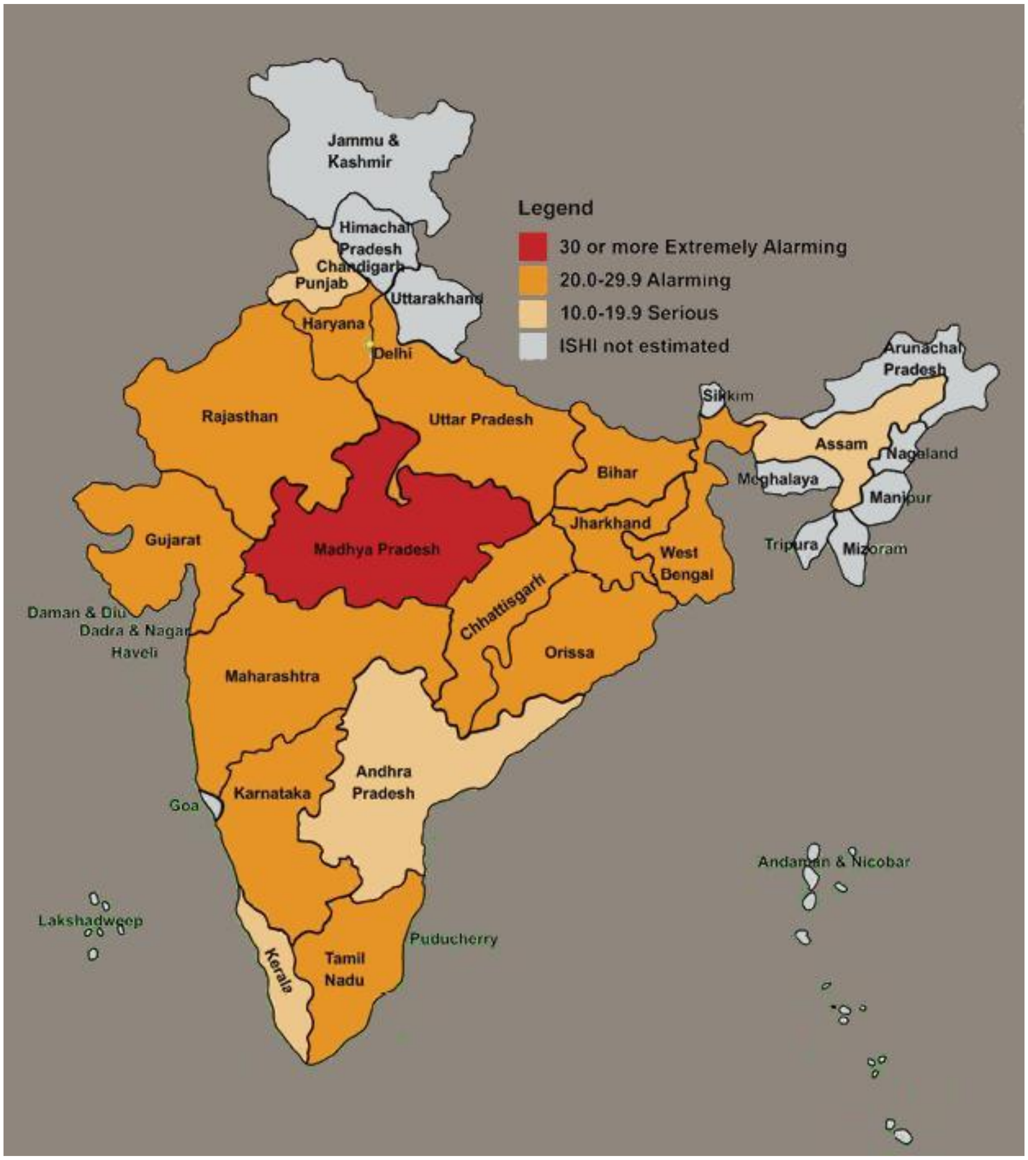
West, the worst rates of stunting and wasting are centred in the Central and Eastern states (Ministry of Health and Family Welfare 2006;Motherchildnutrition.org 2007). Two of the Eastern states, Jharkhand and Orissa, are the focus of this PhD thesis.

Stunting trends for children under-three in Jharkhand show an overall reduction from 54% in 1998/9 to 47% in 2005/6, but an increase in wasting (28% to 36%); Orissa has seen an overall decrease in stunting (49% to 44%) and wasting (30% to 24%) (Ministry of Health and Family Welfare 2006). State-level estimates disguise the markedly higher rates of stunting and wasting in rural compared to urban areas. According to the NFHS-3 stunting amongst under-fives in rural Jharkhand was 53.4% and wasting was 34.1% compared to 34.8% and 24.6% in urban areas. In rural Orissa stunting estimates were 46.5% and wasting was 20.5% compared to 34.9% and 13.4% in urban areas respectively (Ministry of Health and Family Welfare 2006).

A recent analysis of the NFHS-3 identified that 36% of faltering in height-for-age Z-score had already taken place at birth (Mamidi et al. 2011), highlighting the importance of addressing maternal undernutrition in this context. To put NFHS-3 wasting estimates into a global context, unless there has been a food shortage, prevalence tends to be less than 5% amongst under-fives in most countries, with South Asia being the exception (De Onis 2008). In terms of international standards of acceptability the WHO considers wasting of 10-14% as 'serious' and ≥15% 'critical', highlighting the need for action in many parts of India (Fernandez et al. 2002;World Health Organisation 2013).

The NFHS survey is supposed to be conducted every seven years (Ministry of Health and Family Welfare 2006). Critics suggest this time frame is too infrequent to effectively monitor undernutrition and target interventions, and there is an argument for 'more frequent, slimmer surveys' (Haddad and Zeitlyn 2009). NFHS trends also conflict with National Nutritional Monitoring Bureau data from rural villages in nine Indian states, including Orissa, that show a slow decline in underweight and wasting but an increase in stunting over a similar time period (Deaton and Dreze 2009;National Nutrition Monitoring Bureau 2006).

Figure 1.2 The Indian State Hunger Index, from Menon et al, 2009



Given increasing global food prices and several poor monsoons in the years since the NFHS-3, the more recent Hungamaa survey in 2011 provided an important update on child undernutrition (Hungamaa 2011). This survey included the 100 lowest ranking districts on UNICEF's Child Development District Index covering 6 states: Jharkhand, Orissa, Bihar, Madhya Pradesh, Rajasthan and Uttar Pradesh; 12 high ranking districts from Kerala, Himachal Pradesh and Tamil Nadu served as a comparison (Hungamaa 2011;UNICEF 2011). The results indicate that although there has been a decline in undernutrition since the NFHS-3, levels of underweight (40%) and stunting (~60%) remain excessive in these high burden districts

(Hungamaa 2011). Overall, the available data indicates slow progress towards reducing child undernutrition. At current rates of decline in underweight India may not reach its Millennium Development Goal until 2043 (Haddad and Zeitlyn 2009).

1.6 Differences in undernutrition between social groups

There are large within-state differences for undernutrition that go beyond the rural-urban divide. These often have social determinants that are linked to caste and class (Subramanian et al. 2006). People from *adivasi* groups (meaning 'original inhabitants of the land') are described as 'Scheduled Tribes', and together with people from 'Scheduled Caste' groups (SCs, formerly known as 'untouchables') are amongst the most underserved socially excluded groups in India. This is reflected in poorer health and nutrition outcomes (Government of India 2005a;Haddad et al. 2012;Subramanian et al. 2006). For example, NFHS-3 analyses indicate that underweight amongst under-fives may be as high as 55% amongst Scheduled Tribes and 48% amongst Scheduled Castes (this is compared to 43% from Other Backward Class groups, and 34% in all other groups). Further analyses indicate that even when education and poverty are equal, health outcomes are still substantially worse for *adivasi* and Scheduled Caste groups (Kumar et al. 2010a).

Social group disparities in health outcomes may be a result of caste-based discrimination and exclusion from quality healthcare (Thorat and Sadana 2009). Observational evidence converges with this hypothesis, and highlights that beliefs about 'untouchability', 'impurity' and 'pollution' through touch and ingestion compromise the delivery of health and nutrition programmes (Mamgain and Diwakar 2012;Thorat and Sadana 2009). Monitoring of the midday meal scheme for preschool and primary school children in 550 villages across five states by the Indian Institute for Dalit Studies identified the following issues: segregated seating by caste; denial of meals for SC children, serving SC children last; punishing SC children requesting food first; poorer quality and lower quantity of food for SC children; serving SC children from a distance (Acharya 2012;Thorat and Sadana 2009). An Action Aid study of 555 villages across 11 states in rural areas pointed to economic as well as social exclusion of SC groups, for example being unable to sell milk to private buyers or cooperatives because of perceived 'pollution' of goods (Shah et al. 2006;Thorat and Sadana 2009). There is also evidence that health and nutrition programmes are designed in a way that may inadvertently exclude marginalised groups. For example, 'fair price' shops that enable poorer people to buy subsidised grain are often located in 'higher caste' areas, and run by elite groups which has resulted in some underserved groups being unable to access their entitlements (Swain and Kumaran 2012).

1.7 National initiatives to improve health and nutrition

There are several government initiatives designed to improve health and nutrition in India that are discussed here, and outlined in Table 1.1.

National Initiatives

Two national government departments are responsible for maternal and child health and nutrition: the Ministry of Health and Family Welfare (MoHFW) and the Department for Women and Child Development (DWCD). This involves some inter-sectoral collaboration to coordinate different elements of some of the larger programmes. There are two major national nutrition and health programmes: the Integrated Child Development Services (ICDS) and the National Rural Health Mission (NRHM). Several other programmes are also highly relevant to nutrition, including the Targeted Public Distribution System for food security, the National Rural Employment Guarantee Scheme, the Total Sanitation Campaign, numerous Self Help Group initiatives for income generation, and more recently health and nutrition groups for adolescent girls. These programmes and sub-programmes are summarised in Table 1.1.

Many of these programmes have suffered from design and implementation problems, although this varies considerably within and between states (Gragnolati et al. 2006a;Haddad and Zeitlyn 2009;Paul et al. 2011). Self-help group (SHG) initiatives for example show an uneven spread, with North Eastern areas seeing lower response rates and higher attrition of groups than Southern areas. This is partly due to lack of access to banks in rural areas, lack of transparency, accountability, and participant knowledge about entitlements (Rajalakshmi 2010). According to some reports, the National Rural Employment Guarantee Scheme has also failed many rural communities: a recent survey in Jhabua district (Madhya Pradesh) showed a mean of 11.51 days of employment, far below the 'guaranteed' 100, with just 0.48% of households getting work for the full duration (Singh 2010). Furthermore, the programme focuses on manual labour jobs that are low paid, and excludes some people with disabilities and illness (Dreze 2010).

The National Rural Health Mission

The National Rural Health Mission was designed to be a decentralised scheme to increase the coverage and quality of primary health care and increase community involvement with health services in rural India. A new cadre of health worker (the Accredited Social Health Activist or ASHA) was created to facilitate this process (Ministry of Health and Family Welfare 2005). Whilst the NRHM has seen some improvement to infrastructure, the coverage and quality of care remains suboptimal. For example, there is still a considerable 'unmet need' for contraception and inadequate access to safe abortion (Paul et al. 2011). Some criticisms include an excessive focus of the ASHA on implementing the JSY voucher scheme (which offers a financial incentive to women to give birth in institutional facilities) at the expense of other activities (Paul et al. 2011). There are also shortfalls in ASHA training and overall financing of the NRHM. There is also evidence of bias in the allocation of yearly funds towards politically visible schemes that are not necessarily the most effective for improving health, but are more likely capture votes (Paul et al. 2011).

The Targeted Public Distribution System

The Targeted Public Distribution System has encountered difficulties in identifying appropriate beneficiaries. This is partly due to flawed assessment methods to identify households that are eligible for Below Poverty Line cards. This has resulted in many deserving households being excluded from the scheme, whilst richer households benefit (Swain and Kumaran 2012). There is also 'leakage' of grain as it travels down the supply chain leading to large shortfalls by the time it reaches villages (Singh 2010). Attempts to increase coverage of the programme have also been problematic, with supply calculations based on population size from the 2001 census which has grown considerably since then. Coupled with inappropriate distribution of below poverty line cards, this is unlikely to improve food security (Singh 2010).

The more recent draft National Food Security Bill has attempted to resolve some of the issues with the Targeted Public Distribution System, and has pledged to provide subsidised food grains to 75% of the rural population (Government of India 2011b). But the bill has been controversial for continuing its targeted approach without improving eligibility assessments, despite evidence that a general non-targeted scheme may work more efficiently and equitably (Khera and Dreze 2011). There are also unresolved issues in terms of lack of accountability and weak monitoring systems (Swain and Kumaran 2012).

There may still be scope to improve the system before the food security bill is finalised (Haddad et al. 2012). This will be even more important given continually escalating food prices worldwide: a recent Rabobank report predicts that global food prices will have increased by 15% by mid-2013 (Singh 2012). National food prices are also escalating: for example, Food Price Watch identified a 25% increase in the price of rice in India in the first and second quarters of 2012, but noted decreases in rice prices in most other regions of South Asia (World Bank 2012). This is further undermining the food security of the poorest households and increasing the risk of undernutrition.

The Integrated Child Development Services (ICDS)

The Integrated Child Development Services (ICDS) is pitched as India's 'flagship nutrition programme' (Ministry of Women and Child Development 2013). However, it is not considered successful despite being 'well designed and well placed' for that purpose (Gragnolati et al. 2006a). It has suffered from implementation difficulties and inequitable service coverage. Gragnolati and others have identified bias towards the supplementary nutrition aspect of the ICDS (which is also affected by leakage and irregular food supplies) at the expense of other ICDS components such as counselling for feeding and caring practices (Gragnolati et al. 2006a;Paul et al. 2011;Saxena 2012). These behaviour change elements of the ICDS may be even more likely to be side-lined in the context of growing food insecurity due to escalating food prices.

The focus on supplementary nutrition has also diverted attention away from pregnant women and children under-two with more time spent providing services for 3-6 year old children (Gragnolati et al. 2006b;Paul et al. 2011). As a result there have been missed opportunities to conduct home visits to provide support and advice for infant and young child feeding, or to give specific support to vulnerable households (Paul et al. 2011). Research also indicates that there is less ICDS contact by poorer households compared with richer (Haddad and Zeitlyn 2009). There remains a bias in funding and coverage of ICDS services towards richer states, whilst poorer states with the highest levels of undernutrition remain underserved, reflecting state differences in political leadership and commitment to reducing undernutrition (Haddad and Zeitlyn 2009).

The Anganwadi centre (AWC) is the central venue from which many current programmes (such as the ICDS) and newly introduced community schemes operate (such as 'Sabla', for female adolescent empowerment). Sabla alone will increase the regular use of AWCs from 2-3 adolescent girls per week to 15-20, whilst the AWC is also used for early child development activities and supplementary feeding for children under six (Department for Women and Child Development 2010;Singh 2010). There is often inadequate space, toilets and drinking water at AWCs, and it will be impossible for many of these programmes to run without significant expenditure on facility improvement (Department for Women and Child Development 2010;Singh 2010). Although Anganwadi workers (AWWs) are supposed to have daily contact with community members, this is not always the case and there is little community ownership or active involvement in the implementation of the ICDS. Only 25% of village leaders have given overt support for the scheme e.g. by making space for the AWC or helping identify beneficiaries (Gragnolati et al. 2006a).

The AWW is a government employee and is not directly accountable to communities, in terms of AWC opening hours, her attendance and the services she provides. There has been a recent shift towards accountability within the ICDS, and more monitoring is taking place. For example social audits of the ICDS were held recently in Orissa and Andhra Pradesh (Haddad and Zeitlyn 2009).

The Indian Planning Commission has recently drawn up plans to reform the ICDS and improve the quality of infrastructure and management of Anganwadi Centres (Indian Planning Commission 2011). This includes greater decentralisation of services by converting the ICDS into ‘mission mode’ and increasing ownership of the ICDS by community members (including women’s groups) so services are more responsive and appropriate for local needs, and should result in more effective public health action (Indian Planning Commission 2011;Paul et al. 2011). The ICDS will also include a greater focus on younger children, a continued emphasis on growth monitoring, and strategies to engage families in behaviour change (Indian Planning Commission 2011). Many of the planned changes reflect those recommended in a recent Lancet report of universal health care coverage in India (Paul et al. 2011). There are also plans to include a World Bank proposal to introduce a second AWW in districts with the highest burden of undernutrition, which has the potential to increase the coverage and quality of implementation of the ICDS (Ministry of Women and Child Development et al. 2006;Paul et al. 2011;Working group on children under six 2007).

Table 1.1 National Health and Nutrition Programmes in India

Programmes and associated initiatives	Key actors	Intended beneficiaries	Description
Integrated Child Development Services (ICDS) (1975-)	Ministry of Health and Family Welfare (MOHFW), ICDS supervisors, Block level Child Development Project Officers, CARE India; Anganwadi Workers (AWWs)	Children <6 years pregnant and lactating women	AWWs deliver services via community-based Anganwadi Centres and home visits. This includes nutrition, sanitation, vaccination/health counselling, ANC, PNC, iron tablets, growth monitoring, referral of undernourished children, organisation/ facilitation of community meetings, pre-schooler development, provision of meals/take-home rations, registration of births and deaths.
ICDS Supplementary Nutrition Programme		Low-income pregnant and lactating women, children <6 years	Food provision 300 days/year (300 calories, 8-10g protein for <6s; 500 calories, 20-25g protein for women). Additional rations for underweight children.
National Rural Health Mission/NRHM (2005-2015)	MOHFW, Department for Women and Child Development (DWCD), Panchayati Raj Institutions, Rural Water Scheme, Education dept, Norway India Partnership Initiative, UNICEF, AWWs, Auxiliary	Underserved rural areas, women and children	Health-service strengthening: patient-welfare societies for community participation, public-private partnerships to improve hospital management; improving quality of health facilities, especially for institutional deliveries (e.g. creating neonatal intensive care units).
NRHM Janani Suraksha Yojana (JSY) scheme		Pregnant women and newborn infants	Aims to increase institutional deliveries. ASHAs incentivised to identify pregnant women and accompany to health facilities for delivery. They also conduct ANC/PNC visits, support breastfeeding and immunisations, and diagnose and treat malaria.
NRHM Village Health		Community members	Monthly community meetings at AWC for: delivery of health services,

and Nutrition Days	Nurse Midwives, ASHAs		discussion of health issues, case-finding and referral of undernourished children, data collection (disability, disease, deaths).
Reproductive and Child Health II (RCH 2005-2010)	MoHFW, DWCD, Care India, UNICEF, United Nations Population Fund, ICDS, AWWs	Women, children <5 years	Aims to reduce infant and maternal mortality. Activities include promotion of contraception, improving safe motherhood services, provision of adolescent sexual/reproductive health services, improving referral systems, use of verbal autopsy tools. Child-based strategies include routine <5 nutrition/ immunisation checks, oral rehydration solution for diarrhoea, identification of feeding problems and essential newborn care.
RCH Teen girls groups (Balika Mandals)		Adolescent girls	Aims to improve maternal/child health & nutrition by working with teenage girls. Focuses on improving knowledge/practices around sexual/reproductive health and gender issues.
Sabla-part of Rajiv Gandhi Scheme for Empowerment of Adolescent Girls (200 district pilot)	MoHFW, ICDS, NRHM, AWWs/CHWs, Non-Governmental Organisations (NGOs)	Girls 11-14 years (not at school) and all girls 15-18 years	Integrated nutrition and health package delivered via AWCs by various health workers and NGOs. Girls are trained to 'upgrade' home, life and vocational skills, and health, hygiene and childcare education. Also aims to return 'out of school' girls to mainstream education. Food rations are provided 300 days/year (600 calories, 18-20g protein, and micronutrients), Iron and folic acid, health checks and referral are also provided.
Indira Gandhi Matritva Sahyog Yojana (2010-12): 52 district pilot	MoHFW, DWCD, ICDS, AWW, AWW-helper	Pregnant/lactating women >19 years, and first two children	Conditional cash transfers for pregnant/lactating women who fulfil certain maternal and child health-related activities to create an 'enabling environment for improved health and nutrition' (4000 IRPs, 3 instalments, 2^{nd} trimester to 6 months of age). Also provides ANC/PNC, promotes service-use, and supports breastfeeding. AWW and helper are incentivised for this.

Targeted Public Distribution System (1997-)	MoHFW, DWCD, Panchayati Raj & private institutions	Households with 'Below Poverty Line' cards	Provides essential food items and monthly household entitlement to 35g of grain at subsidised cost, to improve food security of poorer households.
Total Sanitation Campaign (1999-)	Govt of India (GOI), Panchayati Raj Institutions, Community-based Organisations, NGOs	Rural poor communities	To provide clean water, and develop sanitation facilities to eradicate open defecation in rural areas. Includes information, education and communication methods about sanitation. Financial incentives are available for household toilet construction. There are also efforts to install toilets and provide clean water at schools and AWCs.
National Rural Employment Guarantee Scheme (2005-)	GOI, state governments, Panchayati Raj Institutions	Rural communities	100 days of guaranteed annual paid employment for rural adults. Minimum wage is set by the state government. Aims to increase income, strengthen livelihoods and prevent distress migration. Worksites should provide drinking water, shade and crèche facilities within 5km of the household.
National Rural Livelihood Mission (1999-)	GOI, Governing Council (GC), Executive Committee (EC)	Households with below poverty line cards in rural communities	Income generation strategies via self-help groups (SHGs). Aims to create SHGs, up-skill members to manage the SHG & 'take up microenterprises', provide a revolving fund to strengthen thrift/credit mechanisms, form credit links with banks, subsidise/give technical input for microenterprise.
National Agriculture Development Programme (2007-)	GOI, state governments, Department of Agriculture/allied departments	Rural communities	Aims to incentivise state governments to increase investment in agriculture. Involves the development of agricultural plans considering: eco-climatic conditions, resources, local needs/crops. It also seeks to: 'reduce yield gaps' in key crops via focused interventions, maximise economic return to farmers, and increase productivity of agricultural sectors with holistic approaches.

National Horticulture Mission (2005-2012)	GOI, Department of Agriculture, state & district GCs/ECs, Technical Support Groups	Rural communities	Focus on holistic growth of horticulture sector via research, technology promotion, post-harvest management, processing and marketing, guided by regional 'agro-climatic' conditions. Aims to increase food production and crop diversity, improve nutrition security/income of farmers, develop technologies, create jobs for youth, and build human resource capacity.

1.8 State-level initiatives

There are also state-specific initiatives, and here I focus on programmes in Jharkhand and Orissa where my PhD study is based (Tables 1.2 and 1.3). I then provide details of the main cadres of community and mid-level health workers and their involvement in the delivery of government programmes (Table 1.4).

At the start of this PhD project, the Government of Orissa had a formal Nutrition Plan in place, including provision for four senior posts committed to: monitoring and evaluation, training, behaviour change and communication and nutrition (Government of Orissa 2009). The nutrition plan was created in collaboration with the National Government of India, with inputs from the Norway India Partnership Initiative, The UK Department for International Development, UNICEF and the United Nations Population Fund. It aimed to target the most vulnerable, with inbuilt flexibility of implementation strategies and extra funding to maximise coverage, and sought to strengthen linkages with other government initiatives (especially the ICDS).

Jharkhand did not have an equivalent nutrition plan containing any new innovations or programmes over and above what was already present in national guidelines, although there was provision for small extra financial incentives to AWWs and helpers, and four additional government-NGO linked programmes (Government of Jharkhand 2009).

Details of state level programmes for Jharkhand and Orissa are shown in Tables 1.2 and 1.3.

Table 1.2 Additional Jharkhand State Government and Government-linked NGO Health and Nutrition Programmes

Programmes	Key actors	Intended beneficiaries	Description
The Dular programme (2009-2011)	Department for Women and Child Development (DWCD) and UNICEF /IKEA social initiative	Children <2 years	Aimed to enhance Anganwadi Worker (AWW) coverage and effectiveness with 'overlay' 'local resource groups/LRGs (4-5 local women, motivated and known to particular parts of the community). LRGs focused on mortality, morbidity and undernutrition reduction of <2s (e.g. via promotion of appropriate feeding practices and diarrhoea treatment. LRGs also supported AWWs in preparing food, home visits and identifying pregnant and lactating women.
The USAID micronutrient and child blindness project (Feb 2008-)	USAID, DWCD, UNICEF, The Micronutrient Initiative, Integrated Child Development Services (ICDS)	Mothers and children	A health and nutrition package delivered in 'Mother & Child Health and Nutrition Months' plus biannual vitamin A to reduce maternal and child anaemia. Interventions include iron folic acid provision, de-worming tablets, nutrition and health education, behaviour change and communication (e.g. for hand washing, improved infant and young child feeding and malaria prevention). The project also focuses on advocacy, staff capacity-building, improving supply systems and the use of data in planning and decision-making.
The Vistaar project (2006-2011)	USAID, National & State Governments, DWCD and Ministry of Health and Family Welfare	Mothers and children	Aimed to improve maternal, newborn and child health and nutrition. Reviews were conducted to gauge available evidence for programmes on: complementary feeding, newborn care, delay of marriage/first birth, Village Health Committees (VHCs) and Community Health Worker performance/support. Findings are being used to translate knowledge into practice and decision-making. The project is now giving technical input to maternal and child health programmes, running demonstration and learning projects to fill knowledge gaps and conducting advocacy and capacity-building activities around review themes.

Ranchi Low Birth Weight Project (2006-)	State government, Krishi Gram Vikas Kendra, the Child In Need Institute	Mothers and children	'Quasi experimental action research' that uses a community-based life-cycle approach to reduce low birth weight, and improve maternal and child health and nutrition through behaviour change. Community-based trained volunteers (Sahiyas) work with VHCs to improve diet, reduce workload in pregnancy, ensure ANC provision from health facilities, improve child feeding and caring practices, raise community awareness of health issues, link communities to health systems, and 'ensure provision of mandated public health services' via monthly meetings with Auxiliary Nurse Midwives and AWWs.

Table 1.3 Additional Orissa State Government and Government-linked NGO Health and Nutrition programmes

Programmes	Key actors	Intended beneficiaries	Description
Pustikar Diwas (Feb 2009)	Anganwadi workers (AWWs), UNICEF, UK Department for International Development (DFID), United Nations Population Fund, National Rural Health Mission (NRHM), Accredited Social Health Activists (ASHAs), Norway India Partnership Initiative (NIPI)	Underweight and wasted children	This initiative aims to enhance the referral system for children identified as severely underweight or wasted during Village Health and Nutrition Days, including treatment referrals, nutrition advice, and medical checks at primary and community health centres as appropriate.
The Infant Mortality Rate Mission (2001-2012)	State Government, Integrated Child Development Services (ICDS), AWWs, Auxiliary Nurse Midwives (ANMs), NIPI, Doctors, allied health professionals	Pregnant and lactating women, newborn infants	AWWs and ANMs identify and transport mothers and neonates for urgent institutional care to reduce Infant and maternal deaths. They also use information, education and communication strategies (IEC) e.g. for breastfeeding and maternal health. The mission also provides additional training for doctors and health workers in maternal care.
Mission Shakti, Orissa, (since 2001)	CARE India and Non –governmental organisations: APMAS, PRADAN, LOKADRUSTY, ACCESS, EDI and BISWA	Women/ young women	Aims to promote women's empowerment by creating and strengthening self-help groups (SHGs). Technical advice is provided for income generation, to make credit/market links, resource mobilisation, business plan development, accountancy. Employs a new cadre of worker, between SHG &

			block level, 'Shakti Sahayikas', trained for 6-months on micro-entrepreneurships. Activities are now becoming more health focused (e.g. linking with NRHM & ICDS).
Community mobilisation with women's groups (Nov 2010)	Ekjut, DFID, state government, NRHM, ICDS, Technical Management Support Team	Women and children	Piloting of community mobilisation with women's groups in five villages for improved maternal and child health and nutrition. Bimonthly meetings, facilitated by AWWs and ASHAs, are used to discuss, prioritise and implement solutions to local health and nutrition problems.
Midday Meal Programme (1995-)	SHGs, state government, Department of School Education and Literacy	Primary school children	School meal provision to government and government-aided primary school children aged 6-10 for 210 days per year. Aims to improve nutritional status, school enrolment and attendance. SHGs prepare and deliver food, and procure rice.
MAMATA (2011)	State government, AWWs	Pregnant women >19 years, first two pregnancies	A conditional cash transfer scheme (four instalments starting in pregnancy to 9 months post-partum) that aims to reduce maternal and neonatal mortality and improve health and nutrition. Pregnant women receive money for registering at the AWC, attending for ANC, and attending village health and nutrition days for immunisations.

Government community and mid-level health workers

There are three main cadres of community and mid-level health workers: Anganwadi Workers (AWWs), Auxiliary Nurse Midwives (ANMs), and Accredited Social Health Activists (ASHAs). Table 1.4 details their employee status, key roles and responsibilities, and their coverage in Jharkhand and Orissa. This highlights the considerable overlap between the roles of different health workers and their ever-expanding responsibilities. This has led to tension between different health worker cadres (Grover 2010). The proposed ICDS reforms include three workers (one ASHA and two AWWs) but the plans do not clearly allocate their roles in health and nutrition activities, so there is potential for more role overlap (Indian Planning Commission 2011).

There are also informal and voluntary community-health workers and Traditional Birth Attendants (TBAs) known as Dais. Although TBAs are recognised by the WHO and the Government of India, they are not sanctioned by the government and are paid by families to attend home births, mostly in rural areas. TBAs are usually self-taught or informally trained by family members or other Dais (Dadhich 2009). Some have undertaken a six-day government training in safe delivery and newborn care, but this has ceased since the promotion of institutional delivery and the JSY voucher scheme (Sagdopal 2009;Saravanan et al. 2011).

Anganwadi workers

AWWs are central to the delivery of the ICDS. They have complained of being under-resourced (e.g. having non-functional weighing scales for growth monitoring) and many have experienced long delays in payment (Rajalakshmi 2010). Inadequate training has led to a poor understanding of the growth chart, resulting in data being sent elsewhere for interpretation, delaying feedback to caregivers and action for undernourished children (Rajalakshmi 2010). The excessive workload of AWWs has led to prioritisation of tasks that may be less important for the community but satisfy the demands of supervisors. In a qualitative study, AWWs perceived their most important task to be report writing, whilst growth monitoring was a much lower priority (Dongre et al. 2010). More streamlined data collection could improve data quality and allow AWWs more time with community members. Strengthening data management systems, such as computerising records, would allow easier analysis of programme performance and to plot nutrition trends for more responsive action (Gragnolati et al. 2006b).

ANMs and male Multipurpose Health Workers (MPHW-M)

ANMs and male Multipurpose Health Workers (MPHW-M) jointly manage the health sub-centre. They are supposed to have 'gender neutral' roles, but this is often not the case in practice. This has resulted in vertical programme delivery by MPHW-Ms (such as disease control), which can exclude other programmes perceived as less worthwhile, and leaves a disproportionate workload for the ANM (Nair et al. 2001). ANMs cover a large catchment area, and one survey suggests that only one-third of households receive their mandated home-visit every three-months (Grover 2010). This has led to bias towards the ANM's own village over remote villages and hamlets. ANMs began as midwives and providers of 'basic curative services', but now they also deliver target-oriented family-planning and disease prevention services. Some suggest the midwifery aspect of the ANM role has suffered as a result, compromising maternal health (Grover 2010). On the positive side, the NRHM is seeking to provide an extra ANM at each sub-centre, and some states have sanctioned the building of a large number of additional AWCs to fill gaps in ICDS services (Indian Planning Commission 2011).

ASHAs

ASHAs (called 'Sahiyyas' in Jharkhand) are a relatively new cadre of health worker, mandated to carry out NRHM activities on an incentivised basis. This may have relieved some of the burden on other health workers, although there are issues with role overlap, lack of training, and a bias towards particular NRHM activities that need resolving as previously discussed (Grover 2010;Paul et al. 2011).

Community-based services, such as those provided at Anganwadi and sub-centres and during home visits, are crucial entry points for health and nutrition interventions in settings where the most vulnerable groups may be isolated from formal healthcare providers (Paul et al. 2011). A recent Lancet review also highlights the huge potential of health workers to improve health, provide case management, prevention, health promotion and to mobilise communities because of their close links with hard to reach populations (Haines et al. 2007).

Table 1.4 Government community and mid-level health workers

Cadre & Programme	Employee status	Notional roles and Responsibilities	Coverage and Recruitment
Anganwadi Worker (AWW), Anganwadi Helper (AWH): Integrated Child Development Services (ICDS)	Works through ICDS; not officially a government employee (no pension or maternity entitlements). AWW paid IRP 1438-1653/ month depending on experience, AWH IRP 750 rupees/month. Limited extra incentives available.	Links community members with higher levels of the health system. Key in delivery of ICDS and associated sub programmes. AWW 'helper' assists with food preparation and distribution. Services and activities often delivered at the community-based Anganwadi Centre (AWC).	One AWW and one AWH serve 400-800 people, 300-800 in Tribal areas. New 'mini AWWs' cover small remote tribal blocks (150-300 population) Jharkhand coverage: 35881 AWCs + 2551 mini-AWCs (Govt Jharkhand 2010; no functionality data available). Orissa coverage: 41697 AWCs + 4819 mini-AWCs, 19221 new AWCs sanctioned in 2008/9 (Govt Orissa, 2010).
Accredited Social Health Activists (ASHA) or 'Sahiya': National Rural Health Mission (NRHM)	Attached to the Ministry of Health and Family Welfare (MoHFW), working under the remit of the NRHM. ASHAs are incentivised for discrete activities. Mission-based employee.	Takes pregnant women for institutional delivery (JSY voucher scheme), provides health counselling, community mobilisation, community leadership, health awareness-raising, and interpersonal communication with community members (e.g. at village health nutrition days).	One ASHA per 1000 population, increasing slightly in disadvantaged areas. In Jharkhand Recruitment 100% (n=40788), 81% fully trained. In Orissa, >99% recruited (n=34252), >94% fully trained (NRHM 2009).

Multi-purpose health workers: Auxiliary Nurse Midwives (ANM) Or Female Multi-purpose Health workers, Male Multi-purpose Health Workers (MPHW-M), and 'Helpers'	Permanent employees of the Ministry of Health and Family Welfare (with benefits e.g. pension), jointly managing one health sub-centre. Supervised by Lady Health Visitors and Male Health Assistants. ANMs wage is 6000 IRP/month, MPHW-M salary is set by state.	Jointly provide 'door step health and family welfare services'. This includes information, education and communication, collection of health data, registration of pregnant women, antenatal injections/iron folic acid tablets, postnatal care, and one home-visit every 3 months per household in the catchment area. Also provides midwifery, target-oriented family-planning, and disease control services (e.g. National Malaria Eradication and sanitation programmes).	One ANM, MPHW-M and helper per ~1000 households, 1 sub-centre per 3000 population in hilly areas, 1/5000 in non-hilly areas. Jharkhand: 61% of population have a sub-centre within 3 kms. 91% staffed by an ANM, 43% by two ANMs, 19% have a MPHW-M. 44% of ANMs are resident at the sub-centre. Orissa: 81% of population have sub-centre within 3kms. 78% are staffed by an ANM, 52% with two ANMs, 60% by a MPHW-M. 81% of ANMs are resident at sub-centres (Ministry of Health and Family Welfare 2010).

1.9 The importance of community-based behaviour change interventions in rural India

Many of India's national and state programmes include interventions to modify mothers' and families' behaviours, such as complementary feeding counselling, hand washing guidance, and the prevention and treatment of infections. Behaviour change activities such as these will be central to the effectiveness of the 13 priority interventions specified in the Scaling-Up Nutrition framework (Scaling Up Nutrition 2010). These interventions also have the potential to be sustainable in the long-term, can be delivered at low cost, and do not depend on complex supply chains unlike the Targeted Public Distribution System or Supplementary Nutrition Programme.

There is strong evidence that strengthening behaviour change activities within community-based services in India can have positive impacts on neonatal mortality. For example, Bang et al focused on improving neonatal care and the management of sepsis through home visits by trained health workers in rural Maharashtra. The study achieved very high coverage and reductions in neonatal and infant mortality rates were approaching 50% (Bang et al. 1999). Kumar et al tested the effect of group meetings and antenatal and postnatal home visits by community health workers to rural households in Uttar Pradesh. This behaviour change intervention aimed to improve essential newborn care practices, breastfeeding and recognition of danger signs for child health, resulting in a greater than 50% reduction in neonatal mortality (Kumar et al. 2008). A further study in rural Jharkhand and Orissa demonstrated a 45% reduction in neonatal mortality after three years of a community mobilisation intervention using women's groups (Tripathy et al. 2010). The groups prioritised local maternal and newborn health problems and devised strategies to address them through a participatory learning and action cycle. Behaviour change, particularly around essential newborn care practices, was considered central to the impressive result of the trial (Rath et al. 2010;Tripathy et al. 2010).

It would be valuable to understand the impact of applying community-based behaviour change approaches on undernutrition reduction. This would include interventions from the household level, up to and including primary health care facilities. In the next chapter I will review the evidence for community-based behaviour change interventions to improve child growth in low and middle-income countries to identify which types of intervention appear to be the most effective, and to more clearly delineate the evidence gap that this thesis aims to fill.

Chapter 2

Literature review

2.1 Introduction

In the previous chapter I highlighted the potentially important role for behaviour change interventions to reduce undernutrition and promote child growth. Behaviour change has been identified as one of a set of priorities for nutrition strategies in low and middle-income countries (Scaling Up Nutrition 2010). Considering the higher burden of undernutrition in rural areas, coupled with more limited access to formal health services, it is pragmatic to focus on community-based behaviour change approaches. This review aimed to gauge the strength of the evidence and effectiveness of different community-based behaviour change interventions for child growth in low and middle-income countries.

2.2 Efficacy or effectiveness?

In the epidemiological literature 'efficacy' commonly refers to interventions carried out under 'ideal' conditions, analogous to a laboratory setting: 'the extent to which a specific intervention, procedure, regimen, or service produces a beneficial effect under ideal conditions' (UNSCN 2004; Last 1988). Effectiveness on the other hand refers to interventions carried out under realistic conditions, where compliance to a treatment option may be influenced by behavioural factors, as well as coverage and quality of programme implementation: 'the extent to which a specific intervention, procedure, regimen, or service, when deployed in the field, does what it is intended to do for a defined population' (ibid). This review is focused on interventions seeking to change behaviour in community settings and would not be able to achieve the rigour of an efficacy study, even for studies with a cluster randomized controlled trial design. As such, the interventions included in this review will be measuring effectiveness rather than efficacy.

2.3 Defining 'community-based' interventions

The terms 'community-based' and 'community-level' are worth clarifying here as some researchers see them as distinct. The former can refer to interventions aimed at changing behaviours of individuals; the latter approach often involves targeting geographically defined communities, which it seeks to transform through resource mobilisation and mass behaviour change (O'Dwyer et al. 2007). The reality of many community health programmes is that they involve both community-based and community-level elements (ibid). This review aims to cover both types – where the location of intervention delivery will include entire geographically defined areas or particular groups within those areas, and the range of associated behaviour change approaches (with some exclusions detailed below). For simplicity I will refer to these as community-based interventions.

I have also drawn upon an article from the Lancet neonatal survival series to define the intervention delivery mode that is the focus of this review (Darmstadt et al. 2005). This article emphasised the value of incorporating community-based intervention packages into the health systems of low and middle-income countries to reduce neonatal deaths and distinguished between three intervention delivery modes: facility-based clinical care, outreach and 'family-community'. Facility-based care denotes clinical services staffed by skilled personnel for diagnosing and treating acute health problems, delivered within high quality facilities. 'Outreach' refers to general, population-wide programmes delivered periodically either through 'static' health facilities or community/home visits by minimally trained health workers. 'Family-community' refers to family-oriented or community-oriented interventions that aim to improve health behaviours, such as care-seeking and child care practices, and to increase demand on health services (Darmstadt et al. 2005). Examples of interventions delivered in the context of the family-community include behaviour change communication, community mobilisation and empowerment, and other forms of household and community engagement. There is also potential for community-based case-management of illness. All of these interventions can be delivered by community-health workers (Darmstadt et al. 2005).

Whilst the authors acknowledged that a blend of all three delivery modes would be ideal, facility-based care remains less accessible for many people living in resource-poor settings. Their analysis of the evidence singled out 'family-community' as the most effective approach for reducing neonatal mortality in high burden areas, because it is more cost-effective and likely to achieve greater coverage than the other approaches (Darmstadt et al. 2005). The same argument could apply to interventions to reduce undernutrition in high burden settings. For this reason I have chosen to focus my review on family-community interventions to improve child growth in low and middle income countries, referred to forthwith as community-based behaviour change interventions.

2.4 Existing reviews of community-based behaviour change interventions to improve child growth

There are several reviews on similar topics but to the best of my knowledge, none have considered a wide range of community-based behaviour change approaches to improve the growth of children under-five in low and middle-income countries. Some reviews are narrow in terms of the interventions they consider, for example only considering responsive feeding (Bentley et al. 2011), complementary feeding (Dewey and Adu-Afarwuah 2008), growth monitoring (Panpanich and Garner 2000), or conditional cash transfer programmes (Lagarde et al. 2007). Other reviews are more descriptive, and do not attempt to analyse the effectiveness of different behaviour change approaches (Pridmore and Carr-Hill 2011), do not include interventions from low and middle-income countries (Miller et al. 2011), or solely report on cost-effectiveness (Edejer et al. 2005).

Several reviews of community-based behaviour change interventions have not included growth outcomes, instead focusing on early child development (Maulik and Darmstadt 2009;Mejia et al. 2012), perinatal deaths (Lassi et al. 2010;Schiffman et al. 2010;Thaver et al. 2009) or the prevention of nutritional rickets (Lerch and Meissner 2007). One review included intrauterine growth restriction and low birth weight as outcomes, but not growth of children up to the age of five (Bhutta et al. 2005). A further review considered community-based intervention packages for maternal and child health, but child growth was a secondary outcome limited to children under six months of age (Haider and Bhutta 2009). Finally, one review of the effectiveness of lay health workers to deliver maternal and child health interventions allowed any maternal or child health outcome (implicitly including child growth), but restricted study designs to randomised controlled trials (Lewin et al. 2010); I have allowed a broader range of study designs in this review to build a more comprehensive picture of the evidence.

2.5 Literature review parameters

Population: Children under-five in low and middle-income countries (or studies where the majority of children were under-five during the intervention). Although children under-two are a key age group for nutritional intervention 'under-five' is a widely recognised group and is likely to have been the focus of several interventions. I have limited studies to low and middle-income countries because this is where the major burden of undernutrition is and interventions may not be comparable between lower and higher income countries.

Intervention: Community-based behaviour change interventions. 'Community-based' includes the household-level up to primary healthcare. I excluded interventions with facility-based components according to the Lancet definition described above (Darmstadt et al. 2005). 'Behaviour change interventions' were defined as interventions aiming to change specific behaviour(s) in individuals, families or communities to promote child growth or reduce undernutrition. Interventions must have involved at least one element of behaviour change. Possible approaches were health education, participatory interventions, direct psychosocial inputs such as developmental stimulation and indirect approaches such as cognitive behavioural therapy for maternal depression. Other interventions involving at least one element of behaviour change and satisfying the above criteria were also considered. Health education, behaviour change communication, community mobilisation, positive deviance, cognitive-behavioural therapy, responsive feeding and conditional cash transfer programmes are defined in Box 2.1.

Control: Acceptable comparison groups included: no intervention/standard care, alternative interventions (e.g. food supplements) or other behaviour change interventions.

Outcomes: Linear or ponderal growth outcomes measured at baseline and end-line. Specific growth outcomes included: weight or weight-for-age Z-score (WAZ), length/height or length/height-for-age Z-score (LAZ/HAZ), weight-for-height/length Z-score (WLZ/WHZ) and mid-to-upper arm circumference. Studies that only included birth weight or intrauterine growth restriction outcomes were excluded. Whilst these are critical nutrition outcomes, the focus of this thesis is on child growth beyond the immediate postnatal period.

Additional inclusion and exclusion criteria: In line with the Cochrane Effective Practice and

Organisation of Care Review group acceptable study designs were: randomised controlled trials, non-randomised controlled trials, controlled before-and-after studies (i.e. baseline and end-line measurements for intervention and control groups), interrupted time series and repeated measurement studies (Effective Practice and Organisation of Care (Cochrane) review group 2011).

I restricted articles to those published in English since 1990. The following studies were considered beyond the scope of this review: cost-effectiveness studies, evaluations of emergency nutrition programmes involving special features and settings (e.g. refugee camps, Community Management of Acute Malnutrition), obesity prevention, interventions reliant upon phone technologies, interventions solely focused on food provision or micronutrient supplementation, agricultural and food security interventions, and media/social marketing interventions. There were no exclusions as to the cadre or training level of health workers that may have delivered interventions. Multiple articles reporting on the same participants and intervention were treated as one study.

Box 2.1 Definitions of selected community-based behaviour change approaches

a. **Health education:** 'Communication of information, fostering the motivation, skills and confidence necessary to take action to improve health…and the communication of information concerning the underlying social, economic and environmental conditions impacting on health, as well as individual risk factors and behaviours, and use of the health care system' (World Health Organisation 1998)

b. **Behaviour change and communication** (previously 'information, education and communication'): Aims to 'achieve or consolidate behaviour or attitude changes in designated audiences, using a combination of communication technologies, approaches and processes in a flexible and participatory…systematic and well researched manner'. Further requirements are 'supportive social environments' and the role of 'expert' re-defined as 'communicator' for sustainable behaviour change or social norm change (UNICEF 2006)

c. **Community mobilisation:** 'A capacity building process through which community members, groups or organisations plan, carry out and evaluate activities on a participatory and sustained basis to improve their health and other conditions, either on their own initiative or stimulated by others' (Howard-Grabman 2007)

d. **Positive Deviance and undernutrition:** Caregivers whose children thrive despite socio-economic adversity and high community-levels of undernutrition are assumed to have uncommon 'positive deviant' caring and feeding behaviours. The positive deviance approach recruits these caregivers to teach other community members how to use local, affordable, nutritious and uncommon foods. Positive deviance also has a social mobilising function: people are motivated to learn about solutions from within the community, rather than feeling criticised about local practices by external actors (Marsh et al. 2004)

e. **Cognitive-behavioural therapy:** Counselling sessions using active listening and guided discovery techniques aim to change negative cognitions and maladaptive behaviours, and encourage participants to explore and test alternative thoughts and behaviours as homework (Rahman et al. 2008)

f. **Responsive feeding:** Based within a Responsive Parenting framework, it 'reflects reciprocity between child and caregiver'. It comprises four stages: 1) caregiver provides an interaction promoting environment 2) child 'responds and signals' to the caregiver 3) caregiver responds rapidly, in a developmentally appropriate and emotionally supportive way 4) 'child experiences predictable responses' (Black and Aboud 2011)

g. **Conditional cash transfers:** cash transfers by governments to individuals or households to reduce income poverty, often within wider social protection programmes. Conditional transfers are contingent on particular behaviours (e.g. attendance for nutritional counseling), whilst others may not have conditions attached (Save the Children 2009)

2.6 Literature search methods

An initial search of Pubmed was made in 2010 using the search terms shown in Box 2.2. I updated and expanded the review in December 2012 to include Web of Science, Psychinfo, Cochrane Review, WHO, UNICEF, and conducted purposive searches of the Journal of Nutrition, The Lancet and Maternal and Child Nutrition.

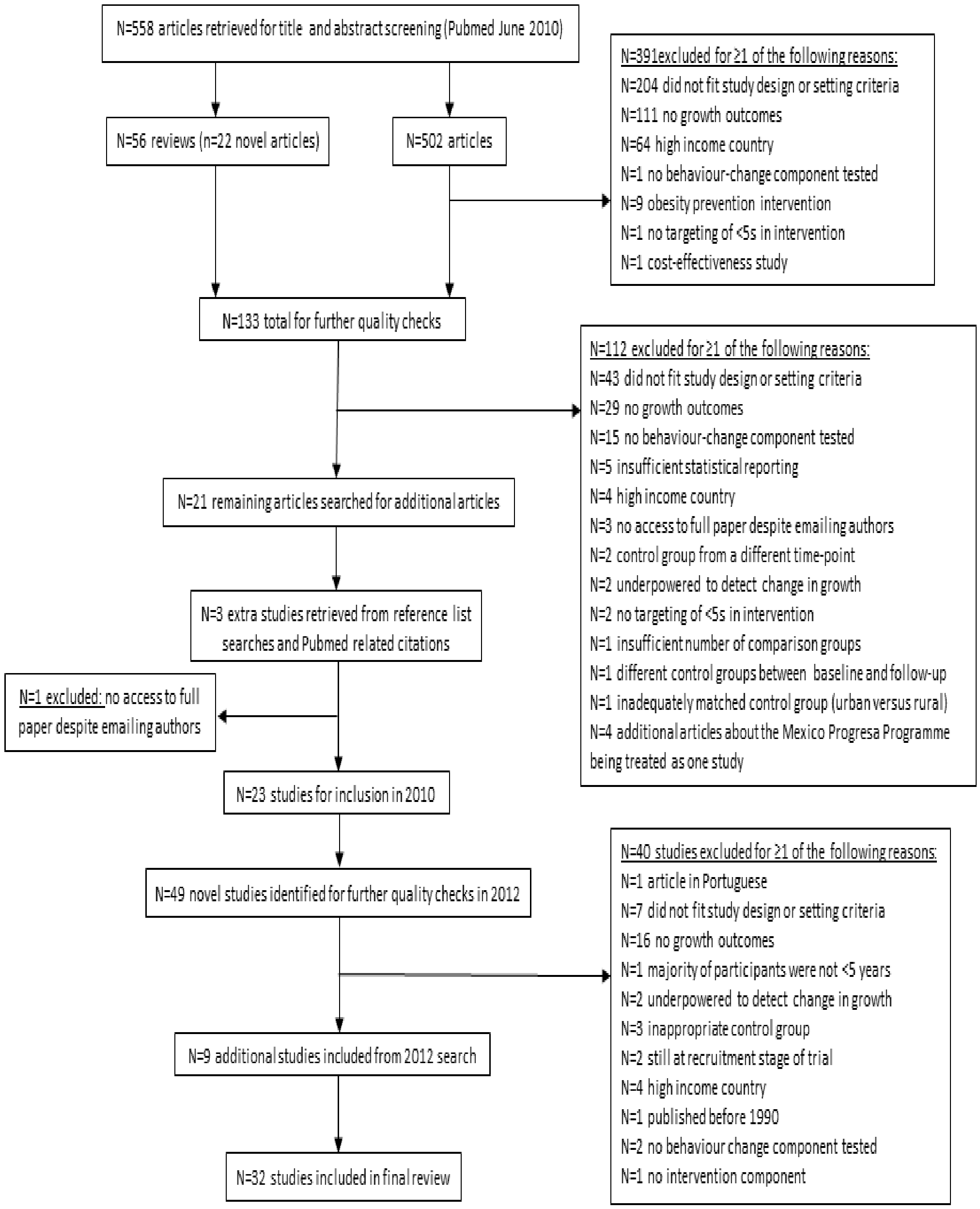
Box 2.2 Search terms:

I combined the following search terms with AND:

1. Community OR 'home visit' OR household OR 'primary care'
2. Intervention OR program* OR promotion OR participation OR mobilisation OR evaluation OR behaviour change OR education OR counselling
3. Growth OR development OR nutrition OR height OR length OR weight OR MUAC OR mid upper arm circumference OR malnutrition OR undernutrition OR stunting OR wasting OR underweight
4. Child OR infant OR newborn OR preschool* OR 'under-five'
5. Low and middle income country OR developing country

Titles and abstracts were screened for relevance, and reviews and reference lists of included papers were searched for novel studies. Inclusion and exclusion criteria were applied to potentially relevant articles, and quality checks identified extra exclusion criteria. These included: inadequate or absent data reporting (e.g. just a statement of 'no change'), being clearly underpowered to detect changes in growth outcomes (e.g. no evidence of sample size calculation and a very small n), inadequate control group (e.g. a minimum of two intervention and two control groups, and no adjustment or acknowledgment of large baseline differences in analyses (Effective Practice and Organisation of Care Cochrane review group 2011). Details of the literature search are presented in Figure 2.1.

Figure 2.1 Flowchart of literature review process



2.7 Characteristics of included studies

32 studies were included in the final review: 23 from the initial search in 2010, and nine when I

updated the review in 2012. 78% (n=25) were cluster randomised controlled trials, or randomised controlled trials. Six studies used a controlled before-and-after design, and one was a non-randomised controlled trial.

The interventions were implemented in 16 low and middle-income countries. 59% (n=19) were from South Asia: nine from Bangladesh, six from India, two from Pakistan and two from Nepal. Three studies were from two African countries, seven were from Mexico, Central and South America and the Caribbean, and three further studies were carried out in Vietnam, China and Iran.

About half of the studies focused on general health and nutrition behaviours. Several studies explicitly mentioned hand washing and hygiene (n=7), child development and stimulation (n=9), growth monitoring (n=4), responsive feeding (n=6), complementary feeding (n=9), breastfeeding (n=5) and maternal mental health (n=3). Three interventions provided supplementary food to all groups and five to some experimental groups. Two further studies provided micronutrient supplements or Vitamin A to selected groups. The remaining 22 studies did not involve supplementary feeding or micronutrients.

The interventions and their effect on child growth are described in Tables 2.1-2.3, grouped by behaviour change approach. I identified five broad types of behaviour change: health education (Table 2.1), behaviour change and communication (Table 2.2), studies using a mixture of behaviour change methods, multi-component interventions with more than two distinct components including behaviour change and non-behaviour change approaches, and cognitive behavioural therapy (Table 2.3).

Health education and behaviour change communication were the dominant approaches, used in 13 and 11 studies respectively. Four studies used a mixture of behaviour change methods including health education with positive deviance and community mobilisation. Three multi-component interventions used health education in combination with activities such as deworming, immunisations, food provision, community mobilisation, growth monitoring and psychosocial stimulation; two also used conditional cash transfers to incentivise behaviour change. One final study used cognitive-behavioural therapy for maternal depression.

Table 2.1 Description of health education interventions

Study no	First author and date	Country	Study design	Child age	Growth Outcomes
1	Aboud et al (2008)	Bangladesh	Randomised Controlled Trial	12-24 months	Attained and gained weight
Intervention	**Responsive feeding:** n=32 village-clusters with existing parenting groups were randomly selected and randomised to: intervention (6 sessions about maternal responsive feeding and child self-feeding, n=102 mother-child pairs) or control (6 regular nutrition education and complementary feeding sessions, n=100 mother-child pairs). Sessions held by local trained peer educators. Data collected at baseline, 2 weeks and 5 months post-intervention. Researchers were blinded to condition. 10% of each group lost to follow-up.				
Results and study grade	Intervention group was significantly heavier (d=0.28, p=0.0021) and had greater weight gain (d=0.48, p=0.002) than controls. Study grade: high				
2	Aboud et al (2009)	Bangladesh	Randomised Controlled Trial	8-20 months	Weight gain, WAZ[1]
Intervention	**Responsive feeding:** n=37 village-clusters with existing women's groups were randomised to: intervention (n=19 clusters, n=108 children) or control (n=18 clusters, n=95 children). Both groups received five sessions of nutrition education. The intervention group received six extra sessions on child self-feeding and maternal verbal responsiveness during feeding and a booster session six weeks before endline. Data collected at baseline, two weeks and five months post-intervention. Researchers were blinded to condition.				
Results and study grade	No impact on weight gain or WAZ at post-test (both groups WAZ=-1.93) or five months (intervention=-1.87, control=-1.86). Potential for control group contamination. Study grade: moderate				
3	Ahmed et al (1993)	Bangladesh	Controlled before and after study	<19 months	WAZ[1], HAZ[2]
Intervention	**Hygiene education:** n=185 households with children <19 months from five rural villages with a high prevalence of poor hygiene, diarrhoea and malnutrition were assigned to the intervention. Five matching villages (socio-demographics, hygiene and childcare factors) were controls (n=185 households). The 7-month 'clean life campaign' involved ground sanitation, personal and food hygiene, delivered by health workers and volunteer mothers twice weekly to 3-5 mothers.				
Results and study grade	14% reduction in severe underweight in the intervention group, significantly greater than controls, adjusted for socio-demographics (p<0.05). The intervention group also had significantly lower HAZ scores than controls at end-line. Limitations: lack of sample size calculation, no adjustment for clustering, results not fully reported, questionable suitability of HAZ as an outcome and potential data collection bias. Study grade: very low				

4	Bhandari et al (2001)	India	Randomised Controlled Trial	6-12 months	Weight and length gain, WAZ[1], HAZ[2] WHZ[4]
Intervention	**Responsive and supplementary feeding:** n=418 infants from a south Delhi slum were recruited using household survey data. Children were stratified by weight-for-height (≤80% or >80% NCHS median) and randomised to: (1) monthly food supplementation and nutritional counselling (2) monthly nutritional counselling (3) monthly home visit (4) control (no intervention). Groups 1-3 were visited twice a week for a morbidity assessment. Intervention lasted 8 months.				
Results and study grade	Small impact of education and food versus control (+250g); no impact of education only versus control. No impact on length/LAZ or WHZ of either intervention. Study grade: high				
5	Bhandari et al (2004)	India	Randomised Controlled Trial	<18 months	WAZ[1], HAZ[2], weight and length gain
Intervention	**Nutrition and health education:** n=8 rural communities were pair-matched on household characteristics and randomised to health and nutrition education (n=552 households) or no intervention (n=473 households). The intervention involved trained health workers delivering locally developed nutrition and hygiene counselling through monthly home visits from birth to 12 months, growth monitoring every three months and immunisations. Measurements taken at baseline and every 3 months until 18 months of age.				
Results and study grade	The intervention group had a small but significantly greater length gain than controls (0.32cm, p=0.036) after adjusting for maternal employment, weight, length and breastfeeding status at 6 months. The effect was greater for males (0.51cm). There was no effect on LAZ, WAZ or weight gain. Study grade: high				
6	Bowen et al (2012)	Pakistan	Cluster randomised controlled trial	<30 months	WAZ[1], HAZ[2], BMI Z-score[3]
Intervention	**Hand washing and water treatment:** n=47 urban neighbourhoods with ≥1 hour of running water per week and a child <5 years randomised to one of five groups: two water treatment groups (flocculent disinfectant or sodium hypochlorite), a soap and hand washing promotion and disinfectant group, soap and hand washing only, or no intervention. Soap and hand washing groups received 'instruction and encouragement' and materials by field workers during twice weekly home visits. This study followed-up the two soap and hand washing groups and the control groups (n=461 households). Children aged 5-7 years, <30 months during intervention.				
Results and study grade	No group differences for HAZ, WAZ or BMI Z-score. Limitations: possible bias as data collectors may have been aware of group allocations, study powered to detect change in developmental scores but not anthropometry, limited water access may have undermined intervention. Study grade: very low				
7	Elizabeth & Sathy (1997)	India	Controlled before and after study	6-24 months	Weight and height gain
Intervention	**Psychosocial/developmental stimulation and food supplementation:** n=332 underweight children from 10 deprived areas were randomised to (1) nutrition education (breastfeeding, weaning, diet during illness), strengthened primary healthcare (e.g. deworming, medication) and food supplementation; n=118 (2) intervention 1 plus individualised child stimulation, play therapy and motor coordination tasks, daily living training and psychosocial inputs; n=127 or (3) no intervention; n=87. Interventions took two years: weekly for 3 months, fortnightly for 3				

	months, and monthly for 18 months.				
Results and study grade	Significant increase ‘normal’ weight in all groups, but more so in the intervention groups; significant increases in ‘normal’ height were limited to the intervention groups. Limitations: no sample size calculation, insufficient data reporting and potential bias of data collectors. Study grade: very low				
8	George et al (1993)	India	Randomised Controlled Trial	<60 months	Weight gain, WAZ[1]
Intervention	**Growth monitoring:** n=12 non-adjoining poor rural villages were pair-matched (caste, road access, distance to health clinics, crops) and randomised to growth monitoring or non-growth monitoring interventions (n=550 children per group). Both groups received fortnightly home visits by trained local women for health education, received immunisations, weekly clinics for curative care, deworming, and materials for home gardens. The growth monitoring group also had their growth measured monthly and mothers received guidance about use of the growth chart. Measurements taken every 4-5 months until 60 months.				
Results and study grade	After 30 months of intervention there were no group differences (both groups improved by ≥0.2 WAZ). Limitations: results not fully reported. Study grade: moderate				
9	Hamad et al (2011)	Peru	Randomised controlled trial	<5 years	WAZ[1], HAZ[2], BMI for age[3]
Intervention	**Health education:** Microcredit groups (each 15-20 members) were randomised to: (1) health education based on Integrated Management of Childhood Illness modules or (2) no intervention (n=1855). Loan officers who led microcredit groups were trained to deliver education sessions over 8 monthly meetings.				
Results and study grade	No group differences for child anthropometry. Limitations: reluctance of loan workers to deliver health education, high variability in loan worker skills, no sample size calculation, inconsistent statistical reporting (e.g. the number of children per group at end-line), unclear if data collectors were blinded to condition, potential doubt over generalisability to malnourished population. Study grade: very low				
10	Salehi et al (2004)	Iran	Controlled before and after study	<59 months	WAZ[1], HAZ[2], WHZ[4], arm circumference
Intervention	**Nutrition education:** n=960 Qashqa’i tribe families randomly selected from 48 sub-tribes of Iran. N=406 children were randomised to intervention, n=405 to control. The intervention was a one-year community-based education programme, tailored to families from researcher observation of food preparation and cooking methods. Measures at baseline and 3-months post intervention.				
Results and study grade	Increases in WAZ, HAZ, WHZ and arm circumference were significantly greater in the intervention group than controls (by 0.45, 0.41, 0.27 SDs and 0.5cm respectively), although both groups showed significant improvements. Limitations: no sample size calculation, no adjustment for higher percentage of malnutrition in intervention group at baseline, or obvious confounders (e.g. tribal group), or multiple comparisons. No baseline arm circumference given, WHZ was normal in both groups at baseline. Study grade: low for WAZ and HAZ, very low for WHZ and arm circumference				
11	Santos et al (2001)	Brazil	Randomised controlled trial	<18 months	Weight and length gain, WAZ[1], LAZ[2], WHZ[4]

Intervention	**Nutrition education:** n=28 municipal health centres were paired on socio-economic factors and child malnutrition then randomised to intervention or control. The intervention gave additional training to doctors on Integrated Management of Childhood Illness modules; doctors at control group centres received no extra training. The first 12-13 children <18 months attending for consultations with 33 doctors were recruited (n=218 intervention; n=206 controls). Child growth was measured at home visits 180 days post-consultation, data collectors were blinded to condition. Children who were hospitalised were excluded.				
Results and study grade	No overall effect on growth. Sub-group of intervention children aged 12-17 months had significantly higher WAZ and WHZ scores than controls; no effect on LAZ in this sub-group. Limitations: possible lack of generalisability because mothers were already motivated to seek care; no information given about reasons for children attending clinics; children not malnourished at baseline; questionable validity of LAZ outcome for short intervention. Study grade: very low				
12	Vazir et al (2013)	India	Cluster randomised controlled trial	3 months	WAZ[1], HAZ[2], WHZ[4]
Intervention	**Complementary and responsive feeding, psychosocial stimulation:** 60 villages in rural Andhra Pradesh non-randomly selected and grouped into threes matched on population size, maternal literacy and birth weight. Village trios were randomised to: (1) standard care (2) standard care and complementary feeding education or (3) intervention 2 and guidance about responsive feeding and child development (n=200 mother-child pairs per arm). Interventions included 30 home visits by trained village women over 12 months. Data collectors blinded to treatment condition.				
Results and study grade	Simpler education group (group 2) had a 79% reduced stunting risk at 15 months than controls; there was no impact of health education + stimulation. No impact of either intervention on WAZ or WHZ. Limitations: results may not be generalisable to small villages, the higher percentage of people from tribal groups in group 3 may have influenced results, food insecurity limited adherence to feeding advice, Z-scores not fully reported, inconsistency (same health education component had differential effects on linear growth between groups 2 and 3); overall weight gain higher in control group than intervention groups, but not mentioned in text (p<0.052). Study grade: low for WAZ, moderate for WHZ, high for LAZ.				
13	Walker et al (1991)	Jamaica	Randomised Controlled Trial	9-24 months	WAZ[1], HAZ[2], arm circumference
Intervention	**Psychosocial stimulation and supplementary feeding:** n=129 stunted children in a poor area of Kingston were identified via household surveys, age-stratified (>16 months or ≤16 months) and randomised to: (1) no intervention (n=33) (2) supplementary food (n=32) (3) stimulation via weekly home-visits by health workers to help mothers structure play sessions with toys and cognitive stimulation (n=30) (4) interventions 2 and 3 (n=34). A further group of non-stunted children were matched to every 4th intervention child (age, sex and location). Measures were taken at baseline, 6 months and 12 months post-intervention.				
Results and study grade	Stimulation had no impact on growth. Supplemented groups had significantly greater weight and length gains (adjusted for age) than other stunted groups at 6 months (p<0.01). Mean HAZ increased in all groups (0.7cm in stunted non-supplemented, 1.1cm in stunted				

supplemented groups). Non-stunted children significantly taller than all other groups at 12 months. Limitations: no sample size calculation and potential contamination of control group. Study grade: low

[1]WAZ – Weight-for-age Z-score

[2]HAZ/LAZ – Height-for-age or length-for-age Z-score

[3]BMI – Body Mass Index

[4]WHZ/WLZ – Weight-for-height or weight-for-length Z-score

Table 2.2 Description of behaviour change and communication interventions

Study no	First author and date	Country	Study design	Child age	Growth Outcomes
1	Aboud & Akhter (2011)	Bangladesh	Cluster Randomised Controlled Trial	8-20 months	Weight and length gain
Intervention	**Responsive feeding and stimulation, with or without micronutrient supplementation:** n=302 mother-child pairs randomised to: (1) control group: 12 health and nutrition education sessions by a health worker over three months (n=110) (2) The same 12 sessions plus 6 sessions with a peer-educator (trained local woman), including modelling and coached practice in self-feeding, and verbal responsiveness during play (n=92) or (3) intervention (2) plus daily micronutrient sprinkles (n=100). Measurements at baseline, post-test and 3-month follow-up. Data collectors blinded to condition.				
Results and study grade	No impact of education only on WAZ compared to controls. There was a small impact of education + micronutrients on WAZ (d=0.15) and weight gain (d=0.38) compared to the education only group. There was no impact of either intervention on length gain. Limitations: loss to follow-up was higher for those with lower baseline home environment scores; results not fully reported. Study grade: moderate				
2	Arifeen et al (2009)	Bangladesh	Randomised Controlled Trial	7 days-59 months	HAZ[1], WHZ[2]
Intervention	**Integrated Management of Childhood Illness (IMCI), July 2001-June 2007:** n=20 first-level government health facilities randomised to: (1) IMCI health worker training, health system strengthening, family and community activities (e.g. theatre groups to communicate IMCI messages) and usual care or (2) usual care. N=4400 children were randomly selected (n=220 per cluster)				
Results and study grade	Stunting declined significantly faster in the intervention group than the control (percentage point difference 7.3%). There was no impact on wasting. Study grade: high				
3	Bhandari et al (2003)	India	Randomised Controlled Trial	3-6 months	HAZ[1], WHZ[2]
Intervention	**Exclusive breastfeeding promotion:** n=8 communities were pair-matched (prevalence of child stunting, wasting, recent morbidity, mortality and socioeconomic status) and randomised to: (1) control group or (2) education to promote exclusive breastfeeding for 6 months and complementary feeding thereafter. Messages conveyed to caregivers of children <2 years via government health workers and specially trained health workers at monthly meetings, plus additional meetings for message repetition. Measurements at 3 and 6 months for n=1115 infants born 9 months after health worker training (n=552 intervention, n=473 control).				
Results and study grade	There were no growth differences between groups at 3 or 6 months. Limitations: potential bias as mothers recalled breastfeeding status for 4, 5 and 6 months at 9 month visit. Study grade: moderate				
4	Brown et al (1992)	Bangladesh	Controlled before and after study	6-12 months	WAZ[3], arm circumference
Intervention	**Nutrition education:** n=3 villages were identified for intervention and n=62 weaning age children were selected using census data; n=55				

	children of the same age were selected from 5 other villages (1 hour walk away) as controls. The intervention was 5-months of complementary feeding messages delivered by volunteers via modelling techniques (e.g. home demonstrations of how to enrich foods), encouragement to continue breastfeeding, advice about feeding frequency and hygiene. Children were 9-18 months at end-line.				
Results and study grade	Mean WAZ significantly higher (0.46) and arm circumference significantly greater (0.3cm) in the intervention group than the control. Limitations: no sample size calculation, potential bias as intervention implementers also collected data. Study grade: moderate for WAZ, low for arm circumference				
5	Hamadani et al (2006)	Bangladesh	Randomised Controlled Trial	6-24 months	HAZ[1], WHZ[2],WAZ[3]
Intervention	**Psychosocial/developmental stimulation:** n=20 community nutrition centres randomised to: (1) standard care - the Bangladesh Integrated Nutrition Programme (n=102) or (2) standard care plus weekly group meetings and home visits for 1 year to improve mother-child interaction and provide developmentally appropriate activities, led by local 'play-leaders', using stories, songs and books (n=104) or (3) control group: n=107 normal weight children, matched to every 2nd child in groups 1 and 2 (age, sex and village) recruited from community nutrition centres. Interventions took 2 years.				
Results and study grade	No intervention effect for weight or height indicators in adjusted analyses; there was a significant increase in wasting in all groups. Limitations: no sample size calculation and potentially underpowered; results not fully reported. Study grade: low				
6	Langford et al (2011)	Nepal	Non-randomised controlled trial	3-12 months	HAZ[1], WHZ[2], WAZ[3]
Intervention	**Hand washing and hygiene:** n=8 Kathmandu slum settlements were divided into Northern and Eastern locations and randomised to intervention or control (no intervention). N=45 children were randomly selected from intervention areas and n=43 from control areas using household survey data. The intervention: 6-months of hand washing promotion to change attitudes and social norms and create demand for good hygiene. Methods included a community play, posters and discussions, and daily home visits by ‘community motivators’ for two weeks, decreasing to once a week. Community motivators also held fortnightly mother’s meetings to promote hand washing and provided soap. Child growth was measured weekly.				
Results and study grade	No impact on child growth: WAZ and WHZ worsened faster in the intervention group (not significantly). Limitations: pre-existing group differences not accounted for, limited access to water and cost may have undermined hand washing, possible bias in self-reported behaviour, intervention may have been too brief to reduce stunting, no adjustment for clustering, unclear why WHO growth standards not used. Study grade: very low				
7	Lutter et al (2008)	Ecuador	Controlled before and after study	9-14 months	Weight and linear growth, WLZ[2]
Intervention	**Information, education and communication with food supplementation:** n=10 primary health clinics were selected for intervention, and 6 for control. Both areas were eligible for intervention but a phased-roll out was planned. Intervention: Ecuador’s National Food Nutrition Programme, targeted at infants and young children in poor areas to improve feeding behaviours and dietary quality. Key components:				

	information, education and communication, health worker training in nutrition counselling, community participation and provision of micronutrient fortified food. Health workers made weekly home-visits to children. Children were measured at baseline and after 11 months (N=338 intervention; n=296 controls).				
Results and study grade	Significant intervention impact on weight gain compared to controls (0.38kg, p=0.029). No intervention impact on linear growth (near significant for children 12-14 months at enrolment (p=0.08). No impact on WLZ. Limitations: low study power due to 50% loss to follow-up, this was associated with lower baseline WLZ and results may represent healthier children; characteristics of initial refusals not described, potential bias in data collection by health workers implementing the programme; unclear if potential contamination of control group; children not wasted at baseline in either group. Study grade: low for weight gain, very low for linear growth and WLZ				
8	Roy et al (2005)	Bangladesh	Randomised Controlled Trial	6-24 months	WAZ[3], WAM[4], Weight gain,
Intervention	**Nutrition education with and without supplementary feeding:** n=282 underweight children randomised to: (1) intensive nutrition education e.g. cooking demonstrations, dietary advice, caring practices and disease control twice a week for 3 months by trained health workers (2) intervention (1) plus supplementary food (3) control group (standard care). Weight measured at baseline, 3, 6 and 9 months.				
Results and study grade	Percentage of moderate malnutrition reduced by 10% more in education group than controls, and 20% more in education + supplementary food group than controls at 6 months Limitations: results represent children already engaged with health services, results not fully reported, no baseline WAZ given; intervention implementers collected data. Study grade: moderate				
9	Roy et al (2007)	Bangladesh	Randomised Controlled Trial	6-9 months	HAZ[1], WAZ[3], WLZ[2], MUAC[5], weight and length change
Intervention	**Nutrition/health education:** n=121 randomly selected community nutrition centres were randomised to: (1) standard care: information, education and communication (health and nutrition), supplementary food and micronutrients, behaviour change for improved child care, pregnancy practices and maternal nutrition (n=306) or (2) standard care plus weekly nutrition education for 6 months (n=305). Measurements at baseline, 6 and 12 months				
Results and study grade	LAZ and WAZ were significantly higher in the intervention group than the control at 6 months (0.23 and 0.66 respectively). Effects remained at 12 months. No impact on WLZ or MUAC. Limitations: biased to children already engaged with healthcare. Study grade: high for LAZ and WAZ, moderate for WLZ and MUAC				
10	Ruel et al (2008)	Haiti	Randomised Controlled Trial	6-41 months	HAZ[1], WHZ[2], WAZ[3]
Intervention	**Nutrition education, cooking demonstrations and supplementary feeding:** n=20 paired clusters (geography, ecology, health-care access, presence of World Vision staff) were randomised to a recuperative or preventive three-year intervention for child undernutrition. Both groups involved mothers' clubs, rally posts for cooking demonstrations and discussions, and monthly food rations in exchange for attendance. Interventions varied in number, focus, timing and sequence of meetings. The preventive group included age-specific nutrition				

	education concerning children 6-23 months (n=748) and 18 months of food rations. The recuperative group included nutrition education about undernutrition in underweight children 6-60 months (n=752) and food assistance for 9 months.				
Results and study grade	The preventive group had significantly higher WAZ and WHZ scores than the recuperative group (both 0.24). HAZ was also higher in the preventive than the recuperative group, but not significantly (p=0.07). Study grade: high				
11	Shi et al (2010)	China	Randomised Controlled Trial	2-12 months	Weight and length gain
Intervention	**Health/nutrition education:** n=8 townships were paired (population size, geographic and economic factors) and randomised to: (1) health and nutrition education, group training (e.g. cooking demonstrations, hygiene and complementary feeding) and home visits every 3 months to identify feeding problems and provide nutritional counselling or (2) control group: standard care including breastfeeding support and complementary feeding advice. N=559 children (n=294 intervention, n=305 control) took part. Measures at baseline, 6, 9 and 12 months.				
Results and study grade	Intervention group gained 0.22kg more weight and 0.66cm more length than controls, adjusted for socio-demographics. Limitations: greater weight gain may represent catch up growth as controls were heavier at baseline (p=0.08) and there was no group weight difference at end-line; no explanation of control children being significantly taller at 9 months; unclear if children were undernourished at baseline (mean birth weight normal in both groups); data not clearly reported; potential bias as data collectors implemented the intervention. Study grade: low for length, very low for weight gain				

[1]HAZ – Height-for-age Z-score

[2]WHZ/WLZ– Weight-for-height or weight-for-length Z-score

[3]WAZ – Weight-for-age Z-score

[4]WAM – Weight-for-age percentage of the median

[5]MUAC – Mid-upper arm circumference

Table 2.3 Descriptions of other behaviour change interventions

Study no	First author and date	Country	Study design	Child age	Growth Outcomes
Mixed behaviour change methods					
1	Alderman et al (2009)	Senegal	Controlled before and after study	6-35 months	WAZ[1]
Intervention	**Nutrition education, growth promotion and community mobilisation:** n=220 village-clusters were randomly selected and randomised to: (1) intervention: nutrition/health education, weight promotion and community mobilisation by community health workers or (2) control: core health services. 20 households per cluster randomly selected from census data according to presence of a child <3 years. Measures at baseline and 2 years.				
Results and study grade	Intervention showed a 17% reduction in underweight compared to controls, with adjustment for important confounders Study grade: high				
2	Le Roux et al (2010)	South Africa	Randomised Controlled Trial	<5 years	Rehabilitation to WAZ[1] >-2.00
Intervention	**Positive deviance with health education:** n=788 households with ≥1 underweight child <5 years or an infant with low birth weight (<2500g) were randomised using (2:1) to intervention (n=536) or control (n=252 control). The intervention group received home visits by 'positive deviant' Mentor Mothers who were trained to deliver health education, recognise neglect, encourage depressed mothers to engage more actively and bond with their children and improve consistency of daily routines. Mentors shared their own positive coping strategies. The intervention took 1 year. Measures at baseline, 3, 6, 9 and 12 months.				
Results and study grade	The intervention group five times more likely to have rehabilitated to WAZ >-2.00 than controls at 3 months; 43% versus 31% had rehabilitated by 12 months. Limitations: mentors reassigned some families to the intervention so the study is not truly randomised, potential contamination of controls via neighbours taking part in the intervention, potential bias as women implementing the intervention also collected data. Study grade: moderate				
3	Le Roux et al (2011)	South Africa	Randomised Controlled Trial	<6 years	Weight gain, WAZ[1]
Intervention	**Positive deviance with health education:** n=679 households with ≥1 underweight child <6 years or a low birth weight infant (<2500g) were randomised (2:1) to intervention (n=500) or standard care (n=179). The intervention was identical to the le Roux study described above, but the mother-child cohort was different. Measures at baseline, 3, 6, 9 and 12 months.				
Results and study grade	WAZ was 0.17 higher in the intervention group and they gained significantly more weight than controls (p<0.01). Limitations: as for the above study, mentors reassigned some families to the intervention group so the study is not truly randomised, potential contamination of				

	the control group via neighbours taking part in the intervention; potential bias as women implementing the intervention collected the data. Study grade: low				
4	Schroeder et al (2002)	Vietnam	Randomised Controlled Trial	5-30 months	WAZ[1], HAZ[2], WHZ[3]
Intervention	**Community empowerment, positive deviance and nutrition education:** n=6 communes were pair-matched (rice production, altitude and percentage of malnourished children) and randomised to intervention or control. N=240 children were randomly selected from hamlets with the worst rates of malnutrition (n=120 per group). The intervention: growth monitoring in alternate months for children <3 years, 'positive deviance inquiry' to identify positive caring and feeding practices, and local, affordable nutritious food for young children, and daily nutrition rehabilitation sessions for 2 weeks per month applying information collected through positive deviance inquiry. Children in control areas received deworming. Measures at baseline, 2, 3, 4, 5, 6 and 12 months.				
Results and study grade	No overall group differences for WAZ or HAZ. WAZ and HAZ declined at a slower rate in a subgroup of children <15 months who were underweight/stunted at baseline in the intervention group compared to controls. No group differences for WHZ. Limitations: no sample size calculation, subgroup analysis involved fewer than 20 children, analysis not clearly presented. Study grade: low				
Multi-component interventions					
5	Maluccio & Flores (2004)	Nicaragua	Randomised Controlled Trial	<5 years	WAZ[1], HAZ[2], WHZ[3]
Intervention	**Conditional cash transfer programme:** n=42 clusters (1-5 communities of 100 households) were selected for high poverty and programme implementation capacity. Clusters assigned to intervention or control using stratified randomisation (strata based on marginality score). The control group received the intervention in phase II. The intervention: demand side activities including money transfers for attending education workshops, taking children to clinics, school attendance/enrolment. Supply side activities included: health education workshops, growth monitoring of children, deworming, iron tablets and vaccinations.				
Results and study grade	Underweight decreased by 6.2% more in the intervention group than the control, and was 6.8% lower at end-line; HAZ scores increased by 0.13 in the intervention group relative to controls (not significant); No WHZ group differences. Limitations: full details of analyses are not provided, children were not wasted at baseline. Study grade: high for WAZ, moderate for HAZ, low for WHZ				
6	Pant et al (1996)	Nepal	Randomised Controlled Trial	6 months-5 years	WHZ[3]
Intervention	**Nutrition education and vitamin A supplementation:** n=457 sub-districts from 7 lowland and highland districts were randomly selected. N=40000 children were randomised to: (1) nutrition education, deworming, immunisations, antibiotics for acute respiratory infections, and oral rehydration solution (2) bi-annual mega-dose vitamin A or (3) control group: ‘treatment’ during annual measurement only. Measures at baseline, 12 and 24 months.				
Results and	No intervention impact: relative risk of wasting was the same for intervention and control groups Limitations: results are not fully or				

study grade	precisely reported, unclear which annual treatments were received by controls or if other treatments were accounted for. Study grade: moderate				
7	Rivera et al (2004)	Mexico	Randomised Controlled Trial	4-36 months	Height gain
Intervention	**Conditional cash transfer programme:** n=347 poor rural Mexican communities from 6 states were randomised to intervention (n=205) or control (delayed intervention, n=142). N=373 children <12 months were randomly selected from intervention households and n=277 children from control areas. The intervention: daily nutritional supplements to women and children 4-23 months and underweight children 2-4 years, nutrition education, healthcare and cash transfers every 2 months. Cash transfers were universal and contingent on attending healthcare appointments, immunisations, well baby care clinics, growth monitoring sessions, and perinatal care. Extra transfers were available for families with older children to encourage school attendance. Mean monthly transfers were $25, equivalent to a 20-30% increase in household income. Data collected at baseline, 1 and 2 years.				
Results and study grade	The poorest and youngest at baseline (<6 months) were 1.1cm taller than control group counterparts (p=0.046). Limitations: results not fully reported. Study grade: high				
Cognitive behavioural therapy					
8	Rahman et al (2008)	Pakistan	Randomised Controlled Trial	6-12 months	WAZ[1], HAZ[2]
Intervention	**Cognitive behavioural therapy for maternal depression (CBT):** n=40 clusters were randomised to CBT delivered to mothers in the perinatal period by trained primary health workers (n=463 women) or usual care (n=440 women; untrained health workers). All groups received equal numbers of home visits. Measures at 6 and 12 months; interviewers were blinded to condition.				
Results and study grade	Stunting was 5% lower in the intervention group than the control group (p=0.07). There was no impact on WAZ. Study grade: high				

[1]WAZ – Weight-for-age Z-score

[2]HAZ – Height-for-age Z-score

[3]WHZ – Weight-for-height Z-score

2.8 Grading the quality of evidence

There are several approaches to grading the quality of evidence for particular interventions and outcomes. I drew upon guidelines from the Grades of Recommendation, Assessment, Development and Evaluation (GRADE) Working Group (Atkins et al. 2004). These guidelines involve assigning each study an initial grade based on study design and through a series of steps the grade is increased or decreased according to different aspects of study quality. Two further steps include consideration of the 'directness' of each study (i.e. extent to which participants, interventions and outcomes are relevant to the target group) and the consistency of findings across studies (Atkins et al. 2004). Randomised trials are classed as high quality and observational studies as low quality (other studies are considered 'very low'). I have adapted these guidelines to allow categorisation of non-randomised trials and controlled before-and-after studies. These have a stronger design than observational studies, but have greater potential for bias than randomised trials, therefore I have categorised them as moderate quality.

The GRADE group recommends increasing the grade of a study if there is a strong association with the outcome. They advise raising the grade by 1 if the relative risk is >2 or <0.5 or there is evidence of a dose-response gradient, and raising the grade by 2 if the relative risk is >5 or <0.2. If adjustment for plausible confounders is likely to have reduced the strength of the effect but it remains statistically significant and/or clinically meaningful the GRADE group suggest raising the grade by 1 (Atkins et al. 2004). Statistics other than relative risk were reported in the findings of the studies I identified. I used common thresholds to classify effect size for Cohen's d (0.2=small effect, 0.5 medium, 0.8=large); I categorised a Z-score change of 0.2 as small and ≥0.4 as moderate to strong. For percentage point differences, >5% was considered small, and >10% as large. In another case, I defined a weight gain of 250g more than controls as small (in line with the author's description; Bhandari et al. 2001); anything above 500g was defined as a large effect. Increases in arm circumference of >0.25cm were considered small and >0.5cm large.

Reasons to decrease the study grade include serious (-1) or very serious (-2) limitations to the study quality, an important inconsistency (-1), some uncertainty (-1) or major uncertainty (-2) about intervention directness, vague or scant data (-1) and a high likelihood of reporting bias (-1) (Atkins et al. 2004). The grading process for each study is presented in Appendices 2.1-2.3. I have listed the grades for each study in Tables 2.1-2.3. In some cases I have assigned the same study more than one grade, depending on the appropriateness and strength of association with each outcome. I have listed the key findings and limitations of the studies in the tables as way of explanation.

2.9 Impact of health education on child growth

Five out of 13 health education interventions measuring weight or weight-for-age outcomes were graded moderate to high quality (38%). The findings were mixed: three found no impact (Aboud et al. 2009;Bhandari et al. 2004;George et al. 1993) and two found a modest effect (Aboud et al. 2008;Bhandari et al. 2001). The three interventions reporting no impact focused on responsive feeding, general health education and growth monitoring. The two interventions reporting a positive impact both focused on responsive feeding. One of these studies compared responsive feeding with and without supplementary food against a control group and observed an effect for the supplemented group only (Bhandari et al. 2001). The majority of the low or very low graded studies for these weight outcomes observed no impact (n=5), one reported a small effect and two reported large effects.

10 health education studies measured height or height-for-age outcomes and only three were graded as moderate-high. These studies tested the effect of responsive and supplementary feeding, general health and nutrition education, and a combination of complementary and responsive feeding education with psychosocial stimulation. One had no effect (Bhandari et al. 2001), one had a small effect (Bhandari et al. 2004) and one had a large effect (Vazir et al. 2013). The majority of the low graded studies found no impact (n=5) although one small and one large effect were reported. Six health education studies measured weight-for-height and two were graded as moderate-to-high quality (Bhandari et al. 2001;Vazir et al. 2013). Neither intervention had a significant impact. Only two health education studies considered arm circumference as an outcome. These studies were graded as low and very low: one found no effect, the other a strong effect (Salehi et al. 2004;Walker et al. 1991).

In summary, the effectiveness of health education as a behaviour change approach to improve weight or weight-for-age is uncertain. This is partly due to the large number of lower quality studies testing this type of intervention, but even the higher quality studies report inconsistent findings. Most of the high quality studies observing an impact were applicable to weaning age children and older, and one study only observed the effect when education was combined with food provision. The findings are also mixed for the small number of higher quality studies measuring height or height-for-age, so again, the effectiveness of health education for this outcome is uncertain. The only consistent result amongst higher quality studies was the finding of no impact on wasting.

2.10 Impact of behaviour change and communication on child growth

Ten behaviour change and communication studies assessed impact on weight or weight-for-age and six were graded as moderate-high quality. Of the higher quality studies, two reported no effect (Aboud and Akhter 2011;Bhandari et al. 2003), one a small effect (Ruel et al. 2008) and three reported large effects (Brown et al. 1992;Roy et al. 2005;Roy et al. 2007). The studies finding no effect focused on responsive feeding and stimulation (with or without micronutrient supplementation) and exclusive breastfeeding (Aboud and Akhter 2011;Bhandari et al. 2003). The study observing a small impact compared a preventive versus a recuperative health and nutrition programme where the former was more effective, although both groups received food rations (Ruel et al. 2008). The three studies finding large effects applied to weaning aged children or older. Two focused on general health and nutrition education through multiple channels, and one found the effect doubled when the behaviour change component was combined with supplementary food (although was still significant for the behaviour change only group). There is slight uncertainty about the representativeness of these two studies as they recruited children already engaged with primary health services (Roy et al. 2005;Roy et al. 2007). The third study reporting a strong effect focused on complementary feeding (Brown et al. 1992). Of the four lower graded studies half saw no effect and half a small effect.

Nine behaviour change and communication studies measured height or height-for-age: five were graded as higher quality. Three of these studies found no impact, these were the studies that focused on responsive feeding, stimulation and micronutrient supplementation, preventive versus recuperative nutrition care and exclusive breastfeeding respectively (Aboud and Akhter 2011;Bhandari et al. 2003;Ruel et al. 2008). The two studies observing a small impact included the study focused on general health and nutrition education that may have limited generalizability to hard to reach populations (Roy et al. 2007); the other study tested the effect of messages based on the integrated management of childhood illness versus standard care

(Arifeen et al. 2009). Three of the lower graded studies found no effect on height (Hamadani et al. 2006;Langford et al. 2011;Lutter et al. 2008), and one found a large effect (Shi et al. 2010).

Six studies measured weight-for-height outcomes, three of which were graded as high quality (Arifeen et al. 2009;Roy et al. 2007;Ruel et al. 2008). Only the preventive versus recuperative study showed a modest impact. None of the other studies, regardless of grade observed any intervention effect. Only two studies measured arm circumference, one was graded as high quality and observed no intervention impact (Roy et al. 2007) and the other was lower quality and reported a small effect (Brown et al. 1992).

In summary, the evidence for the effectiveness of behaviour change and communication approaches to improve child growth is mixed. Amongst higher graded studies, impact on weight or weight for age was inconsistent. A greater number of studies using this approach appear to have had a positive impact than health education approaches although some of these effects may have been influenced by the provision of supplementary food and in two cases children may not have been representative of those most at risk of undernutrition. The findings for height and height-for-age were also mixed, and the majority of higher graded studies observed no effect. Similarly, higher graded studies observed no impact on wasting, and the only highly graded study measuring MUAC observed no effect.

2.11 Impact of mixed behaviour change approaches on child growth

Two out of four mixed behaviour change approaches were graded as moderate to high. Both of these studies found a positive impact on WAZ, one small (Alderman et al. 2009) and one a moderate to large effect (le Roux et al. 2010). The Alderman study used a mixture of health education, community mobilisation and growth monitoring and promotion, and the le Roux study tested the impact of positive deviance and health education on rehabilitation of children to WAZ >-2.00. Of the two lower graded studies one found no effect (Schroeder et al. 2002) and one a small effect (le Roux et al. 2011). Only one mixed behaviour change study (positive deviance with health education) measured HAZ (Schroeder et al. 2002). This study was graded low and observed no impact on stunting. None of the mixed approaches measured weight-for-height or arm circumference.

In summary, my review suggests that mixing behaviour change approaches, such as health education with community mobilisation or positive deviance can have a positive impact on child weight-for-age. However, this is a tentative finding based on just two, very different studies. Very few studies tested mixed approaches with height outcomes, and none measured weight-for-height or arm circumference.

2.12 Impact of multi-component interventions and cognitive-behavioural therapy on child growth

A single and highly graded multi-component intervention measured WAZ (a conditional cash transfer programme in Nicaragua) and observed a small effect (Maluccio and Flores 2004). It was not possible to consider the consistency of this finding as there were no other comparable studies. Two multi-component interventions measured height outcomes, both were conditional cash transfer programmes from Latin America, and both were graded moderate to high quality. Their findings were conflicting however: one observed no effect (Maluccio and Flores 2004), the other a strong effect (Rivera et al. 2004). Two multi-component interventions measured weight-for-height, one was judged as low quality for this outcome (Maluccio and Flores 2004), the other as moderate quality (Pant et al. 1996), although neither observed any impact. The cognitive-behavioural therapy study was judged as high quality. It observed no impact on WAZ and a moderate impact on HAZ (Rahman et al. 2008). Again, as this was a stand-alone study it was not possible to report on consistency of these findings.

In summary, as very few multi-component interventions focusing on child growth outcomes were identified, it is difficult to draw firm conclusions about their effectiveness for reducing undernutrition. Only one study considered weight-for-age, and the two studies measuring height had conflicting findings. Neither of the two studies measuring weight-for-height observed any impact. The cognitive-behavioural therapy intervention reported a small positive impact on HAZ, but in the absence of similar interventions it is not possible to judge the likely effectiveness of this approach in a more general sense.

2.13 Review limitations

There are several limitations to this review. In practice it was difficult to make definitive categorisations about the interventions either because they were not described in sufficient detail or because they employed a mixture of approaches. There is also considerable overlap in the definitions of some approaches, particularly health education and behaviour change and communication.

Secondly, I did not consider additional study outcomes such as impact on breastfeeding and dietary intake. Although these are important, specified outcomes varied substantially and were beyond the scope of this review which was focused on the effectiveness of different community-based behaviour change interventions for child growth.

Thirdly, despite systematically applying GRADE criteria, this approach still involves an element of subjectivity. Ideally there would have been a second person to independently grade the studies to assess agreement, but these resources were not available. Other grading criteria exist, but GRADE is a widely used approach (e.g. by the Cochrane Collaboration) and I felt it was appropriate for this review.

Fourthly, it is probable that by focusing on peer-reviewed articles other relevant studies from the grey literature were excluded; similarly those written in languages other than English would not have been included. Whilst a large number of community-based behaviour change interventions focusing on child nutritional outcomes are likely to be present in the grey literature, it is difficult to know how many of these would have complied with the fairly rigorous inclusion criteria I set out. Unfortunately a thorough search of the grey literature exceeded the time available for this review.

Finally, the studies were extremely varied in focus, methods and outcomes. Even if the same outcome was measured, the growth standards used were not always consistent (e.g. NCHS versus WHO) and may not have been directly comparable. There was also heterogeneity in reporting, with older studies often being less rigorous, perhaps because reporting guidelines, such as the CONSORT checklist for reporting randomised trials were yet to be developed (CONSORT 2010). Nevertheless, this review served the purpose of clarifying which kinds of behaviour change approaches have been used, and how effective interventions have been for a range of child growth outcomes.

2.14 Summary

Health education and behaviour change and communication have been the dominant behaviour change approaches to address undernutrition in low and middle income countries.

This review casts some doubt over the effectiveness of these approaches. At best the findings are inconsistent, even amongst higher quality studies. In several cases positive effects were seen only when education was combined with food or micronutrients. The only consistent finding from higher quality studies was of no impact on wasting (although relatively few studies measured this outcome).

Less common approaches found included conditional cash transfer programmes and cognitive behavioural therapy for maternal depression. These interventions showed varying degrees of promise, but with the small numbers of studies available it is difficult to gauge the effectiveness of these approaches. The two studies using a mixture of behaviour change methods also showed some potential. These included positive deviance and community mobilisation in combination with health education, and both reported significant impacts on underweight. This is a tentative finding due to the small number of studies identified and no data were available for other growth outcomes.

Behaviour change is a key component of community-based interventions to reduce child undernutrition. This review suggests that the more common approaches of health education and behaviour change and communication may have a limited impact. Clearly there is scope to test different community-based approaches that may prove to be more effective. It is timely to test different types of behaviour change interventions that engage the most underserved communities who are at the greatest risk of undernutrition in cost-effective, sustainable ways. This thesis explores the potential of an alternative behaviour change approach to reduce child undernutrition – community mobilisation. Interventions based on community mobilisation do not feature as prominently in the peer-reviewed literature as health education, which may reflect the dominance of health education over other approaches and an evidence gap in evaluating and publishing community mobilisation interventions with robust designs. The rationale, aims and research questions and a full intervention description are discussed in detail in the following chapter.

Chapter 3

Rationale for the PhD study

3.1 Moving beyond traditional behaviour change approaches

As stated in the previous two chapters behaviour change interventions play an important role in promoting the feeding, caring, hygiene and care-seeking practices needed to positively influence growth. My literature review identified that health education and behaviour change and communication were the most commonly used approaches, but when used alone (i.e. without food or micronutrients) they have not demonstrated consistent results. Other reviews suggest that positive effects observed from these types of intervention are rarely sustained in the long-term (Bolam et al. 1998;Nutbeam 2000). For example, several of the health education and behaviour change and communication studies in the previous chapter reported low caregiver recall of nutrition messages at follow-up (Aboud et al. 2009;Lutter et al. 2008). This highlights the need to engage more effectively with community members about health and nutrition, for meaningful and sustainable behaviour change and undernutrition reduction.

What is clear is that active involvement of community members is necessary for health and nutrition interventions to be effective, but in reality people are more commonly treated as passive recipients of health information (Walley et al. 2008). The emphasis on education rather than active involvement in community interventions shows a continued reliance on unidirectional delivery mechanisms (Pelletier 2002). This means that interventions may not be perceived as relevant, or important enough to warrant a change in practices. Equally, nutrition strategies may be inadequately tailored to meet local requirements because there has been no prior consultation with community members about barriers to behaviour change (Pelletier 2002). For example, some studies from my literature review identified that caregivers could not adhere to complementary feeding guidance due to extreme food insecurity (Aboud et al. 2009).

There is evidence that consultation and partnerships with community members about healthcare, rather than unidirectional approaches, can effectively reduce undernutrition. The Iringa nutrition intervention in Tanzania in the 1980s used a participatory approach for the identification of health problems and the generation and implementation of solutions at all levels (including households, communities and the regional government). The programme achieved impressive reductions in the prevalence of severely underweight children under-five from 56% to 38% over four years (Pelletier and Jonsson 1994).

3.2 Community participation

The principles of Alma Ata ('primary health care for all') were developed in 1978 and emphasised the importance of community participation and empowerment in healthcare planning and interventions (World Health Organisation 1978). Recent reflections on the implementation of Alma Ata have underlined the failure of many existing interventions to impact on health outcomes because they do not engage sufficiently with communities (UNICEF 1990;Walley et al. 2008).

Community participation itself is a problematic concept because it has multiple definitions. This makes it difficult to gauge how effective participatory approaches are in improving uptake of services and health outcomes, and the sustainability of these improvements (Draper et al. 2010). Participation is not a unitary concept, and definitions are likely to vary according to the ideological positions of those deciding to implement 'participatory' interventions. This will influence the way interventions are carried out and why, and the expectations placed on those identified to participate (Morgan 2001).

Participation: the utilitarian position

Far from being a unified approach, participatory interventions may be underpinned by diverse, and even incompatible perspectives. At one extreme is the utilitarian position, often adopted by governments and powerful agencies aiming to achieve a particular outcome (Morgan 2001). Rifkin describes this as a 'target-oriented' approach, rooted in the biomedical model, which attempts to 'convince community people to accept a specific health intervention' (Rifkin 1996). Interventions positioned here have been criticised for commandeering the notion of participation to justify the use of community resources as a cost-saving device, or even as a replacement for health services (Morgan 2001).

One international organization criticized for its interpretation of participation is the World Bank. The World Bank defines participation as ‘a process through which stakeholders influence and share control over development initiatives, and the decisions and resources that affect them’ (World Bank 1996). ‘Stakeholders’ include not just the community members who are supposed to benefit from an intervention, but anyone else who ‘could affect the outcome of a proposed Bank intervention or be affected by it’, including World Bank officials (World Bank 1996; Morgan 2001). This enables the organization to pursue self-serving interests and the interests of anyone else deemed to be a stakeholder (who may have the potential to gain financially) in the absence of clear accountability mechanisms (Morgan 2001).

Participation and empowerment

At the other extreme are empowerment approaches (Rifkin 1996). The empowerment perspective is based on the idea that inequitable distribution of resources drives poor health, and that by democratizing local decision-making, inequities in resource allocation can be reduced (ibid). By involving community members in decision-making the assumption is that health service delivery will improve, uptake of health services will increase and health inequalities will diminish (Draper et al. 2010). Arnstein (1969) also working within the empowerment framework defines citizen participation as ‘the redistribution of power that enables the ‘have-not’ citizens, presently excluded from the political and economic processes, to be deliberately included in the future’. In the context of health interventions, this could involve community members taking responsibility for identifying and prioritizing local problems, and deciding upon acceptable processes to address them (Morgan 2001).

There is disagreement between empowerment advocates about the extent to which external actors should be involved in the process. Activists such as Freire have argued that when communities gain knowledge they alone can drive social change through a reactive process of ‘concientization’ (Freire 1972). Activists continue to call for more radical action through social movements to achieve democracy, social justice and empowerment and to challenge the structural drivers of poverty and inequality (Morgan 2001). However, others consider that it may be unrealistic to assume that communities living in conditions of subjugation and poverty have the necessary power and resources to demand social change without outside help (Chambers 1998). An entirely bottom-up approach may also assume an overly simplistic relationship between donors and communities (Brett 2003). Pragmatists argue for a more realistic approach involving respectful collaboration between donors and community members to achieve agreed goals, and that novel ideas and resources from outside should be permitted (Morgan 2001).

Participation: a product or a process?

There is general agreement amongst theorists that participation should be considered as a process rather than a product. Oakley argues that participation is 'not an input to the project but the basis upon which it operates' (Oakley 1999). Rifkin (1996) stresses that participation can be considered as 'an iterative learning process', and this may create more realistic expectations about the likely impact of participatory projects. In practice it is difficult to resolve this dynamic context-specific concept with the systematic approaches required to operationalize, implement and evaluate health interventions. Equally, it may not be conducive to the needs of policy makers who want to understand if and how particular approaches influence health outcomes (Morgan 2001). This presents a number of challenges including how to define and when to measure the 'success' of an on-going intervention. Intervention evaluations themselves may also be too technical to include community members in the process (Morgan 2001). Compromises can be reached. For example, elements of the process that are amenable to systematic implementation could be identified (e.g. participants could proceed through defined stages of an intervention) whilst acknowledging that the process itself will not be uniformly carried out.

Typologies of participation

Participation remains a fraught and heavily debated concept and interventions claiming to be participatory often lack clear positioning on the participation spectrum. A number of typologies have been designed to encourage more conscious applications of participatory theory to intervention designs (e.g. Rifkin et al. 1988, Draper et al. 2010, Howard-Grabman 2007). Situating interventions within these typologies enables more meaningful characterizations of participatory interventions and evaluations of the evidence for distinct participatory approaches. It is also possible to use these typologies to monitor single interventions over time (Draper et al. 2010).

Rifkin's typology (1988), recently updated by Draper et al. (2010) provides a practical and detailed tool for this purpose. The original tool aimed to capture the extent of community involvement in health programmes across five dimensions: needs assessment, leadership, management, organisation, and resource mobilisation. The tool was updated in 2010 to incorporate critical success factors for community participatory programmes from recent literature reviews and was applied to community-based child survival and micronutrient projects in low-income countries (Draper et al. 2010). The five dimensions now include: 1) community leadership and leadership of professionals introducing the programme 2) planning, management, and partnerships between community members and professionals 3) involvement of women 4) external support (financial and programme design) and 5) monitoring and evaluation of participant involvement in the intervention. Each dimension is presented as a continuum, scored from 1 to 5 to illustrate lower and higher levels of participation. 'Values for mobilisation' are represented at lower levels (scores 1-2), followed by 'values for collaboration' (scores 3-4); 'values for empowerment' are represented by a score of 5. Draper et al also provide an explanatory table including descriptions of each indicator at different points on the continuum to facilitate scoring.

The five continuums can be assembled as a spidergram, joining in the centre at zero, where the positioning of marks for adjacent dimensions can be connected with straight lines giving the appearance of a web; this represents wider and narrower dimensions of participation for a particular intervention (Rifkin 1988; Draper et al. 2010). I have applied this tool to the intervention that is the focus of this thesis in figure 3.2, section 3.7.

Defining community

The term 'community' is also problematic and theorists have struggled to pinpoint a singular definition (Jewkes and Murcott 1996). Multiple working definitions exist in the health literature although there are commonalities between them, particularly the notion of 'sharing': shared beliefs, shared needs, shared voice, and shared geographical boundaries (Jewkes and Murcott 1996). However, the assumption of shared interests by those on the outside of a community may not be consistent with any individual's own sense of shared interests on the inside. The term community can erroneously imply homogeneity between 'members', shared priorities, and equal distribution of power. Projects that do not take account of heterogeneity within communities have the potential to reinforce rather than address inequalities (Morgan 2001).

A second issue is defining the membership of a given 'community' (Morgan 2001). People identified as belonging to a particular community by external actors may not actually consider themselves to be members of that community, and it then becomes an externally imposed construct (Jewkes and Murcott 1996).

Whilst there can be no single definition of community, and therefore no right or wrong use of the term, it is important to be aware that different actors will define and understand community and its membership very differently. This could affect the way the intervention is received and perceived as relevant by different 'members', and the extent to which different people benefit. This may result in a different patterning of effect than is expected by those designing and implementing an intervention.

My use of the term 'community' in this thesis is largely restricted to geographically defined clusters of villages and hamlets. These clusters were purposefully selected for intervention by Ekjut (the implementers of the intervention). Study clusters were considered to be particularly underserved with regards to health service access and most inhabitants were likely to be at extreme socio-economic disadvantage. However, within these geographic clusters live diverse groups of people from different social backgrounds, where even within the same social groups the idea of shared needs and a common voice cannot be assumed. Further contextual detail about the study areas is given in chapter 4.

3.3 Defining community mobilisation

My literature review identified an evidence gap in the published literature surrounding the potential for strategies that go beyond traditional education methods to reduce child undernutrition and treat community members as active participants in their own health. Community mobilisation is one example of a participatory intervention that could be tested for effectiveness to impact upon child growth through behaviour change. There appears to be little published evidence exploring the mechanisms through which this approach could be effective for improving child growth.

Community mobilisation can be considered as a sub-type of community participatory approaches and has also suffered from the problem of multiple definitions or use of the term without attempting to define its meaning. The definition I have used is as follows: 'a capacity building process through which community members, groups or organisations plan, carry out and evaluate activities on a participatory and sustained basis to improve their health and other conditions, either on their own initiative or stimulated by others' (Howard-Grabman 2007).

Community mobilisation can manifest in a number of ways, but one type involves community members following a 'participatory learning and action (PLA) cycle'. This begins with formative work to characterise the context and for external facilitators to gain permission, acceptance and community trust (although facilitators are ideally local). Facilitators and community leaders then begin awareness-raising (e.g. about maternal and child undernutrition) and enlist the participation of those most affected and interested, opening-up discussions of current practices. Problems are then prioritised and strategies to tackle them are planned and implemented, followed by a monitoring and evaluation phase (Howard-Grabman 2007).

All stages in the cycle are crucial to ensure community ownership and long-term commitment to changes in practices when facilitation ceases, and to ensure original community innovations are considered. Transparency, accountability and lobbying for changes in health entitlements and policies are encouraged, and communities are helped to link with formal health providers for improved access, quality, delivery, and coverage of services. External individuals and agencies may also participate at key times in the cycle (e.g. to provide technical support or knowledge from complementary health programmes). Donors and policy-makers may also be requested to integrate activities with national and regional health strategies, to identify the communities likely to glean the most benefit (e.g. with highest levels of undernutrition) and to provide financial and technical support when required (e.g. for monitoring and evaluation) (Howard-Grabman 2007).

Darmstadt et al (2005) consider community mobilisation and empowerment as central to the effectiveness of family and community oriented services, in terms of overcoming barriers to behaviour change, and to increase the demand on health services to stimulate supply and increase the quality of health service provision. Evidence from India suggests that not only are there issues on the supply-side with India's health and nutrition programmes, but that there is a lack of demand for formal healthcare, particularly in rural areas (Paul et al. 2011). There are many possible reasons for low demand but one important factor is lack of awareness about service entitlements. One randomised-controlled trial in the Indian state of Uttar Pradesh demonstrated that 4-6 public meetings over one year to disseminate information about health and education entitlements led to significantly improved delivery and uptake of antenatal care and vaccinations (Pandey et al. 2007). Knowledge of entitlements, and being mobilised to command them, can clearly improve service delivery and uptake. Community mobilisation is one medium through which entitlements can be communicated and members can organise to lobby for their rights.

Interventions that seek more effective engagement with members of rural communities could be effective in changing health and nutrition behaviours, and may increase health-service demand and stimulate supply. This study is timely as it examines the effectiveness of a community mobilisation intervention to improve growth outcomes in areas with a high burden of child undernutrition. If there is evidence of success with this approach it could provide a model for increasing community participation for better nutritional outcomes.

3.4 Thesis aim, objectives and research questions

Aim: to explore the potential of a community mobilisation intervention with women's groups to improve child growth in underserved tribal communities of Eastern India.

Objectives:

1. To assess the nutritional status of mothers and children in rural tribal communities of Jharkhand and Orissa through a cross-sectional nutritional survey

2. To determine whether the intervention is associated with lower levels of child undernutrition in communities who received the intervention compared to matched communities that did not. I will achieve this by comparing intervention and control groups using the cross-sectional survey data collected at endline.

3. To define and explore hypotheses about the mechanisms behind any impact of community mobilisation on child growth outcomes through further quantitative analyses of the survey and through qualitative methods

Research questions:

1. What is the prevalence of stunting, wasting and underweight of children under-3 in Jharkhand and Orissa?
2. Are levels of child stunting, wasting and underweight different between intervention and control clusters?
3. Are there differences between intervention and control clusters for other behaviours and indicators that the intervention tried to address and that represent plausible pathways to improved nutrition?
4. What are the determinants of stunting, wasting and underweight in non-intervened areas?
5. Through qualitative enquiry I will explore: women's experiences of obtaining food for themselves and their families, common feeding and hygiene practices, and women's views about the causes of child undernutrition.

3.5 The intervention: community mobilisation with women's groups

This thesis builds on a previous cluster-randomised controlled trial of a community mobilisation intervention with women's groups to reduce neonatal mortality and maternal psychological distress (July 2005-2008) (Tripathy et al. 2010). The trial was implemented by an Indian NGO called Ekjut working in collaboration with the UCL Institute for Global Health.

Community mobilisation with women's groups to reduce neonatal mortality

The trial included 36 clusters of villages and hamlets (of approximately 6000 people each) from three contiguous districts of Jharkhand and Orissa. The majority of the population were from rural, tribal communities. Clusters were randomised to the intervention group (community mobilisation with women's groups and health-service strengthening) or to health service strengthening only, stratified by district. Intervention and control clusters were separated by a geographical 'buffer' region to minimise the risk of contamination (Tripathy et al. 2010).

Health-service strengthening involved setting up cluster-level 'village health committees', in line with National Rural Health Mission objectives. Committees consisted of 10 village representatives per cluster who met every two months to discuss the design and management of local health services, and health entitlements for women and new born infants. In addition, frontline healthcare staff from seven clusters in Jharkhand took part in 'appreciative inquiry' workshops to enable committees to qualitatively assess service quality (Tripathy et al. 2010).

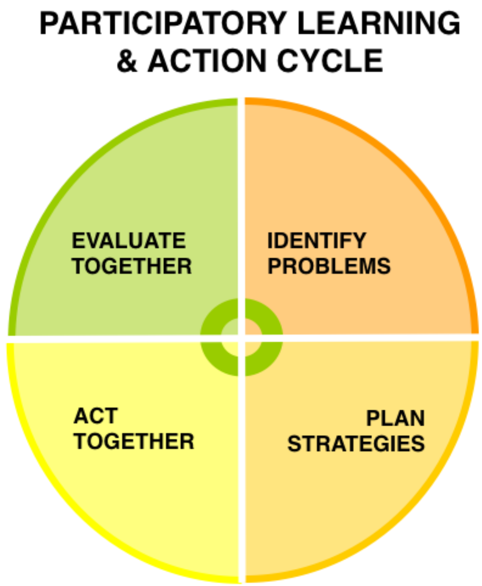
Gaining consent from community members to carry out the study began 10 months prior to the start of the intervention, in accordance with the preliminary phase of community mobilisation (Howard-Grabman 2007). Ekjut field staff met with gram sabhas (village councils), village headmen, and locally elected panchayat representatives in all districts to build trust and cooperation, raise awareness of maternal and neonatal health issues and ultimately to gain permission to work with women's groups and begin surveillance of births and deaths in the study areas (Tripathy et al. 2010).

The intervention capitalised on the presence of existing women's groups in some clusters, set up by the NGO PRADAN for micro-credit activities (n=172), as well as creating new women's groups where necessary (n=72). There was one women's group per 468 population and attendance by newly pregnant women rose from 18% to 55% over the three-year study period. New births, maternal and neonatal deaths or deaths of women of reproductive age were identified using key informants (ANMs or active community members; 1 per 250 households). Mothers of infants were interviewed 6 weeks postnatally to gather data on background characteristics, care-seeking and homecare practices, and antenatal, perinatal and postnatal information. Maternal psychological distress was identified as a primary outcome in year 2 of the study, and whilst not directly addressed, women identified by interviewers as severely distressed were referred to tertiary mental health services. The women's group cohort remained open for the duration of the study to women 15-49 who had given birth during the study period, although other community members were allowed to attend meetings (Tripathy et al. 2010).

The process of community mobilisation with women's groups

Women's group facilitators (living locally, and trained by Ekjut) carried out monthly meetings with 13 groups each. They facilitated discussions about common maternal and newborn care problems using story-telling, games and picture cards; materials were adapted from a similar trial in Nepal (Manandhar et al. 2004). This process followed a community participatory learning and action cycle including four distinct sequential phases (illustrated in figure 3.1).

Figure 3.1 The Women's Group Participatory Learning and Action Cycle



In early meetings of phase 1, facilitators sought to engage with participants and clarify the nature of the relationship between Ekjut and the women's group. In the facilitator manual this is described as one of partnership and minimal dependency: 'to help communities to help themselves and at the same time to learn from them…where the organisation and the community walk together'. Women then discussed local practices around maternal and newborn health, before moving on to prioritising particular issues for intervention through voting (Tripathy et al. 2010).

After prioritisation, story-telling became central. This allowed group members to develop an in-depth understanding of the health issue. Facilitators were given the core elements of a story relating to causes and effects of a particular health problem, and then made it into a complete narrative, adding local elements. Facilitators supplemented the story with their own drawings to illustrate the important points linking cause and effect, and then asked participants to re-tell the stories. Cause and effect were further explored with the 'but why' approach to each component of the problem, starting with the outcome (e.g. still-births) and working backwards to identify each precipitating cause. Causes included immediate medical causes as well as underlying and basic causes. Meetings in this phase also included awareness-raising about recognising danger signs and when formal emergency healthcare assistance was required, and advice to rectify obviously harmful practices emerging from group discussion (Rath et al. 2010).

In phase 2 women developed local strategies to tackle the priority problems and presented their ideas to the wider community to gain support. Initially, the concept of strategy development was communicated through the 'bridge game'. Here groups used local props to symbolise the building of a bridge made up of local actions that enabled access to improved maternal and child health. As women suggested strategies to build the bridge the facilitator helped the group decide if it was feasible by asking how it could be achieved. The best ideas were shortlisted and a small number were eventually chosen, including assignment of tasks to individuals (Nirmala Nair, personal communication, January 2010). Phase 3 involved implementing the chosen strategies, and in the final phase groups evaluated their activities. Some examples of strategies used by the groups include saving for an emergency fund to allow transportation to hospital, emergency drills in the event of post-partum bleeding, and lobbying for an Anganwadi Worker to cover their hamlet (Tripathy et al. 2010) (Suchitra Rath, personal communication, January 2010).

Results of the neonatal mortality trial

Over the three-year study period, neonatal mortality was 32% lower in the intervention group than the comparison group, and 45% lower in the final year of the trial. Maternal psychological distress scores were not significantly different between groups overall, but moderate distress was reduced by 57% in the intervention areas compared to the comparison areas in the final year of the trial (Tripathy et al. 2010). A process evaluation identified six factors instrumental to the success of the intervention: high population coverage, targeting of marginalised communities, on-going and active recruitment of pregnant women, high acceptability of the intervention, mobilisation of community members outside the groups, and increased skills, knowledge and the development of Freire's 'critical consciousness' (Rath et al. 2010). Critical consciousness refers to the outcome of a pedagogical process that seeks to educate underserved groups about the wider societal structures that maintain their position in society; this new awareness is intended to be empowering and stimulate positive social change; the process is termed 'conscientization' (Freire 2005).

3.6 The development of a new cycle of women's groups for maternal and child health

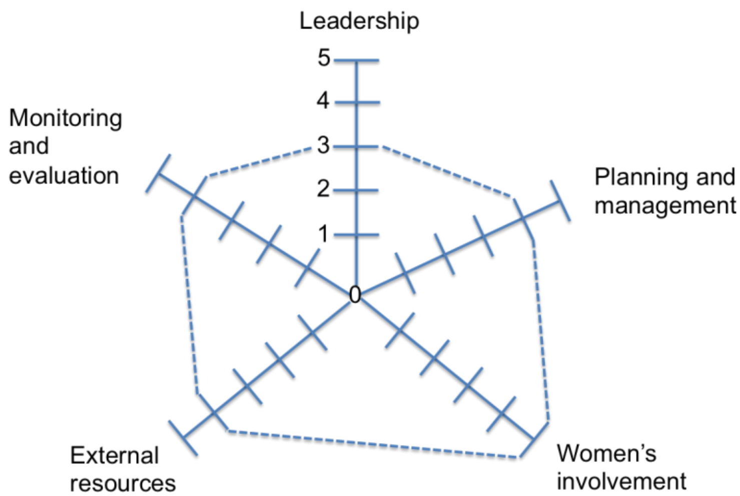
Due to the positive results of the trial a subsequent cycle of women's group (known as 'cycle 2') was developed. All group suggestions of important maternal and child health problems beyond pregnancy and the neonatal period were compiled into a set of 20 topic-based meetings. The meetings remained open to all but caregivers of under-fives were particularly encouraged to attend. The first 10 meetings included discussions around the prevention and management of childhood illnesses and nutrition: diarrhoea, essential newborn care practices, acute respiratory infections, child immunisation, child malnutrition, breastfeeding and complementary feeding, immunisations, worm prevention and growth monitoring. The meetings were also an opportunity to share technical knowledge with communities, such as how to make oral rehydration solution for diarrhoea management. The second set of 10 meetings covered women's health and body mass index, malaria, maternal malnutrition and anaemia, family planning, safe abortion, tuberculosis, and HIV. Cycle 2 began in August 2008, and the nutrition survey data in this thesis were collected after completion of the child health meetings.

Cycle 2 contrasted with the first cycle of meetings in a number of respects, partly to avoid unnecessary repetition (e.g. introduction to Ekjut and their intended relationship with the groups and the concept of facilitation). Problem prioritisation also occurred differently: maternal and child health problems mentioned by groups at the end of cycle 1 were amalgamated into meeting topics for cycle 2 as opposed to individual groups identifying and prioritising their concerns. In this respect cycle 2 effectively began in phase 2 of the action cycle at the 'plan strategies' stage (figure 3.1) and instead of solutions being implemented and evaluated much later in the cycle, they were discussed and agreed upon at each individual meeting for immediate implementation, and evaluated at the next meeting. The mid-point community meeting, and cluster-level community meeting at the end of the cycle occurred as usual, as well as a comprehensive evaluation of all cycle 1 and 2 strategies in meeting 20.

3.7 Situating the intervention within a typology of community participation

I have used the updated framework by Draper et al (2010) originally developed by Rifkin (1988) to characterize the Participatory Learning and Action cycle using women's groups. This is shown in Figure 3.2. Draper et al (2010) applied the updated tool to characterise child survival and nutrition interventions in low-income countries, and included a table describing in detail values for mobilisation, collaboration and empowerment along the continuum for each of the five participation dimensions they considered most important.

Figure 3.2 A spidergram representing the position of the women's groups along five dimensions of participation (based on Rifkin 1988 and Draper et al.2010)



I scored the leadership indicator a three ('values for collaboration'); this indicator refers to the extent that 'professionals' or the intended beneficiaries introduce the intervention (Draper et al. 2010). Draper et al describe this point on the continuum as 'collaborative decision making between health professionals and community leaders' (ibid). Although Ekjut led on the implementation of the intervention, including its introduction to each community, early activities involved multiple consultations with community members and joint decision-making. For example, Ekjut conducted focus groups with community elders, opinion leaders and other community members to develop the selection criteria for women's group facilitators, and asked for local nominations of potential candidates from each village (Rath et al. 2010).

I gave the planning and management indicator a score of 4, which also reflects 'values for collaboration'. This indicator captures the manner in which partnerships between 'professionals' and community members are formed. A score of 4 indicates that potential intervention beneficiaries are 'invited to participate within a pre-determined remit' although the activities carried out 'reflect community priorities'; both parties contribute resources to the process (Draper et al. 2010). This description matches cycle 1 of the groups which operated under the pre-determined remit of newborn mortality reduction, although groups prioritised which problems would be explored within that subject area, and devised and implemented their own strategies to address their chosen problems (Tripathy et al. 2010).

I scored the women's involvement indicator a five to represent 'values for empowerment'. The women's groups are consistent with Draper et al's definition at this end of the continuum: 'the active participation of women in positions of decision-making and responsibility is a programme objective'. Although the women's groups were open to the wider community, women (particularly pregnant women) were encouraged to attend. The act of prioritizing local issues through voting allowed women to exercise active decision-making, and in phase two of the meeting cycle responsibilities for women's group strategies were assigned within the group.

I scored the external support for programme development indicator (finance and programme design) a three ('values for collaboration'). Although this aspect of the intervention shares some of the 'values for empowerment' described by Draper ('the design…incorporates wide community participation, including women and minority groups') it fits more comfortably under the 'values for collaboration' heading. Interventions located at this point on the continuum are externally funded and designed by health professionals, which is consistent with the women's groups. The Participatory Learning and Action cycle, around which the group meetings were structured originated from previous research albeit with local adaptation of tools (Rath 2010).

Finally, I scored monitoring and evaluation as a four. Again, the intervention shares many of the qualities described under the 'values for empowerment' heading for this dimension, including the fact that communities decided upon their own indicators to measure success and that the final phase of the meeting cycle focused on self-evaluation of the groups. However, other aspects of monitoring and evaluation such as the monitoring of newborn deaths were professionally led, and the timing of the 'end' of each meeting cycle was decided upon externally.

3.8 Potential pathways from women's group activities to improved child growth

There are a number of potential pathways through which women's group cycles 1 and 2 could have impacted upon child growth outcomes. I have considered the content of the meetings and common strategies implemented during cycle 1 (these had not been compiled for cycle 2) in relation to the 13 priority interventions identified in the Scaling-Up Nutrition framework (SUN)

(Scaling Up Nutrition 2010); these are summarised in Box 3.1. Possible effects on child growth that match the SUN priorities include improved breastfeeding and complementary feeding practices, improved hygiene and hand washing behaviour, greater uptake of deworming, iron folic acid promotion for pregnant women, and community-case finding of undernourished children. Although the groups did not use zinc for improved diarrhoea management (SUN intervention number 5) they aimed to achieve this through the use of oral rehydration solution so I have included it in Box 3.1.

Indirect pathways to improved child growth include possible improvements to maternal mental health status. Whilst this was not specifically addressed by women's groups, postnatal psychological distress was significantly reduced in the intervention group compared to the previous control group by the end of the trial period (Tripathy et al. 2010). There is growing consensus that there is a link between maternal mental health and child growth (Stewart 2007;Surkan et al. 2011). Maternal physical health is also important for child outcomes. Many women's group meetings and strategies in cycle 1 focused on anaemia reduction and the promotion of a healthy diet during pregnancy. It is plausible that if anaemia was reduced this could have resulted in lower proportions of low birth weight and premature children who would then have a reduced risk of later undernutrition (Lone et al. 2004;Wendt et al. 2012).

There is also the potential for a more general effect on healthcare-seeking that could impact indirectly on health outcomes. As stated before, the focus on raising awareness of entitlements could improve the uptake and quality of health service provision (Pandey et al. 2007). Finally, there are potential longer-term effects of the women's group intervention that could raise the status of women and interrupt the intergenerational cycle of undernutrition. This idea is supported by findings from cycle 1 that demonstrated an association between the women's group interventiob and increased female decision-making power and problem solving skills (Montalvao et al. 2011).

Box 3.1 Pathways to improved child nutrition: priority areas addressed by women's groups

Box 3.1 Pathways to improved child nutrition: priority areas addressed by women's groups[1]

13 Priority nutrition interventions (direct)[1]	Women's Group Meetings		Women's group strategies (% of groups)	
	Cycle 1	Cycle 2	Cycle 1	Cycle 2
Promote good nutrition practices				
1. Breastfeeding promotion	✓	✓	Health workers requested to guide breastfeeding (73%)	
2. Complementary feeding	✓	✓		
3. Hygiene and hand washing	✓	✓	Sanitation against malaria (26%). Safe delivery kits (53%)	Guidance about hand washing practices (100%)
Micronutrients for young children and mothers				
4. Vitamin A				
5. Zinc (diarrhoea management)	(✓)	(✓)		Oral rehydration solution: home preparation guidance and knowledge of entitlement from Anganwadi worker (100%)
6. Multiple micronutrient powders				
7. De-worming		✓		Guidance on worm prevention and entitlements to routine de-worming (100%)
8. Iron FA for pregnant women	✓	✓	Counselling for anaemia reduction (62%). Kitchen gardens (20%)	
9. Iodised oil/salt				
Micronutrients for ALL via food fortification				
10. Iodised salt				
11. Iron fortification of staples				
Therapeutic feeding for malnourished children				
12. Prevent/treat moderate malnutrition		✓		Community case-finding of undernourished children (100%)
13. Treat severe acute malnutrition with RUTF				

[1]13 'highly cost-effective' direct and nutrition specific interventions to reduce 1 million U5 deaths and avert 30 million Disability Adjusted Life Years (Lancet Nutrition Series 2008) and now central to the 'Scaling-up Nutrition Framework' (http://www.unscn.org/files/Announcements/Scaling_Up_Nutrition-A_Framework_for_Action.pdf)

Whilst it is useful to see where the women's group intervention fits within broader recommendations for interventions, it is also worth revisiting the UNICEF conceptual framework to identify potential mechanisms by which the women's groups could improve child growth outcomes. This is illustrated in Figure 3.3.

Figure 3.3 Potential pathways within the UNICEF conceptual framework through which the women's groups could improve child growth outcomes

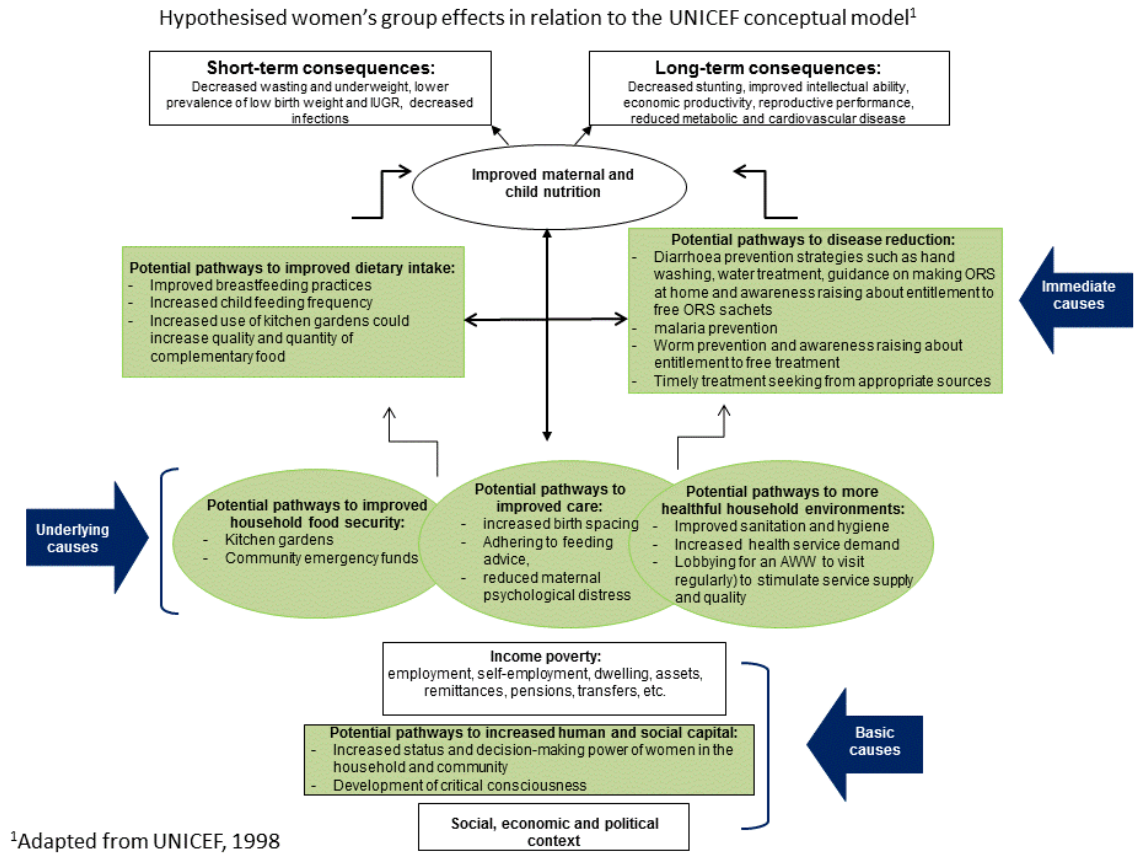


Figure 3.3 demonstrates where I think the women's groups have the potential to improve child nutrition. This could work through several different mechanisms and at different levels of the UNICEF framework.

At the immediate level there have been multiple women's group meetings and activities focused on improved child nutrition: disease reduction (particularly the prevention of diarrhoea), and to a slightly lesser extent the improvement of child feeding practices. At the intermediate level women's groups have also been making considerable efforts to improve aspects of the household environment and factors linked to the care of women and children; to a smaller extent groups have been working to improve household food security (such as through the promotion of kitchen gardens).

This intervention may also prove influential at the basic level: here I have added increased status and decision-making power of women, and the development of a critical consciousness. The benefits and mechanisms through which raising the status of women for improvements in child nutrition and health are well documented. Less common in the expanding literature on community empowerment approaches is the role of critical consciousness for improved health outcomes. A recent commentary has highlighted that although there appears to be a clear association between critical consciousness and improved health, the mechanisms by which this can work are far less obvious (Victora 2013). One example of how this could work (although there are likely to be many) is based on an anecdote from one of the women's groups in cycle 1. An increased awareness of entitlements to free family planning from the ASHA led to the successful lobbying to encourage her to store supplies in the village (previously the ASHA frequently arrived at the village without family planning supplies as they were too heavy to carry). Improved access to family planning could then lead to improved birth spacing, and ultimately better nutritional outcomes for women and children.

A more detailed rationale and statistical testing of each of these potential pathways is provided in chapter 6.

In the next chapter I outline the methods used to develop and carry out the nutrition survey. This is followed by three chapters of quantitative analyses investigating whether women's group membership was associated with changes in nutrition outcomes (wasting, stunting, underweight), and feeding and health behaviours, and finally an analysis of the determinants of undernutrition in the study's control areas.

Chapter 4

Nutrition survey methods: design, data collection and analysis strategies

4.1 Survey design and setting

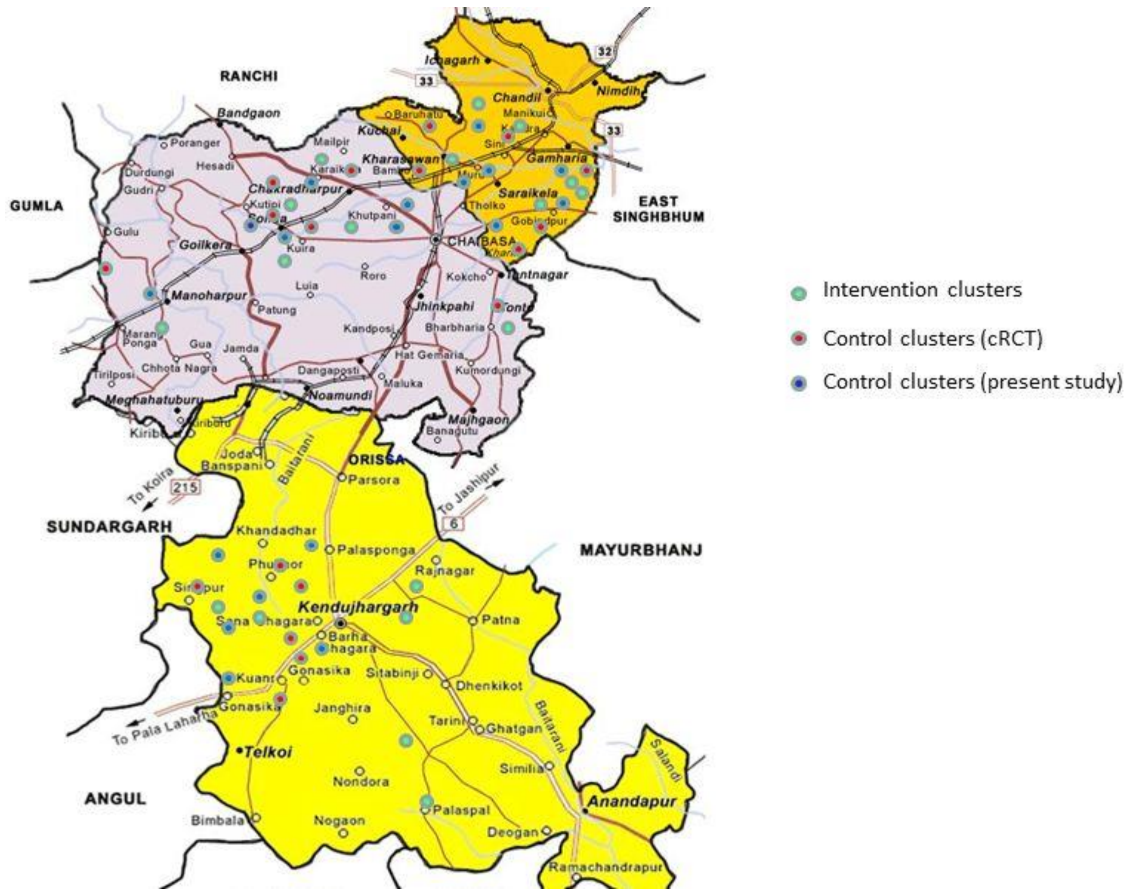
The study area comprised 36 geographic clusters. 18 clusters had been exposed to two cycles of a participatory women's groups intervention: the first cycle aimed to improve maternal and newborn health (2005-8) and the second to improve maternal and child health and nutrition (2008-2010). The other 18 clusters were matched comparison areas (the matching process is described below). All 36 clusters were located in three contiguous districts of Jharkhand (West Singhbhum and Saraikela) and Orissa (Keonjhar). Figure 4.1 shows a map of India's states and union territories. The intervention to improve maternal and newborn health was rolled out to the original control areas of the randomised controlled trial in 2008, so new comparison clusters without intervention exposure were sought from similar areas for the present study. These new clusters were located in the buffer zones separating the original clusters of the randomised controlled trial (see Figure 4.2).

An alternative study design could have involved a survey of administrative blocks using probability proportional to size sampling (World Health Organisation 2010). This could have been followed by a comparison of child anthropometry in blocks with intervention-exposed villages against those without intervention exposure. This would have enabled reporting of undernutrition prevalence, representative at the population level. However, there were a number of reasons against using this approach. Firstly, security considerations meant that Ekjut (the study partners) did not consider it safe for data collectors to be sent to areas where they were not known. We therefore deliberately recruited growth monitors from within each cluster who were responsible for data collection in that area. Secondly, we were trying to detect a small intervention effect on child growth and aimed to select children of women's group members only, rather than sampling children at the cluster level (which would include children of non-women's group members, and who may have had less exposure to the intervention). Probability proportional to size sampling would have precluded selection of children of women's group members only. Finally, retaining the original intervention clusters from the trial served as a follow-up of a cohort of women's group participants, enabling Ekjut to identify areas to address in on-going interventions.

Figure 4.1 Map of India showing states and union territories

www.commons.wikimedia.org/wiki/File:India_states_and_union_territories_map.svg

Figure 4.2 District maps of Saraikela, West Singhbhum and Keonjhar showing approximate locations of study clusters



Identification of comparison clusters

The research team identified the new comparison clusters using the same process as for the randomised controlled trial. An initial core village was identified using the Indian 2001 census, the general area being selected as a feasible working location by Ekjut. Field managers sought permission from village headmen and opinion leaders to undertake research for maternal and child health. Contiguous villages and hamlets were then added until an entire cluster was formed comprising six to ten villages, with approximately 6000 population. Growth monitors were recruited from core villages, and they assisted with the process of adding villages to the cluster by mapping out their local area to identify hidden hamlets not specified in the census.

Villages were gradually added to each new cluster based on matching criteria so that pairs of intervention and control clusters were similar in terms of population size, the proportion of people from Scheduled Tribes and number of Anganwadi Workers (including 'mini' Anganwadi workers with a smaller associated Anganwadi Centre). The matching was based on Indian 2001 census data adjusted for the projected 2009 population, along with recent district government data about numbers of Anganwadi and mini-Anganwadi workers (Appendix 4.1 presents the results of cluster pair-matching). During the village selection process, one village headman declined the invitation to participate; a single village of one cluster was also excluded for security reasons and a new adjoining village selected. An entire cluster was dropped during the preliminary census of children under-three because of concern about the growth monitor's capacity. A new pair-matched cluster was identified and a new growth monitor was recruited, the only person not to be a resident of their cluster but a respected village headman from nearby, who successfully gained permission to work in that community.

State and district characteristics

Jharkhand is one of India's newest states, formally recognised as separate from Bihar since 2000 (Ministry of Health and Family Welfare 2013). 2011 census data estimate Jharkhand's population at nearly 33 million across 24 districts; West Singhbhum has approximately 1.5 million inhabitants, and Saraikela 1.06 million. Orissa comprises 30 districts and has a slightly larger population, approaching 42 million; Keonjhar's population is approximately 1.8 million (Government of India 2011a).

Jharkhand and Orissa are largely rural and many villages and hamlets are located in remote hilly and forested regions. There is a strong reliance upon subsistence farming, but both states are rich in minerals (such as iron) which brings additional employment, much of it informal, in the mining industry. Seasonal migration for daily labour in the summer months is also common (Government of Jharkhand 2013;Government of Orissa 2013a).

A high proportion of people belong to Scheduled Tribes (also known as *adivasi* groups) relative to other social groups. The proportion of *adivasi* groups in the study clusters ranged between 58% and 84% (see Appendix 4.1). More than 26 different *adivasi* groups live in Jharkhand and around 16 groups in Orissa (Government of Jharkhand 2013;Government of Orissa 2013a). Within the three participating districts, the most common *adivasi* groups were Ho, Santhal and Munda and a minority from Juang groups (Government of Orissa 2013b). Whilst *adivasi* groups are recognised as amongst the most underprivileged in India, social organisation and socio-economic position vary widely (Subramanian et al. 2006). For example the Santhal group is one of the largest in India, is less isolated and is now considered a ‘settled agriculturalist’ society. Conversely, Juang communities are characterised by shifting cultivation and are listed as a ‘primitive tribal group’ by the Ministry of Tribal Affairs, with targeted schemes to promote their economy, literacy and population growth (Basu 2000;Ministry of Tribal Affairs 2013).

There are three seasons in Jharkhand and Orissa: Winter (November-February), Summer (March-May) and Rainy (June-October). Food insecurity is widespread and a drought was declared in selected areas in 2010 due to a poor monsoon. Jharkhand and Orissa are two of India’s most food insecure states according to a 2009 report assessing a range of indicators (World Food Programme 2009). A 2007 analysis of food insecurity determinants in Orissa identified the main drivers as lack of physical and human capital, poor economic growth, lack of access to government welfare schemes and public services, absence of land reforms and problems accessing financial credit (Lovendal 2007).

Both Jharkhand and Orissa have been identified by the Indian government as needing targeted support to improve health outcomes, primarily to control the birth rate, reduce the infant mortality rate and the maternal mortality ratio. Keonjhar has been identified as one of fifteen high burden districts of Orissa in terms of undernutrition. Jharkhand and Orissa are also classified as ‘high malaria’ states, and a recent study accounting for bias in reporting of malaria deaths estimated that they account for 10% and 25% of India’s 205 000 annual malaria deaths respectively (Dhingra et al. 2010). Coverage and quality of health facilities, government health initiatives and the prevalence of undernutrition in India were described in chapter 1.

4.2 Ethical approval

Ethical approval was granted for the nutrition survey in the UK by the UCL Research Ethics Committee (Application number 2163/001). We had planned to obtain ethical approval in India, but in the absence of a local university partner or an independent research ethics committee this was not possible. Informed verbal consent to participate in the nutrition survey was sought from each respondent.

4.3 Role of the researcher in the nutrition survey

The nutrition survey required multiple inputs from different people, and it is important to clarify my role within those activities. The design of the survey was organised jointly by me, my supervisors and the staff at Ekjut. Ekjut field managers carried out the process of identifying the new control clusters and got permission from community leaders to carry out the survey; they also recruited the growth monitors and helpers. I led on the development of the survey itself, sourcing the questions and then getting agreement from Ekjut staff about which questions would be included in the final survey. I led on the anthropometric equipment sourcing and training, we jointly decided on the sampling approach (with inputs from a statistician about the sample size calculation), the growth monitors collected the data and were managed by Ekjut field staff. Two data entry clerks entered the data into a database designed by an expert from UCL. I cleaned and prepared the data, devised the analysis plans, and conducted all of the statistical analyses and interpretation of results.

4.4 Census of children under-three

We conducted a census in the new control areas to identify children under-three. We also sought to identify women who were more than six months pregnant so that newly delivered children could be included in the forthcoming nutrition survey. We also collected information on child sex, whether the mother held a Below Poverty Line Card, maternal literacy and social group. To maximise coverage of households, the projected 2009 population for each village was divided by five (assuming five people per household). This gave an approximate number of questionnaires to expect from each village. The growth monitors were also familiar with the villages in their cluster and were asked to survey every house, including hidden hamlets not listed in the census. If there was no response at a household, two further attempts were made before reporting them as a non-responder.

The most difficult information to obtain was children's date of birth: formal birth registration is low, and mothers were often unaware of precise dates of birth. To facilitate this process we developed an events calendar, incorporating local and national dates of importance, growth monitors' knowledge of additional tribal festivals, and phases of the moon. The census was conducted between November 2009 and February 2010 after piloting. Field managers checked data quality and growth monitor performance at weekly face-to-face meetings. The final response rate was 87.8% (n=20,918/23,814).

4.5 Nutrition survey participants

Participants were children under three and their mothers. Multiple births were excluded, as were maternal deaths, because multiple births and children whose mothers have died are known to be at increased risk for undernutrition and mortality (Hong 2006;World Health Organisation 2005;Zhang et al. 2011). If mothers had more than one child under three, both siblings were eligible to take part. Participants from the intervention clusters were limited to women's group members (women had to have attended at least one meeting). Women from the control clusters who had heard of Ekjut and were able to name a women's group facilitator, and those who said they were currently participating in any other NGO-led health or nutrition interventions were excluded.

4.6 Growth monitor recruitment and training

Growth monitor candidates were nominated by community leaders during the process of gaining consent to work in each core community. Selection criteria included being male (for safety reasons), owning a bicycle and having at least 10 years of education. Candidates were interviewed and completed a written test, including arithmetic and the ability to read numbers to two decimal places. After growth monitors were hired, they were asked to identify a 'helper' to assist them during data collection.

All growth monitors took part in a six-day residential training course prior to data collection (24 attended the course in Jharkhand, 12 in Orissa). The focus was on ensuring data quality, particularly in terms of anthropometric measurements. Initial training in anthropometry included WHO training videos, demonstration of equipment, and practice using the equipment with each other and with children of staff members. This was followed by two field visits to local villages: the first to practice weighing and measuring children in a field setting; the second to gauge the quality of the growth monitors' measurements through a standardisation session.

In the standardisation session growth monitors were put into small groups and paired with a 'gold standard' measurer. These were Ekjut field managers who I had trained in anthropometry.

At the time I had two and half years of prior experience measuring child anthropometry and received a refresher training session from a paediatrician before training Ekjut staff. All of the growth monitors and each gold standard measurer took two complete sets of measurements of the same ten children. I calculated intra-observer variability between first and second measurements to assess whether growth monitors were within acceptable WHO error limits: 97.4% were within a 7mm difference for height or length, 99.4% were within 5mm for mid-to-upper arm circumference (MUAC), and 85% were within 100g for weight (De Onis 2006). To assess inter-observer variability I subtracted each growth monitor's mean measurement for each child from the gold standard's mean measurement and applied the WHO error limits as above. Measurement differences were acceptable for 80.3% (weight), 87.1% (height) and 84.1% (MUAC) of growth monitors. Emergency Nutrition Assessment (ENA) SMART software was used to calculate growth monitors' precision and accuracy of measurement in relation to the gold standard as well highlighting digit preferences (SMART 2007). This information was used to give growth monitors individualised feedback and extra support where necessary. Growth monitors were concerned that the weighing scales were inconsistent so we decided to weigh children three times during the survey, allowing calculation of an average to minimise error (details of the equipment used are provided below).

Other aspects of the training included practice listening to and recording numbers, and handwriting checks (growth monitor 'helpers' also underwent this aspect of the training). Growth monitors were shown how to manage and store the equipment safely, and were asked to carry out a weekly calibration of the scales using a 1kg weight. Several days were spent going through the nutrition survey to clarify and refine questions. Growth monitors then piloted the questionnaire in their respective clusters. The questionnaire took about one hour to administer, excluding time taken for anthropometry.

The nutrition survey included a scale to assess maternal psychological distress. Ekjut staff with previous experience of administering this scale (the K10 psychological distress tool) trained growth monitors to ask these questions sensitively (Kessler et al. 2002). Growth monitors were also given guidance and practice interpreting the charts representing maternal Body Mass Index and child weight-for-age, and about how to decide whether mothers or children should be referred for higher-level care (the referral process is described below). On the final day of the Jharkhand training two nurses from the local malnutrition treatment centre visited. They gave details about the treatment that malnourished children receive at the centre and distributed referral slips. In Keonjhar, growth monitors were visited by the assistant Child Development Project Officer who oversees the Integrated Child Development Services at the block-level.

4.7 Nutrition survey content and indicators

In addition to anthropometry, the nutrition survey captured the following information: respondent and household socio-demographic characteristics; household environment, standard of living and sanitation; dietary adequacy and diversity; pregnancy history, antenatal, perinatal and postnatal information; maternal physical and mental health; current health of the child (diarrhoea/fever/cough); healthcare seeking; breastfeeding and complementary feeding; and contact with the Anganwadi worker.

Survey questions were drawn from the following sources: National Family Health Survey-3 (Government of India 2006), Integrated Management of Childhood Illnesses (World Health Organisation and UNICEF 1997), Infant and Young Child Feeding manual (World Health Organisation 2009), Demographic Health Survey (DHS 2013), FANTA (Food and Nutrition Technical Assistance 2013), and surveys from other women's group sites in partner countries of the UCL Institute for Global Health (Bangladesh and Nepal) to enable cross-site comparisons. Some questions were also taken from the existing Ekjut surveillance questionnaire. To avoid repetition for mothers in intervention areas, some questions were asked only in the control areas; skip patterns were included as appropriate. Information provided by Ekjut women's group facilitators and from focus group discussions about the names of local foods allowed the development of a food glossary to assist with the recording of dietary intake. These foods were classified by food group and whether they were rich in particular vitamins for the purpose of analyses (the focus groups are described in chapter 8).

Maternal psychological distress was measured with the Kessler-10 (Kessler et al. 2002). This includes 10 questions that assess the frequency of depression and anxiety symptoms in the last four weeks on a five-point Likert scale (1=none of the time, 5=all of the time). This measure has been established as a valid and reliable screening tool for common mental disorders in developing countries, including India (Kessler and Ustun 2008;Patel et al. 2008). The K-10 was also used in the previous randomised controlled trial to assess psychological distress six weeks after delivery. I have applied the same thresholds to categorise distress as used in the trial: 10-

15=none/mild, 16-30=moderate, 31-50=severe psychological distress (Tripathy et al. 2010).

The final version of the survey was translated into Hindi and Oriya by the Ekjut team.

4.8 Referral pathway

The survey included a referral pathway for mothers experiencing symptoms of severe psychological distress, represented as a flow chart for growth monitors to use. A second referral pathway for children ensured that those identified as moderately or severely malnourished (according to MUAC, the local weight-for-age chart, bilateral pitting oedema, or those with signs of marasmus and/or kwashiorkor) were referred to the Anganwadi worker or a higher-level health facility as appropriate. Procedures were in place to arrange emergency transport where necessary.

4.9 Anthropometry equipment

- Weighing Scale - SECA 874: A battery-powered digital weighing scale including a mother and baby taring button, and with a graduation weight: 50 g < 150 kg > 100 g
- Length measurement (children under 2 years and those not able to stand): SECA measuring mat; measures to the nearest 5 mm
- Height measurement (for mothers, children older than two years and those under-two unwilling to lie down): Leicester height measure; measures to the nearest 1 mm
- UNICEF arm circumference colour-banded tape: red=<115 mm (severely malnourished), yellow=≥115-<125mm (moderately malnourished), green =≥125mm (adequate nutrition)

4.10 Sample size calculation

The survey's sample size was calculated to enable us to detect a difference of 0.2 in weight-for-height z-scores between intervention and comparison groups; this was considered realistic and meaningful in terms of intervention impact. The sample size also took into account potential clustering in the data, as participants within a cluster would be expected to have more similar outcomes than participants between clusters (clustering is described in more detail below).

To estimate the likely extent of clustering within the data we drew upon two published intraclass correlation coefficients from similar studies: 0.017 and 0.054 (Patel et al. 2003;Rahman et al. 2008). We used an intermediary intraclass correlation coefficient of 0.032-0.034, at the 5% significance level, 80% power and a standard deviation of 1 for both intervention and control groups. With assistance from a statistician we also adjusted the sample size to allow stratification of analyses by district using the method described in Hayes and Moulton (2009) in case of substantial between-district variability. We also increased the sample size by a further 20% to account for attrition from seasonal migration, which was expected to be increasing towards the end of the data collection period. The final required sample size was n=5184, and we aimed to sample n=144 children per cluster.

4.11 Sampling strategy

Data collection was due to take place over 13 weeks (Mid February-Mid May 2010), although it eventually continued until the end of June 2010. The minimum child age was eight weeks and the maximum 2.99 years. As part of the surveillance system in the intervention clusters (set up for the randomised controlled trial) Ekjut data monitors interviewed all women six-weeks postnatally as standard. There was an approximate two-week time lag for data to be entered into the database and hence the minimum child age was eight weeks. The same age limits were applied when sampling children in the control areas to ensure comparable age ranges.

In the census of children under-three in the control areas, pregnant women were asked to estimate their gestation period. Women estimating their pregnancy as six months or more were expected to have delivered eight weeks before data collection, and thus we included their unborn children in the sampling list. As previously noted, we excluded multiple births, maternal and neonatal deaths and stillbirths.

In the intervention areas, we used Ekjut surveillance data to randomly select 144 children per cluster using Stata 10.0. In two intervention clusters there were only n=118 and n=104 eligible children and in these clusters all eligible children were selected. In the control areas we followed the same random sampling procedure in Stata but deliberately oversampled above n=144. This was to account for potential data entry errors in the census survey for which there was minimal time for data cleaning prior to data collection.

After random sampling, children were randomly assigned a testing week (1-13) to minimise bias, and eligibility of children according to their projected age on their given testing date was checked, resulting in some manual reassignment of older children. Siblings were manually re-assigned to the same testing week (again ensuring age eligibility) to allow mothers with more than one eligible child to be interviewed on a single occasion.

4.12 Data collection

Growth monitors were given lists of children to measure in their cluster during particular testing weeks, arranging interviews in advance where possible to maximise the response rate. Three attempts were made to contact mothers before recording them as a non-responder. Growth monitors' workload averaged just over two surveys per day, assuming a 5-day working week for the initial three-month period of data collection. All growth monitors were in contact with Ekjut field staff by mobile phone, and returned completed data forms and resolved any queries at weekly supervision meetings with field managers; random spot checks were conducted of growth monitors in the field.

4.13 Response rate

The response rate for the planned sample was 85.7% for the intervention group (n=2163) and 86.6% for the control group (n=2267). Using census data from the control areas and Ekjut surveillance data from the intervention areas I compared responders and non-responders for maternal literacy, social group and Below Poverty Line card possession.

In the intervention areas maternal literacy (partial or full reading ability) was significantly higher in the responder group (31.6%) than the non-responder group (20.1%): χ^2 (1)=18.730, p=<0.001. The Cramer's V statistic indicates a small but significant effect size (0.090, p<0.001); the odds ratio shows that responders were 46% less likely to be illiterate (no reading) than non-responders. In the control areas maternal literacy was slightly higher in the responder group (29.9%) than in the non-responder group (25.3%): χ^2 (1) = 2.940, p=0.086. The Cramer's V statistic reflects a small effect size (0.034, p=0.086) and the odds ratio shows that responders were 20% less likely to be illiterate than non-responders.

In the intervention sample there was no difference in proportions of different social groups between responders and non-responders: Fisher's exact test (3) = 4.612, p=0.175. Nearly 80% of the sample comprised tribal groups, 3.7-4.7% Scheduled Caste groups and 13.5-17.6% Other Backwards Class groups (very few were 'other' group). Similarly in the control areas there was no difference in the proportion of different social groups by responder status ($\chi2$ (3) = 3.251, p=0.354), and these were also very similar to the intervention sample.

There was no difference in the proportion of women with a below poverty line card by responder status: intervention responders (61.9%) versus non-responders (63.0%): χ^2 (1) = 0.145, p=0.703; control group responders (61.8%) versus non-responders (65.1%): χ^2 (1) = 1.311, p=0.252. Overall, these comparisons indicate a slight response bias towards literate women, which was slightly more pronounced in the intervention group than the control. There were no significant differences by social group or below poverty line card.

4.14 Data quality and preparation

Data were entered and managed in an Access database (2007) designed by a database expert at UCL. Field limits were set where possible to flag up data entry errors in real time. Key variables (dates, sex, and anthropometric measurements) were double-entered by data entry clerks. Using a Visual Basic programme I identified discrepancies between first and second entries. Mistakes were rectified by returning to the original data form and entering the correct information. I also ran frequencies and scatter plots to identify out of range values and outliers.

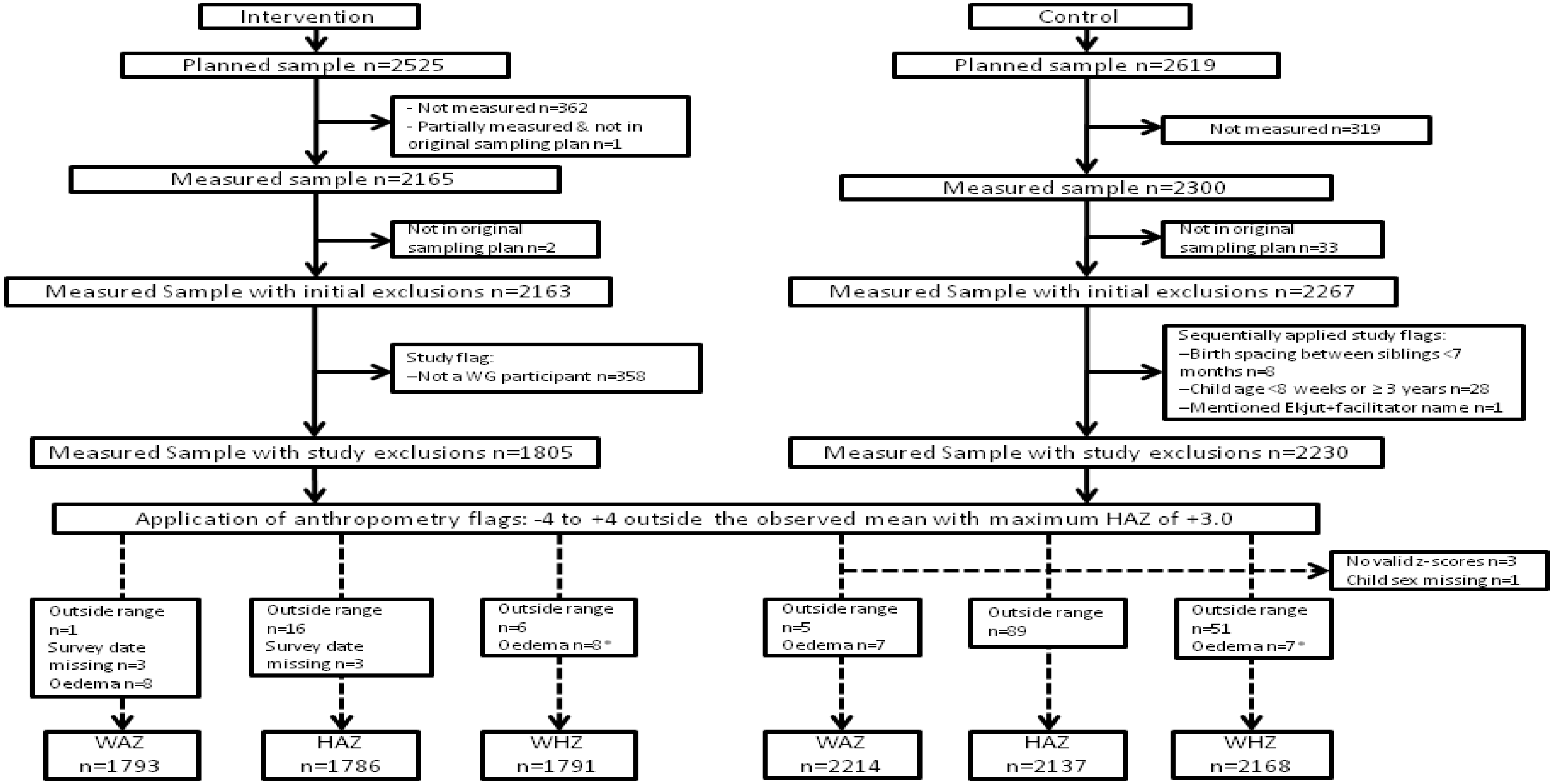
I excluded some cases based on study eligibility. One key inclusion criteria for the intervention group was that women had attended at least one women's group meeting; a series of filter questions revealed that n=358 had never done so and were excluded. Similarly, one woman in the control group had heard of Ekjut women's groups and was able to name a facilitator, so was excluded. A number of children who were not in the original sampling list were measured in error (intervention n=2, control n=33), 28 children in the control area did not meet the age criteria and eight women reported implausible dates of birth between siblings (<7 months) and were excluded.

Flagging criteria were also applied to anthropometry data to identify implausible z-scores using ENA for SMART software (version 2007). This programme can be customised to flag different cases depending on the criteria used. Several flagging options exist including 'SMART' flags (originating from National Centers for Disease Control growth standards) and World Health Organisation criteria. The WHO (1995) recommend including z-scores +/-5 (weight-for-height), -6-+5 (weight-for-age) and +/-6 (height-for-age) from the median of the reference group, provided the sample mean is >-1.50. However the initial mean weight-for-height Z-score for the current study was ≤-1.71 and in this case a flexible range either side of the sample mean is advised (World Health Organisation 1995).

The flexible range of SMART flags exclude cases +/- 3.00 Z-scores from the observed mean for weight-for-height, weight-for-age and height-forage Z-scores. This is relatively strict compared to the WHO who advise excluding cases +/- 4.00 Z-scores (maximum HAZ +3.00) (SMART 2007;World Health Organisation 1995). Although the WHO flexible range was recommended on the basis of NCHS reference data, applying these criteria may have been more appropriate than using the more stringent SMART flags, which could have excluded genuine cases of severe undernutrition.

The flow of participants from the initial sampling stage, through data collection, and after the application of study and anthropometry flags is shown in Figure 4.3. Table 4.1 describes the extent of participation in the intervention by women's group members by district after applying the study and anthropometry flags.

Figure 4.3 Flowchart of participants during sampling, data collection and retained in the final analyses



*Oedema cases were included in prevalence estimates of Global and Severe Acute Malnutrition

Table 4.1 Extent of participation in the women's groups intervention by district

Aspect of participation			West Singhbhum N=601	Saraikela N=598	Keonjhar N=606	All N=1805
Number of meetings attended[1,2]	N		553	586	562	1701
	Mean (SD)		4.74 (4.25)	5.16 (5.48)	5.62 (5.8)	5.17 (5.24)
	Median (IQR)		3 (2,5)	3 (2,5)	4 (2,6)	3 (2,5)
	Mode		2	3	2	2
	Range		1-30	1-38	1-35	1-38
Attended ≥1 maternal and newborn health meeting (Cycle 1)	Yes	% (n)	91.3(549)	95.2 (569)	95 (576)	93.9 (1694)
	No	% (n)	8.5 (51)	4.8 (29)	5.0 (30)	6.1 (110)
	Missing	% (n)	0.2 (1)	-	-	0.1 (1)
Attended ≥1 child health and nutrition meeting (Cycle 2)	Yes	% (n)	91.0 (547)	94.1 (563)	75.1 (455)	86.7 (1565)
	No	% (n)	8.8 (53)	5.9 (35)	24.9 (151)	13.2 (239)
	Missing	% (n)	0.2 (1)	-	-	0.1 (1)
Attended ≥1meeting from both Cycles 1 and 2	Yes	% (n)	91.0 (547)	92.6 (554)	72.4 (439)	85.3 (1540)
	No	% (n)	8.8 (53)	7.4 (44)	27.6 (167)	14.6 (264)
	Missing	% (n)	0.2 (1)	-	-	0.1 (1)

[1]n=104 missing

[2]Missing by district: West Singhbhum (n=48), Saraikela (n=12), Keonjhar (n=44)

More than 90% of participants in West Singhbhum and Saraikela had attended at least one meeting from both women's group cycles. Cycle 2 attendance was slightly lower in Keonjhar (72.4%). The mean number of meetings attended overall was similar between districts.

4.15 The development of socio-economic quintiles

Poverty is one of the root causes of child undernutrition and should be accounted for in statistical models as an explanatory or confounding factor. However, poverty is complex and difficult to measure in a meaningful way, particularly in deprived areas where single measures (e.g. household income) fail to distinguish between poor households. There has been a recent shift towards the creation of multi-domain poverty indices that differentiate between households of differing socio-economic status. For example, the Multidimensional Poverty Index includes ten indicators of health, education and standard of living (Alkire and Santos 2010). Other researchers have included a variety of indicators in principle components analyses

(PCA) to derive socioeconomic quintiles or tertiles (Menon et al. 2000;Vyas and Kumaranayake 2006). Although this study focuses on particularly underserved rural communities, socio-economic variability is still likely to exist and I used a principal components analysis to create socio-economic quintiles. A number of potential variables were considered for inclusion in the analyses, based on elements of the Multi-dimensional Poverty Index and two similar principal components analyses to derive socio-economic quintiles (Menon et al. 2000;Vyas and Kumaranayake 2006).

The initial criteria for inclusion in the analyses were that the indicator should have been measured in both the intervention and control areas, with a minimum of 5% of respondents in each category. There was insufficient variability in sanitation data: >99% of respondents reported open defecation.

The resulting candidate PCA variables were:

1. Household assets: electricity 36.4%; fan 11.7%; radio 18.4%; bicycle 74.9%; motorcycle 6.9% (there was insufficient variability for television ownership).
2. Land ownership: no land 11.3%; <2 bighas/land mortgaged 38.9%; 2-4 bighas 34.1%; ≥4 bighas 15.7% (one bigha is approximately 0.5 acres).
3. Possession of Below Poverty Line Card 61.0%.
4. Maternal literacy: cannot read 71.1%; reads with difficulty 7.2%; reads easily 21.7%.
5. Income group (real income data were not available): this was estimated from a list of 12 occupations representing the main source of household income in the study areas, and additional free text. These were coded as low, middle or high-income with the help of senior staff at Ekjut to reflect how lucrative these occupations would be: poorest (72.2%), medium poor (24.1%), least poor (3.7%). Although the least poor group was <5%, this variable was retained for further testing because it was the only variable to give some indication of current household income.
6. Household overcrowding (the number of people normally living in the household divided by the number of rooms used for sleeping). The United Nations (2011) defines an insufficient living area as more than three people sharing a bedroom (61% in this sample). A limitation of this variable is that we do not have the size of the sleeping area, which is usually included in the calculation.

7. Source of drinking water: unimproved (32%) versus improved or piped into dwelling (68%) (World Health Organisation 2004a).
8. Distance to drinking water source (round trip): inaccessible was defined as >30 minutes (8%) versus accessible (≤30 minutes, 92%) (United Nations 2011).
9. Cooking fuel: According to the multi-dimensional poverty index, households cooking with wood, charcoal or dung are defined as the poorest (91.6%) compared to users of other types of fuel (8.4%) (Alkire and Santos 2010).

These variables were subject to two further stages of testing: firstly, I ran bivariate correlations (Spearman's and Pearson's) to check for strength, direction and consistency of sign between parametric and non-parametric matrices. The strength of correlations varied but most were positive. There were two exceptions: below poverty line card possession was negatively correlated with all other variables, except for a weak positive relationship with land ownership and household income was inconsistently related to other variables. Electricity and radio ownership were negatively correlated, but the relationship was weak and non-significant ($r=-0.19$, $p=0.236$).

In the second stage, mean scores for less widely recognised measures of poverty and those not consistently related to other variables in the first stage (household overcrowding, income, below poverty line card, motorcycle, bicycle, radio and fan) were calculated for each level of more consistent and widely published poverty measures, including maternal literacy, land ownership, electricity, drinking water source, time taken get drinking water and cooking fuel (Alkire and Santos 2010).

This indicated that below poverty line card and household income were distinct from the other indicators of socio-economic status, so they were excluded from the principle components analysis. Below poverty line cards are problematic poverty indicators: evidence suggests that many people meeting the criteria to own a card have not been given one and vice-versa, which might explain the pattern seen here (Singh 2010). The creators of the Multidimensional Poverty Index describe income poverty as distinct from indicators of health, education and standard of living, which may explain why the income indicator does not relate consistently to the other indicators (Alkire and Santos 2010). Radio ownership was consistently related to all variables except electricity and was included in the initial PCA.

Principle Components Analysis

The principle components analysis was run in SPSS version 19 and was set to extract a single component. I ran the model several times to achieve the best possible fit to the data. Both water-related variables and radio ownership were excluded because they reduced model fit or had factor loadings ≥0.4 in line with published guidance (Field 2009). The factor loading for landownership was borderline for inclusion at 0.399 but was retained in the final model (see Table 4.2 for factor loadings of final variables).

Table 4.2 Factor loadings of variables included in socio-economic quintiles

Survey question	Component
	1
Which of these do you presently have in your household? A fan	.743
Which of these do you presently have in your household? Electricity	.661
Maternal literacy recoded for PCA: Cannot read, partial reading, reads easily	.618
Which of these do you presently have in your household? Motorcycle	.566
Which of these do you presently have in your household? Bicycle	.488
Fuel type - dung, wood charcoal=most poor, gas/coal/kerosene/oil= least poor	.468
Land ownership: no land, <2 bighas/land mortgaged, 2-4 bighas, 4 or more bighas	.399

Model characteristics

There was no indication of multicollinearity (all correlations were <0.9; the determinant of the matrix was >0.001 at 0.443) (Field 2009). The sampling adequacy was good: the overall Kaiser-Meyer-Olkin (KMO) value was 0.724 and individual KMO scores were all >0.67 (Field 2009). Similarly, Bartlett's test of sphericity indicated that relationships between variables were significant and suitable for the principle components analyses (p<0.001). Missing data were excluded listwise (n=255) but were accounted for in subsequent analyses using multiple imputation.

Model weaknesses included lower correlations between variables (few were >0.3) compared to published correlations of similar approaches (Menon et al. 2000). Secondly, a high percentage of residuals between the model-based correlation matrix and the actual correlations were >0.05 indicating suboptimal model fit. Field (2009) suggests a benchmark of 50% of residuals at >0.05 as acceptable although there is no formally accepted threshold; 66% of the residuals in the final model were ≤0.065 which is close to Field's recommendation.

The total variance explained by the first principle component was 32.9%. Moderate reliability was found for the components of the model (α=0.562) considering the diversity of included variables. The raw score for the principle component was positively skewed, indicating that a larger proportion of people scored at the lower end of the distribution; this was used to generate SES quintiles.

Socio-demographic characteristics by exposure group

Parental and household level characteristics are shown in Table 4.3.

Table 4.3 Socio-demographic characteristics by exposure group: % (n) unless stated

Characteristic		Intervention n=1805	Control n=2226
Marital status	Married	99.1 (1789)	99.6 (2216)
	Co-habiting/divorced/widowed	0.9 (16)	0.4 (10)
Maternal age marriage	Mean (SD)	18.53 (2.27)	18.44 (2.32)
	Unknown/missing % (n)	0.1 (1)	3.6 (80)
Status within household	Household head	1.4 (25)	0.7 (15)
	Wife	79.3 (1431)	73.6 (1638)
	Daughter in law	18.5 (334)	24.8 (552)
	Other relative	0.8 (14)	0.9 (21)
	Not related	0.1 (1)	-
Maternal age (years)	Mean (SD)	27.40 (5.14)	26.63 (5.27)
	Unknown/missing % (n)	7.6 (137)	7.1 (158)
Paternal age (years)	Mean (SD)	32.04 (5.67)	31.34 (6.24)
	Unknown/missing % (n)	8.6 (156)	8.1 (181)
Religion	Sarna	48.6 (878)	45.7 (1018)
	Hindu	46.5 (839)	51.9 (1155)
	Christian	4.6 (83)	1.4 (31)
	Muslim	0.1 (1)	0.4 (9)
	Other	0.2 (4)	0.6 (13)
Social group	Scheduled Tribe	78.9 (1425)	77.5 (1726)
	Scheduled Caste	3.4 (62)	2.0 (44)
	Other Backwards Class	17.4 (314)	18.3 (408)
	Other/missing	0.2 (4)	2.2 (48)
Maternal literacy	Cannot read	61.8 (1115)	68.0 (1513)
	Partial reading	7.5 (135)	7.0 (155)
	Reads easily	21.5 (388)	21.9 (488)
	Missing	9.3 (167)	3.1 (70)
Maternal education[1]	No schooling	69.4 (1253)	69.0 (1536)

	Primary school (1st-5th year)	5.8 (105)	3.7 (83)
	Secondary school (6th-8th year)	23.5 (424)	25.1 (559)
	≥Higher secondary (≥9thyear)	1.2 (22)	2.2 (48)
Paternal education	No schooling	17.8 (322)	42.3 (941)
	Primary school (1st-5th year)	5.3 (95)	16.1 (358)
	Secondary school (6th-8th year)	5.5 (99)	13.6 (303)
	≥Higher secondary (≥9thyear)	11.2 (202)	28.0 (624)
	Missing	60.2 (1087)	-
Household assets[1]	Electricity	19.4 (351)	50.1 (1115)
	Fan	5.7 (103)	16.5 (368)
	Radio	20.2 (365)	16.8 (375)
	Bicycle	76.1 (1373)	73.9 (1646)
	Motorcycle	6.9 (124)	7.0 (156)
Land ownership[1]	No land	9.4 (169)	12.8 (286)
	<2 bighas[2]/land mortgaged	46.1 (832)	33.1 (737)
	2-4 bighas	33.5 (604)	34.6 (770)
	>4 bighas	11.1 (200)	19.4 (432)
Cooking fuel as poverty Indicator[3]	Least poor	2.4 (44)	13.2 (295)
	Most poor	96.8 (1747)	86.7 (1929)
	Missing	0.8 (14)	0.1 (2)
Below Poverty Line card	No/Applied for	37.0 (669)	37.1 (825)
	Yes	62.9 (1135)	59.5 (1325)
	Missing	0.1 (1)	3.4 (76)
Income category[1]	Lowest	59.6 (1076)	82.3 (1833)
	Middle	37.8 (682)	13.1 (291)
	Highest	2.6 (47)	4.5 (101)
Socio-economic quintile	Lowest SES group	18.7 (338)	19.0 (422)
	Second lowest SES group	19.2 (347)	11.4 (254)
	Middle SES group	25.0 (452)	22.1 (493)
	Second highest SES group	16.5 (298)	18.8 (418)
	Highest SES group	10.5 (189)	25.4 (565)
	Missing	10.0 (181)	3.3 (74)

[1] n=1 missing case for this variable
[2]Bighas are a measure of land area in India, variable by region: 1 bigha is about 0.5 acres in Jharkhand and Orissa
[3]Wood/leaves/dung/charcoal=poorest, coal/oil/kerosene/gas=least poor (Multi-dimensional Poverty Index, 2010)

Testing for exposure group differences for socio-demographic characteristics

I did not test for group differences for variables already included in the socio-economic quintiles, as these were not considered as separate covariates in subsequent analyses. Of these variables a slightly lower proportion of women were illiterate in the control areas (~2%), >50% had electricity in the control group compared to under a fifth in the intervention group, and cooking fuel type indicating greater poverty was 10% higher in the intervention compared to the control areas. A greater proportion of the control group owned no land compared to the intervention group, but nearly double the proportion of control group participants owned >4 bighas (one bigha is about 0.5 acres) compared to intervention group.

I did not test for group differences on father's education because >60% were missing in the intervention group (due to changes in the surveillance questionnaire). From the available data, a slightly greater percentage of fathers in the intervention areas had not received any schooling compared to the control areas (44.8% versus 42.3%). I also excluded age at marriage from these tests because this variable excludes women who were divorced, widowed or unmarried.

The remaining socio-demographic variables were tested for significant group differences using $\chi 2$ or Fisher's exact tests, t-tests or Mann Whitney U tests as appropriate (Table 4.4). For t-tests I also calculated the effect size (r); for $\chi 2$ tests I looked at the strength and direction of standardised residuals (z) to understand the nature and significance of group differences (z +/- 1.96, $p<0.05$) and Cramer's V to estimate effect size (Field 2009). Any significantly different variables were adjusted for in subsequent analyses of primary and secondary outcomes (chapters 5 and 6).

I also tested for group differences on season of measurement: data collection began two weeks later in the control group and slightly more children may have been measured in the summer months, which could relate to differences in anthropometry and other outcomes.

Table 4.4 Socio-demographic and other exposure group differences

Socio-demographic characteristic	χ2/Fisher's exact or t/U	P
Marital status	4.56	0.17
Status within household	24.11	<0.001
Maternal age (years)	4.45	<0.001
Paternal age (years)	4.49	<0.001
Religion	51.90	<0.001
Social group	34.57	<0.001
Maternal education	15.47	0.001
Below Poverty Line card	0.69	0.41
Income category	333.67	<0.001
Socio-economic quintile	162.41	<0.001
Season measured	73.37	<0.001

Results from tests of group differences

There were no group differences for below poverty line card or marital status (the vast majority of participants were married). The remaining variables all showed significant group differences although effect sizes tended to be small, except for income group and socio-economic quintile.

There were significant group differences for income group, and this had a medium effect size (Cramer's V=0.288, p<0.001). Significantly more of the control group were in the poorest income group compared to the intervention (82.3% z=5.7 and 59.6% z=-6.3 respectively). Conversely, there were significantly more respondents in the middle-income group in the intervention areas (37.8% z=11.8) than the control (13.1% z=-10.6). Finally, there were more control group respondents in the highest income category than the intervention group (2.6% z=2.1 and 4.5% z=-2.4 respectively).

There was also a medium effect size for group differences on three out of five socio-economic quintiles (Cramer's V=0.207, p<0.001). The second lowest quintile had significantly more intervention participants (21.4% z=5.5) compared to controls (11.8% z=-4.8); a similar pattern was seen for the middle quintile (intervention z=2.3; control z=-2.0). The reverse was true for the highest quintile, with significantly fewer intervention and significantly more control participants in this group (11.1% z=-7.5 and 26.3% z=6.5 respectively). The differences were not significant for the lowest and second highest quintiles.

Maternal and paternal age were highly correlated (r=0.85, p<0.001) indicating probable multicollinearity. In subsequent analyses I have focused on maternal age as women tend to be the main caregivers and their characteristics may have a stronger influence over child growth.

Despite there being statistically significant group differences for a range of socio-demographic characteristics, most of the associated effect sizes were small, indicating generally well-matched intervention and control groups. The exceptions were income group and socio-economic quintile, which showed moderate exposure group differences, although not clearly favouring one group over the other.

4.16 Statistical approaches

It is likely that the nutrition survey data contains clustered, non-independent observations because particular conditions within clusters (e.g. distance to a health care facility) will be more similar than between clusters. This reduced within-cluster variability may be particularly pronounced in the intervention clusters where additional inclusion criteria required mothers to be a member of an Ekjut women's group, possibly attracting women from more similar backgrounds than non-members. Failing to account for correlated observations in the analyses could seriously affect the results. Specifically, the likelihood of a type 1 error (falsely rejecting the null hypothesis) would increase due to underestimation of standard errors and confidence intervals (Field 2009;Kirkwood and Sterne 2003).

Two main categories of model account for correlated observations: random effects models and generalised estimating equations:

1. Random-effects models explicitly model random intercepts and/or slopes of regression models to estimate the inter-relatedness of responses within a cluster (Kirkwood and Sterne 2003). These models assume that clustered variables are from a 'probability distribution' and that the effects occur randomly within a cluster and are normally distributed. Arguably, random-effects models are superior to generalised estimating equations for linear outcomes because they can model slopes and intercepts, and because they can incorporate three or more

levels of hierarchical data (although in practice results tend to be very similar). However, they can be unstable for binary outcomes if the intra-cluster correlation coefficient is greater than 0.2 because they rely upon 'numerical quadrature' to approximate the normal distribution (Kenward 2008, unpublished course notes; Hayes and Moulton 2009).

2. Generalised estimating equations (GEE) account for clustered data through weighting of observations, and the adjustment of standard errors and parameter estimates (Hanley et al. 2003;Kirkwood and Sterne 2003). These models assume that within-cluster observations are correlated and have the same correlation coefficients (ρ) whilst assuming zero correlation between clusters; this 'exchangeable correlation matrix' would be applicable to individuals living in geographic clusters (Hanley et al. 2003;Kirkwood and Sterne 2003). GEE models estimate the strength of 'ρ' to weight within-cluster observations and construct the most appropriate model for the data. Odds ratios are based on the population average rather than cluster-specific odds ratios in random effects models. GEE is not a maximum likelihood method and does not enable the calculation of likelihood or the use of likelihood ratio tests of model fit. Instead GEE uses 'generalised least squares' and 'robust standard errors' (based on observed variability rather than predicted variability) via a 'sandwich variance estimator'. The Wald test is used to assess model fit in conjunction with probability tables for significance testing. For linear outcomes, GEE may be less efficient than random-effects models, but they are able to cope with highly clustered data testing binary outcomes (Hanley et al. 2003;Kirkwood and Sterne 2003).

Model selection

To decide which approach was the most appropriate for the data I ran binary logistic models testing the effect of exposure group and socio-economic status on two outcomes: global acute malnutrition (GAM) and repeated diarrhoeal infection; I compared results using the two different approaches and assessed the size of the intra-cluster correlation coefficient.

Model 1 (outcome: GAM): Both models gave very similar estimates for exposure group (GEE 0.093 p=0.760 and random-effects 0.099 p=0.753); all quintiles were highly significant. The intra-cluster correlation coefficient for the random-effects model was 0.009 (95% confidence intervals 0.003-0.027) indicating the suitability of this method for GAM because the data are not overly correlated within clusters. This is supported by existing literature that reports undernutrition as clustering strongly within households but not at the village level (Rao et al. 2004).

Model 2 (outcome: repeated diarrhoeal infection): Again both models gave similar results (GEE 0.092, p=0.761 and random-effects 0.111, p=0.739). However, the intra-cluster correlation coefficient for the random effects model was large (0.37, 95% CIs 0.25-0.50) suggesting that this outcome is too highly clustered to use this type of model. For infection-based outcomes such as diarrhoea, it is plausible that clustering will be high within villages (e.g. if a shared water source was contaminated). Behavioural outcomes tested in chapter 6 are also likely to be highly clustered (e.g. health-care seeking and behaviours targeted by women's groups in intervention clusters).

Both types of model gave comparable results for GAM, but the suitability of random effects models was questionable for repeated diarrhoea, and could be problematic for behavioural outcomes. I therefore chose to use GEE models in SPSS (version 19) for the remainder of the analyses. The following sections describe the analysis of the survey data. The analytical strategies described below were set out prior to beginning the analysis.

4.17 Analysis overview

My analyses of the nutrition survey data are presented in the following three chapters.

In chapter 5 I have analysed the association between exposure to the intervention and the primary outcomes: stunting, wasting, underweight and mid-to-upper arm circumference. I adjusted the estimates for clustering and socio-demographic differences between exposure groups. Using backwards, stepwise regression methods, I sequentially removed least significant socio-demographic covariates according to goodness of fit criteria, continuing iterations until the most parsimonious model had been achieved. Backward stepwise methods are preferred to forward methods because they avoid 'suppressor effects' where a predictor may be significantly association with an outcome, but only when certain other variables are controlled for; forward methods increase the risk of type II errors as they may wrongly rid your model of a suppressed predictor (Field 2009;Tabachnick and Fidell 2007). The goodness of fit measures in GEE using SPSS are the 'quasi likelihood under independence model criterion' which assesses the suitability of the underlying correlation structure, and the 'corrected quasi likelihood under independence model criterion' which assesses the fit of model predictors. The principle of 'smaller is better' applies to both criteria, and resembles 'Akaike's information criterion'. A difference of 10 between models using Akaike's information criterion indicates substantial improvement to fit whereas <2 is negligible; I have applied this rule to the GEE goodness of fit measures (Carnegie Mellon University 2010;Field 2009;Reed and Kaas 2010).

In Chapter 6 I have analysed the association between intervention exposure and key health behaviours and indicators related to child growth that were addressed by the women's groups. These analyses are also adjusted for clustering and socio-demographic variables that were different between exposure groups. Again, I used backwards, stepwise regression methods based on differences in goodness of fit between model iterations to achieve parsimony. The models presented in chapter 6 can be divided into the following categories:

1. Pregnancy-related behaviours (e.g. reducing anaemia in pregnancy via dietary changes).
2. Breastfeeding and young child feeding (e.g. early initiation of breastfeeding).
3. Prevention and management of childhood illnesses (e.g. use of oral rehydration solution for child diarrhoea).
4. Hygiene and sanitation related behaviours (e.g. hand washing after defecation).
5. Growth monitoring and case-finding for child underweight (e.g. improved maternal awareness of child underweight).
6. Maternal and child health indicators (e.g. child diarrhoea, maternal psychological distress)

In Chapter 7 I have identified local determinants of child stunting, wasting, underweight and mid-to-upper arm circumference in GEE models adjusted for clustering. I used backwards, stepwise regression methods to identify the most significant determinants of undernutrition based on a threshold p-value of ≤0.1. I restricted the analyses to the control clusters to ensure no confounding or effect modification of the intervention, and focused on the 6.00-23.99 month age group. I considered variables that are known risk and protective factors for child undernutrition in these models, using the UNICEF conceptual framework as a guide (UNICEF

1990;UNICEF 1998).

Interactions

When exposure group emerged as significant (p<0.10) in any of the final models in chapters 5 and 6 I explored interactions with socio-demographic variables identified apriori, and that were significantly different between exposure groups. Significant determinants of undernutrition in the final models in chapter 7 were also explored for interactions if there was theoretical justification for doing so. Kirkwood and Sterne (2003) suggest waiting until the latter stages of analysis to test interaction terms, and to consider them in simple models with few parameters; any interaction terms that are significant in simple models (p<0.10) have been discussed in supporting text.

Kirkwood and Sterne advise against a systematic and exhaustive search for interactions because this can result in chance effects whilst genuine interactions may not be detected (Kirkwood and Sterne 2003). In chapters 5 and 6, I explore interactions between exposure group and: socio-economic status, income group, maternal education and social group. This is due to the potentially differential impact of being of lower socioeconomic status, income, education or from a more disadvantaged social group in the intervention areas compared to the control: during the trial the most disadvantaged groups derived more benefit from the intervention compared to the least disadvantaged whereas disadvantaged groups in the control areas would not have derived any benefit due to non-exposure to the intervention.

The women's groups could have also lessened the impact of challenging environmental and economic conditions because many group strategies involved the diversion of community and household resources to address child health issues. There could have been a further differential effect of status within the household on various outcomes between exposure groups: the trial data indicate that women's groups increased women's decision-making power, perhaps resulting in women having a greater say over the allocation of household resources and child care, regardless of whether they were the wife or the daughter-in law of the household head (Montalvao et al. 2011).

Sibling pairs

To deal with potential within-household clustering of outcomes due to the presence of sibling pairs I re-ran each of the final models, removing one randomly selected child from each pair, to assess whether this made a meaningful difference to the findings. As there were relatively few sibling pairs in the dataset (intervention n=32; control n=44) the inclusion of both children was unlikely to have a strong influence on the results of each model but I wanted to minimise bias where possible.

Missing data

I used multiple imputation to replace missing predictor data with predicted values; I did not impute missing outcome data. The default of most statistical programmes is to exclude entire cases (listwise) if data are missing on *any* variable. This approach would have led to a cumulative loss of participants missing data on any socio-demographic predictors in chapters 5 and 6, and any determinant included in chapter 7. This would have seriously reduced the power of the analyses and the precision of estimates. Ignoring missing data may have also produced biased estimates, particularly if there was a systematic pattern to the 'missingness' (Sterne et al. 2009). Other accepted approaches to dealing with missing data include using partially observed data to create a more general model (random-effects models) and maximum likelihood estimation (Sterne et al. 2009), but these approaches are not compatible with GEE.

The majority of missing data were for maternal age (n=295; 7.3%) and socio-economic status (n=255; 6.3%). Missing socio-economic data disproportionately affected the intervention clusters. This was largely explained by changes to the questionnaire in different years of surveillance: particular versions of the questionnaire omitted some of the household assets that were used to generate socio-economic quintiles leading to missing data. It was more difficult to ascertain the nature of missing data for maternal age as it was spread evenly across socio-economic, education, social and religious groups. It was more concentrated in Saraikela district than any other and on further examination one particular cluster in Saraikela (and hence one particular growth monitor) accounted for more than one-third of missing values (n=101). Here women reported that they did not know their age, and these missing data are more likely to reflect a difference in interview style than a systematic age difference between those able and unable to respond to the question.

Some data may have been missing for other reasons. For example, during piloting, one respondent in the control area was reluctant to provide household asset information because she feared this would compromise her eligibility for a below poverty line card. It is therefore possible that some missing socio-economic data originate from respondents with higher socio-economic status. These types of missing data are referred to as 'missing at random' because there is a systematic difference between missing and observed values that can be accounted for by other variables in the dataset (e.g. maternal educational was positively associated with socio-economic quintile) (Sterne et al. 2009). It is also possible that some cases had data missing 'not at random' whereby there is a systematic pattern of 'missingness' that cannot be explained by other variables in the dataset. There is no ideal approach for dealing with this type of missing data (Sterne et al. 2009).

It is important that the variables included in multiple imputation models are related to the variables affected by missing data. This ensures the most reasonable predicted values are generated. The following variables were included: child age (correlated with maternal age), maternal education (correlated with socio-economic quintile), anthropometric outcomes (all positively correlated with socio-economic quintile and negatively with maternal age), social group (women from Scheduled Tribes tended to be from lower socio-economic groups), religion (Sarna tended to be from lower socio-economic groups), relationship to household head (daughters in law tended to be younger), income group (correlated with socio-economic quintile), district (women from Saraikela district tended to be from higher socio-economic groups).

The multiple imputation method uses the variables in the imputation model to create multiple versions of the original dataset. Each imputed dataset includes predicted values in lieu of missing data, based on the values of other variables in the imputation model. The method also adds appropriate variability to account for statistical uncertainty about the accuracy of the imputations within and between imputed datasets. I created 20 imputed datasets in line with Sterne's recommendation and constrained maternal age to fall between 13 and 55 years in line with the original data. I then re-ran each final model on the imputed datasets (Sterne et al. 2009). This produced a pooled estimate which I have presented alongside findings from the final listwise models, based on STROBE reporting guidelines for observational studies (Sterne et al. 2009;STROBE 2007).

The following chapter explores associations between intervention exposure and a range of child anthropometric outcomes.

Chapter 5

Were levels of child undernutrition lower in intervention areas compared to control areas?

5.1 Chapter overview

In this chapter I present the associations between exposure group and child anthropometric outcomes, before and after adjustment for socio-demographic variables. I adjusted for socio-demographic variables that were significantly different between exposure groups and were associated with the outcome at $p<0.10$ in simple univariate generalised estimating equation models (GEE) that also included exposure group. The full models, including the contribution of all predictors to each outcome are reported in the appendices. The appendices also include estimates for model predictors from multiple imputation models accounting for missing data and models with one randomly selected child of each sibling pair excluded.

5.2 Association between intervention exposure, child wasting and acute malnutrition

I considered child wasting as a linear outcome (weight-for-height Z-score/WHZ) as well as the binary outcomes Global Acute Malnutrition (GAM) and Severe Acute Malnutrition (SAM) to allow incorporation of oedema cases (GAM is defined as WHZ <-2.00 +/- oedema and SAM is defined as WHZ <-3.00 +/- oedema). The final models testing the association of intervention exposure with these three outcomes, adjusted for socio-demographic variables, are shown in Table 5.1. Results from multiple imputation and sibling-adjusted models are presented in appendices 5.1-5.3.

Table 5.1 Associations between intervention exposure, child wasting and acute malnutrition adjusted for socio-demographic variables (0=control, 1=intervention)

Outcome	Mean (SD) or % (n)			Unadjusted	Adjusted
	Intervention N=1791 +8 oedema	Control N=2198 +7 oedema	Total N=3959 +15 oedema	β/OR (95%CI)	β/OR (95%CI)
Weight-for-height Z-score[1]	-1.78 (1.07)	-1.68 (1.24)	-1.72 (1.17)	-0.105 (-0.255-0.046)	-0.049 (-0.174-0.076)
Global Acute Malnutrition[2]	41.7% (751)	39.2% (853)	40.4% (1604)	1.118 (0.915-1.366)	1.020 (0.843-1.233)
Severe Acute Malnutrition[3]	14.1% (253)	13.6% (295)	13.8% (548)	1.037 (0.798-1.348)	0.926 (0.724-1.184)

[1]Adjusted for socio-economic quintile, social group and maternal age
[2]Adjusted for socio-economic quintile, religion and maternal age
[3]Adjusted for socio-economic quintile, social group, maternal age and relationship to household head

Mean weight-for-height Z-scores were very low in both groups and GAM and SAM were very high. Wasting, GAM and SAM were marginally higher in the intervention group than the control but the associations were not significant in unadjusted or adjusted models. There was almost no effect of removing one of each sibling pair on WHZ (β=-0.048 95%CI -0.173-0.077), and no effect for GAM (Adjusted Odds Ratio/AOR=1.020, 95%CI 0.843-1.233) or SAM (AOR=0.926, 95%CI 0.724-1.184). Pooled estimates from multiple imputation models also indicated no association of exposure group with WHZ, GAM or SAM, consistent with listwise models: β= -0.057 (95%CI -0.177-0.062), AOR=1.045 (95%CI 0.873-1.252) and AOR=0.968 (0.770-1.215) respectively.

WHZ standard deviations were lower in the intervention sample than the control (1.07 and 1.24 respectively). Figures 5.1 and 5.2 show the distribution of weight-for height Z-scores in intervention and control groups in relation to the WHO reference group. These demonstrate that WHZ was normally distributed in both groups but that both distribution curves were substantially shifted towards the lower end of the spectrum.

Figure 5.1 Distribution of weight-for-height Z-scores in the intervention clusters (n=1791+ oedema)

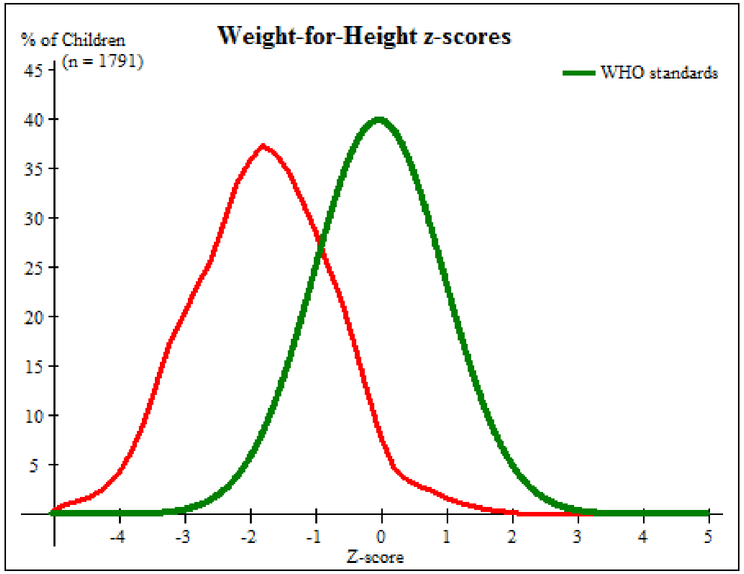
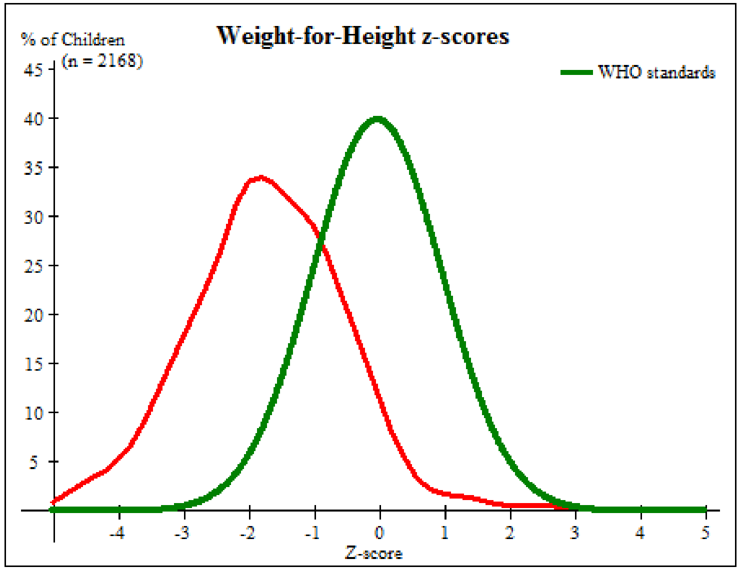


Figure 5.2 Distribution of weight-for-height Z-scores in the control clusters (n=2168 + 7 oedema)



5.3 Association between intervention exposure and child stunting

I considered child stunting as a linear outcome (height-for-age Z-score/HAZ) and as a binary outcome representing severe stunting (HAZ <-3.00) because of the exponential mortality and morbidity risks at the severe end of the spectrum (Pelletier et al. 1993). The final models testing the association of exposure group with HAZ and severe stunting, adjusted for socio-demographic variables, are shown in Table 5.2. Models featuring all predictor associations and those from multiple imputation and sibling-adjusted analyses are presented in appendices 5.4-5.5.

Table 5.2 Association between intervention exposure, child height-for-age Z-score and severe stunting adjusted for socio-demographic variables (0=control, 1=intervention)

Outcome	Mean (SD) or % (n)			Unadjusted	Adjusted
	Intervention N=1786	Control N=2137	Total N=3923	β/OR (95%CI)	β/OR (95%CI)
Height-for-age Z-score[1]	-2.37 (1.26)	-2.19 (1.64)	-2.27 (1.48)	-0.178 (-0.392-0.036)	-0.216 (-0.406- -0.026)
Severe stunting (HAZ <-3.00)[1]	30.0% (536)	32.8% (702)	31.6% (1238)	0.875 (0.656-1.166)	0.886 (0.684-1.147)

[1]Adjusted for socio-economic quintile, religion, maternal education, income, social group and maternal age

Mean height-for-age Z-scores were very low in both groups. Intervention exposure was associated with significantly lower HAZ-scores compared to controls in the adjusted model, equivalent to a difference of 0.216 SD units. The removal of one child per sibling pair weakened the association very slightly although the effect remained significant β=-0.206 (95%CI -0.393- -0.018). The association was not significant when missing data were accounted for in multiple imputation models, the confidence intervals were also narrower reflecting a more precise estimate: β=-0.161 (95%CI -0.340-0.018). Standard deviations were substantially larger in the control areas compared to the intervention areas (1.64 and 1.26).

I explored the following interactions with exposure group in simple models with HAZ as the outcome: socio-economic quintile, income group and maternal education. Exposure group*maternal education was borderline significant for women with no schooling compared to women completing primary school (p=0.067): in control areas mothers who had attended primary school had children with lower HAZ-scores than those without schooling; the reverse effect was seen for the intervention group. There was a significant exposure group*income group interaction (p=0.047), where being in the middle income group was associated with higher HAZ-scores than the lower income group in the control areas whereas this difference was not observed in the intervention areas.

Nearly a third of all children were severely stunted. The proportions of severely stunted children were similar between intervention and control groups and were not significantly different. Consistent with the final listwise model there was no association of the intervention with severe stunting when one of each sibling pair was removed or in multiple imputation models: AOR=0.869 (95%CI 0.669-1.130) and AOR=0.869 (95%CI 0.688-1.100) respectively.

Figure 5.3 indicates that intervention HAZ-scores were normally distributed and were shifted noticeably towards the lower end of the spectrum compared to the WHO reference group. Figure 5.4 shows a longer and flatter distribution of HAZ-scores in the control areas and a wider dispersion of scores; again scores were shifted towards the lower end of the spectrum in relation to the WHO reference group.

Figure 5.3 Distribution of height-for-age Z-scores in the intervention clusters (n=1786)

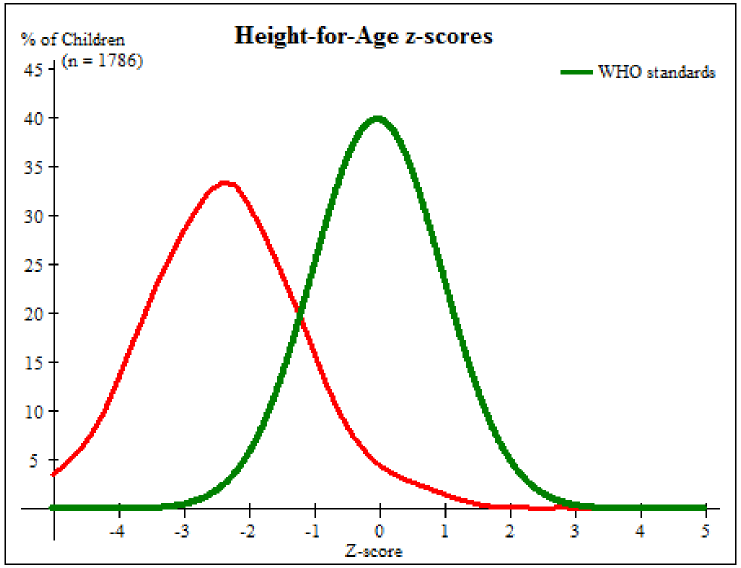
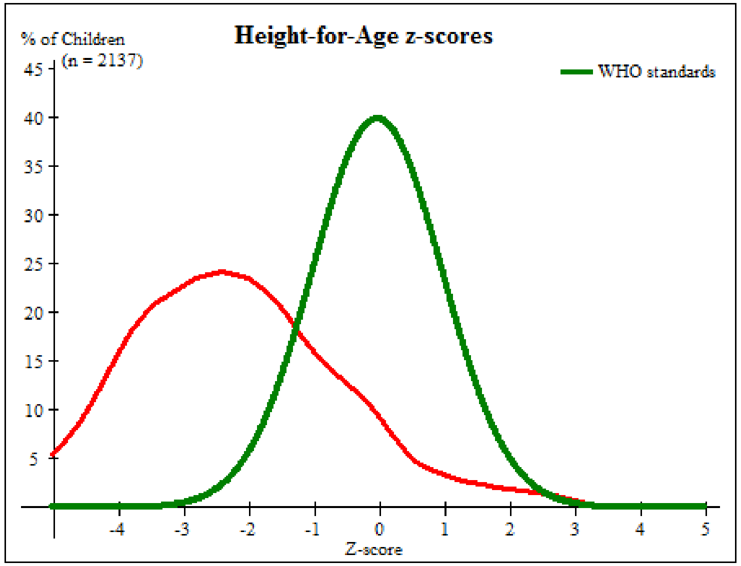


Figure 5.4 Distribution of height-for-age Z-scores in the control clusters (n=2137)



5.4 Association between intervention exposure and child underweight

I considered child underweight as a linear outcome (weight-for-age Z-score/WAZ) and a binary outcome (severe underweight/WAZ <-3.00) again because of exponential mortality and morbidity risks in the severe category (Pelletier et al. 1993). The final models testing the association of the intervention with WAZ and severe underweight, adjusted for socio-demographic variables, are shown in Table 5.3. Multiple imputation and sibling-adjusted models are presented in appendices 5.6 and 5.7.

Table 5.3: Associations between intervention exposure, child weight-for-age Z-score and severe underweight, adjusted for socio-demographic variables (0=control, 1=intervention)

Outcome	Mean (SD) or % (n)			Unadjusted	Adjusted
	Intervention N=1793	Control N=2214	Total N=4007	β/OR (95%CI)	β/OR (95%CI)
Weight-for-age Z-score[1]	-2.58 (1.05)	-2.40 (1.28)	-2.48 (1.19)	-0.184 (-0.357- -0.011)	-0.158 (-0.300- -0.016)
Severe underweight (WAZ <-3.00)[2]	35.1% (630)	32.0% (708)	33.4% (1338)	1.146 (0.880-1.492)	1.113 (0.884-1.402)

[1]Adjusted for socio-economic quintile, maternal education, income, social group and maternal age
[2]Adjusted for socio-economic quintile, maternal education, social group, religion and maternal age

Mean weight-for-age Z-scores were low overall. The intervention was associated with significantly lower WAZ-scores compared to the control, equivalent to 0.158 SD units in adjusted models. The same finding was observed when missing data were accounted for in multiple imputation models (β=-0.145, 95%CI -0.278- -0.013) and in the sibling-adjusted model (β=-0.151 95%CI -0.291- -0.010). I explored interaction terms between exposure group and significant socio-demographic predictors, but none were significant.

Overall more than a third of children were severely underweight. There was no association between the intervention and severe underweight in the final model, the sibling-adjusted model (AOR 1.100, 95%CI 0.872-1.389) or the multiple imputation models (AOR=1.081, 95%CI 0.868-1.349). The distributions of WAZ-scores for intervention and control groups are presented in figures 5.5 and 5.6. This demonstrates a considerable shift towards the underweight end of the spectrum in both groups compared to the WHO reference group. The control group had a slightly flatter curve than the WHO reference and intervention groups; standard deviations were also substantially higher in the control areas.

Figure 5.5 Distribution of weight-for-age Z-scores in the intervention clusters (n=1793)

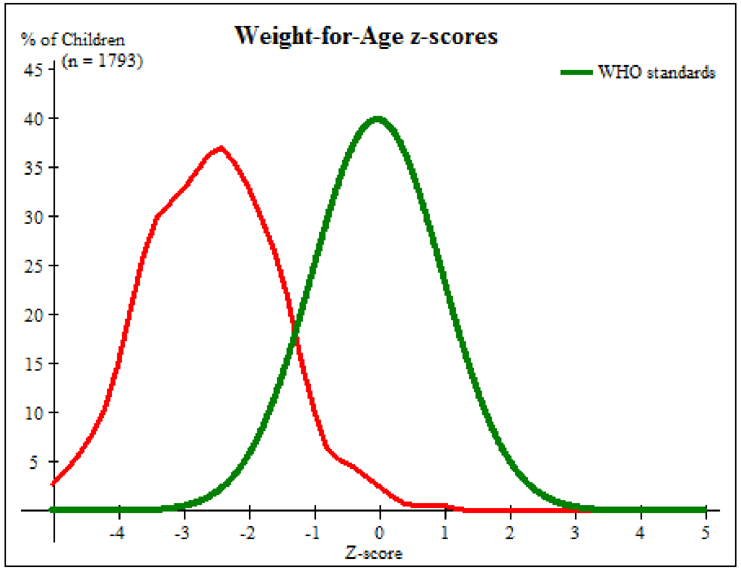
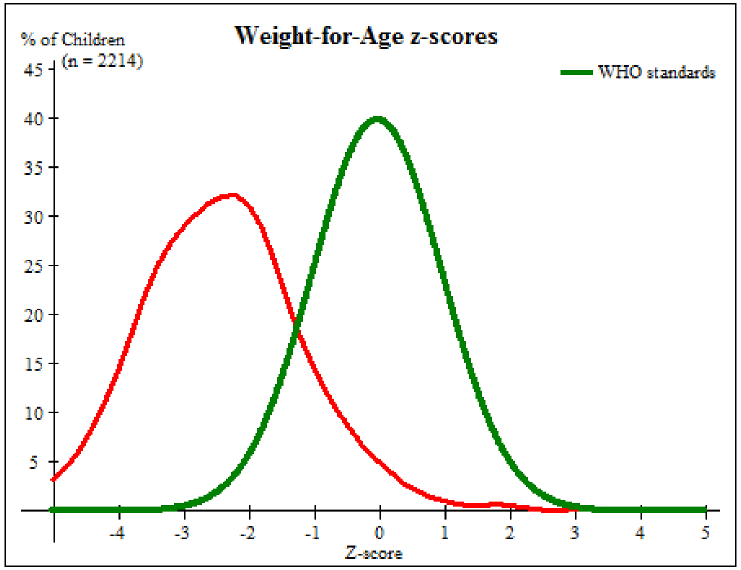


Figure 5.6 Distribution of weight-for-age Z-scores in the control clusters (n=2214)



5.5 Association between intervention exposure and child mid-to-upper arm circumference

I considered mid-to-upper-arm circumference (MUAC) as a linear outcome and as two categorical outcomes representing moderate-to-severe malnutrition (MUAC <125mm +/- oedema) and severe malnutrition (MUAC <115mm +/- oedema). The final models testing the association of the intervention with MUAC derived outcomes, adjusted for socio-demographics are presented in Table 5.4. Multiple imputation and sibling-adjusted models are presented in appendices 5.8-5.10.

Table 5.4 Association between intervention exposure, child mid-to-upper arm circumference, moderate and severe malnutrition in unadjusted and adjusted GEE models (0=control, 1=intervention)

Outcome	Mean (SD) or % (n)			Unadjusted	Adjusted
	Intervention N=1804	Control N=2226	Total N=4030	β/OR (95%CI)	β/OR (95%CI)
MUAC measurement (cm)[1]	13.1 (1.06)	13.2 (1.11)	13.2 (1.09)	-0.082 (-0.280-0.117)	-0.011 (-0.205-0.184)
Moderate-to-severe malnutrition (MUAC <12.5cm +/- oedema)[2]	24.3% (439)	23.1% (515)	23.7% (954)	1.069 (0.749-1.525)	1.074 (0.766-1.507)
Severe malnutrition (MUAC <11.5cm +/- oedema)[3]	5.7% (102)	5.6% (124)	5.6% (226)	1.106 (0.648-1.594)	0.858 (0.542-1.359)

[1]Adjusted for socio-economic quintile, social group, maternal age, income, household status
[2]Adjusted for socio-economic quintile, social group, maternal age, household status
[3]Adjusted for socio-economic quintile, maternal age, household status

Mean MUAC reflected 'adequate' nutritional status (i.e. ≥12.5cm) in both groups and the standard deviations were comparable. Nearly a quarter of children were classed as moderate to severely malnourished and just over 5% were classed as severely malnourished. There was no association between intervention exposure and MUAC in the listwise model, the sibling-adjusted model (β=-0.012, 95%CI -0.209-0.185) or the multiple imputation models (β-0.055, 95%CI -0.234-0.124). Similarly there was no association between intervention exposure and moderate-severe or severe malnutrition in listwise models, sibling-adjusted models (AOR=1.061, 95%CI 0.754-1.492 and AOR=0.852, 95%CI 0.528-1.375 respectively) or multiple imputation models (AOR=1.000, 95%CI 0.723-1.384

and AOR=0.904, 95%CI 0.592-1.381 respectively).

5.6 Discussion

There was no significant association between exposure group and weight-for-height, GAM, SAM or any of the MUAC derived outcomes. Children in the intervention areas had significantly lower WAZ and HAZ-scores than children from the control group in adjusted models, although the HAZ association was not significant in multiple imputation models. There was no exposure group association with severe underweight or severe stunting. I had planned to adjust for season of measurement (which was significantly different between groups) but it was not retained in any of the final models after applying goodness of fit criteria.

Classification of undernutrition severity in the study areas

In general, the anthropometric data reveal worryingly high proportions of undernourished children and extremely low mean anthropometric Z-scores. The WHO provides guideline thresholds to define nutritional emergencies: GAM <5% is considered acceptable, 5-9% is poor, 10-15% is serious and >15% is critical. Our data are suggestive of a 'critical' nutrition situation (World Health Organisation 2013). It should be noted that our sample is of children under-three whereas the WHO refers to children under-five. Although younger children may be more likely to be identified as wasted (particularly for MUAC which increases with age), our data far exceed the critical thresholds for each outcome and this difference in age groups could not completely account for these findings (Thi Hop et al. 1998).

The Integrated Food Security Phase Classification uses nutritional indicators, crude death rates and a range of other criteria to classify food insecurity as one of five phases: generally food secure, moderately/borderline food insecure, acute food and livelihood crisis, humanitarian emergency and famine/humanitarian catastrophe (Food and Agriculture Organisation 2008). Not all indicators need to be present to classify food security status but two key components are nutrition and mortality rates. The prospective surveillance system that exists in the intervention areas does not allow for the calculation of the crude death rate, hence we cannot classify the study areas. However, the percentage of GAM we have observed fit the category for famine/humanitarian catastrophe (>30%). Dietary diversity in this sample is also extremely poor for the majority of children six months or older (this will be explored further in chapter 7) where regular eating of ≤3 food groups is characteristic of a humanitarian emergency (Food and Agriculture Organisation 2008). Although we only have cross-sectional data, and the 'regularity' aspect of dietary intake cannot be confirmed with a single measurement, such low dietary diversity is a worrying sign for food security. Similarly, we have qualitative and quantitative data about food security, household shocks and livelihoods, which suggests high levels of food insecurity and unsustainable coping strategies (this will be examined further in chapter 8).

The Integrated Food Security Phase Classification also uses stunting to define earlier phases of food insecurity (Food and Agriculture Organisation 2008). Stunting >20% indicates 'moderate/borderline' food insecurity and a recent review suggests that >40% could be indicative of an 'acute food security and livelihood crisis' (Young and Jaspars 2009). The WHO classifies stunting prevalence according to community-level severity where <20% is low, 20-29% is medium, 30-39% is high and ≥40% is very high. Again our data fit easily into the highest category of risk regardless of the standard used: 59.9% of children had HAZ-scores <-2.00.

The WHO has not provided MUAC thresholds to define the severity of a nutrition situation. The Food Security Nutrition and Analysis Unit developed approximate thresholds for community-level severity for Somalia (FSNAU 2012). They define a prevalence of MUAC <125mm as acceptable if it is below 5% (unless this has increased from previous assessments, in which case it would become an 'alert'), 5-9.9% is 'serious', 10-14% 'critical' and ≥15% 'very critical'. Again, our data fit easily into the 'very critical' category with about a quarter of children having MUAC scores <125mm.

The WHO Expert committee (1995) also categorise community-level prevalence of child underweight (WAZ <-2) as follows: low <10%, medium 10-19%, high 20-29%, and very high ≥30%; the overall percentage of underweight children in this study was 66.8% (data not shown). A recent review recommended the Integrated Food Security Phase Classification extend their criteria to include underweight non-pregnant women aged 15-49 years (Body Mass Index <18.5). The authors consider >40% maternal underweight to be suggestive of a humanitarian crisis (Young and Jaspars 2009); 53.6% of women in this sample were underweight. It is clear that by current definitions our data would be considered as reflecting a critical situation.

It is possible, despite careful data cleaning and exclusion decisions, that I included some false cases of undernutrition as well as excluding some genuine cases. However, the shapes of the distributions indicate normality, and the standard deviations are well below the maximum reported in an analysis of 51 Demographic and Household Surveys (Mei and Grummer-Strawn 2007). It is also possible that, despite good anthropometry training, the growth monitors faced difficulties in measuring length of children under-two using the rollameters provided (chosen for practical reasons because they were lightweight and easily portable). Anecdotal reports from another site suggested they may be less reliable than other instruments such as Shorr boards because they can stretch, leading to over-reporting of stunting and under-reporting of wasting (Audrey Prost, personal communication, November 2012). I feel this is unlikely for the present study as each growth monitor was given a new rollameter, and each measured a relatively small number of children under-two (children older than 2 were measured with a stadiometer); we also observed very high levels of wasting in the survey.

Comparison with other nutrition surveys

Mean WHZ-scores for children under-three in the National Family Health Survey-3 (NFHS-3) were -1.6 for Jharkhand and -1.0 for Orissa (Government of India 2006); these estimates are considerably higher than our survey mean of -1.72. The percentage of children with GAM in our sample was very high at 40.4%. This is higher than the percentage of children with moderate-severe wasting in the NFHS-3 for the same age group (Jharkhand 35.8%; Orissa 23.7%), although the NFHS-3 does not include oedema. Our results were more similar to the NFHS-3 data for under-fives from tribal groups who had a mean WHZ-score of -1.8 and where 39.6% were moderate-severely wasted. Whilst these age groups are not directly comparable with our data and the sampling approaches were different (we only measured children in one district whilst the NFHS-3 covered multiple districts and provide representative estimates) these data suggest little improvement of child nutritional outcomes amongst the most disadvantaged social groups.

More recent data are available from the Hungamaa nutrition survey collected in 2010, although again there are sampling and reporting differences that make it difficult to directly compare with our data (for example, mean Z-scores are not given) (Hungamaa 2011). The Hungamaa survey covered multiple districts of six states (including Jharkhand and Orissa) where 100/112 districts were the lowest ranked on UNICEFs 'child development district index' (the other 12 districts were the best performing districts to provide a contrast) (UNICEF 2011). One of the lowest ranking districts was West Singhbhum and Hungamaa data indicate that 26.5% of children under-five were moderately-severely wasted which is far lower than our GAM estimate for that district (43.3%). Although we included oedema and the Hungamaa estimate did not (it is reported separately), oedema was relatively rare in both surveys for West Singhbhum (≤1.7%) so this would not have strongly influenced the difference. In the 100 lowest ranking districts, 11.4% of children were moderately-severely wasted which again is much lower than our estimate, although unexpectedly, the 12 highest performing districts had higher wasting levels the lowest ranking and raises some concern about the quality of Hungamaa data. Possible reasons for the lower wasting levels seen in the Hungamaa survey compared to our survey include a difference in children's age range, and because the Hungamaa survey was representative at the district-level whereas ours was not and deliberately targeted the most disadvantaged groups (Hungamaa 2011).

MUAC was not measured in the NFHS-3, but was included in the Hungamaa survey of children under-five. Hungamaa district-level data for West Singhbhum report 13.55% moderate-severe malnutrition (MUAC <125mm) and 2.83% severe malnutrition (MUAC <115mm) (Hungamaa 2011). Our MUAC data for West Singhbhum show a much higher rate of moderate-severe malnutrition at 27.38%, and in the severe category (6.74%). In the 100 lowest ranking Hungamaa districts the data indicate a 10.2% prevalence of moderate-severe malnutrition (MUAC <125mm) and 1.7% severe malnutrition (MUAC <115mm), which again are much lower estimates than observed in our data (23.7% and 5.6% respectively).

Height-for-age and severe stunting

The NFHS-3 reports mean HAZ-scores for children under-three in Orissa as -1.7, and in Jharkhand as -1.8, which are far higher than our estimates (-2.27) (Government of India 2006). The NFHS-3 data for under-fives from tribal groups is closer to ours, which were -2.1 for both Jharkhand and Orissa. The Hungamaa survey did not provide mean HAZ scores, although they do report the prevalence of severe stunting, which for children under-five in West Singhbhum was 27.1%, compared to 34.0% of under-threes in our data (Hungamaa 2011). In the NFHS-3, the percentage of severely stunted children under-three was 19.4% in Orissa and 25.0% in Jharkhand, and for under-fives from tribal groups was 28.4% and 29.9% respectively (Government of India 2006). Our data show a higher proportion of severe stunting than this, particularly in Orissa (37.8%); our Jharkhand estimate was similar to the tribal group estimate (28.6%).

Weight-for-age and severe underweight

The NFHS-3 mean WAZ-scores for children under-three were -2.1 in Jharkhand and -1.7 in Orissa, and for under-fives from tribal groups were -2.4 and -2.1 respectively (Government of India 2006). In our survey the overall mean WAZ was worse at -2.48, and for Orissa were much worse (-2.61) although our Jharkhand estimate was similar to the under-five tribal group (WAZ= -2.42). The NFHS-3 prevalence of severe underweight was just over a quarter for Jharkhand (26.2%) and 15% for Orissa, and was worse for under-fives from tribal groups (33.6% and 22.9% respectively) (Government of India 2006). Again our data generally show worse estimates: a third of children were severely underweight (33.4%), more so in Orissa (37.3%) than Jharkhand (31.5%). The Hungamaa survey in West Singhbhum reports severe underweight as 23.3% and for the 100 lowest ranking districts 16.4%; our data are far less favourable than this (Hungamaa 2011). There is also DLHS-2 weight-for-age data available for West Singhbhum, which, although less recent, showed that a quarter of children were severely underweight in 2002 (25.69%) (Ministry of Health and Family Welfare 2010), which is still more favourable than our 2010 data in the most disadvantaged groups. This suggests that little has changed in terms of severe child underweight in West Singhbhum since 2002 and this problem continues to be common, particularly amongst disadvantaged groups.

Why was there no 'effect' of women's groups on child wasting?

Weight-for-height Z-scores and GAM (and to a lesser extent MUAC) are indicators that are particularly responsive to intervention and had the greatest potential to change as a result of women's group activities. Unfortunately this was not reflected in the analyses but there are a number of possible reasons for this lack of 'effect'. I use the word 'effect' here with caution because the cross-sectional design does not allow attribution of causality, nor does it provide baseline anthropometry to allow adjustment for potentially significant pre-existing differences between groups. It is likely that there were a greater proportion of surviving children born at low birth weight in the intervention areas than the control areas because Cycle 1 of the women's groups significantly reduced neonatal mortality. It seems very unlikely that the intervention could have caused wasting, but as a result of enhanced neonatal survival this could mean that we measured a group who were more undernourished at birth in the intervention areas and who were more likely to suffer from undernutrition and infection at the point of the survey. This is compared to the control areas where low birth weight infants would have been more likely to die in the neonatal period, biasing our control sample towards the selection of healthier children.

It is possible that we were too soon to observe an impact upon acute malnutrition. Although all of the children's nutrition meetings had taken place at the point of measurement, many of the behaviours being addressed could have taken a longer time to change in a meaningful way, and to be understood by other household members involved in child care (e.g. feeding and hand washing behaviours). Interestingly, when the data are split by <6 months and ≥6 month age groups, there appear to be higher WHZ-scores, similar GAM, and a slightly lower percentage of SAM in the intervention group compared to the control, whereas the reverse relationship is seen in older children. MUAC is also slightly higher in the <6month group in the intervention areas compared to the control, and fewer children were identified as moderate-to-severe (32.0% versus 38.1%) or severely malnourished (11.2% versus 13.2%) than in the control areas; again the reverse is seen in children ≥6 months.

Notwithstanding my earlier argument that a greater proportion of the intervention group might have been more undernourished at baseline due to Cycle 1, mothers of the youngest aged children (who account for <8% of the sample) were exposed to both women's group cycles, some early in their second trimester of pregnancy. Arguably, the additional pregnancy inputs (such as a focus on diet and iron) could have prevented some low birth weight, and because cycle 1 was more effective after being established for several years, the youngest children in the intervention areas may have derived more benefit than the older children who were exposed to the intervention later in their development. This hypothesis would need to be investigated in a larger sample (we were underpowered to stratify the current analysis by age) in an area with established Ekjut women's groups that have exposed women to activities and knowledge during pregnancy.

The control area wasting estimates had a larger SD than the intervention areas. It is possible that this was due to greater heterogeneity in the control areas, as well as accidental inclusion of false cases of undernutrition or exclusion of some genuine cases, both of which could have increased the standard deviation. However, the shape of the distribution indicates normality, and the standard deviation is well below the maximum reported in an analysis of 51 Demographic and Health surveys: HAZ standard deviations were 1.20-1.92, WAZ SDs were 1.11-1.47 and WHZ SDs were 1.02-1.64 which the authors say reflect genuine heterogeneity within national data (Mei and Grummer-Strawn 2007). The control area participants were selected at the cluster level whereas the intervention participants were all women's group members and were probably more similar to each other in ways that may not have been captured by the socio-demographic measures we used. Another possible reason for the larger SD could be due to differences in the quality of measurements taken by growth monitors in the intervention and control areas. Perhaps the intervention monitors were more committed in the knowledge that Ekjut were actively working in their area and the women (who were also group members) may have been more engaged with the study and cooperative with measurements than monitors and respondents in the control areas where there was no intervention besides additional referral of undernourished children.

The women's groups and stunting

Height-for-age was significantly lower in the intervention areas than the control, although this was non-significant in the multiple imputation models, which arguably provide a more precise estimate. Even so, there is no evidence of a positive effect of the intervention on height-for-age, but is it fair to conclude that it was ineffective? I would suggest that it is too soon to tell, and that our measurements were too soon post-intervention to see an impact on an indicator that can take several generations to shift (Martorell and Zongrone 2012). Again we are faced with the possibility that children in the intervention areas were more likely to be stunted if they were vulnerable and/or stunted at birth, but survived as a result of Cycle 1, which would partially account for the higher levels of stunting seen in the intervention areas.

HAZ standard deviations were higher in the control areas than in the intervention areas. As previously mentioned, this could be due greater heterogeneity in the control sample, and to greater commitment by growth monitors and mothers to the survey in the intervention areas. However, the difference in SD between groups for HAZ was much larger than for WHZ, which could be explained by less accurate child dates of birth in the control areas. In the intervention areas, we relied upon the existing surveillance system for child date of birth, and this was designed to identify pregnant women and interview them 6 weeks postnatally. No such surveillance existed in the control areas and here we had to rely upon maternal report or the child's vaccination card (which are known to be prone to error). Patel and colleagues (2012) speculate that women may underestimate the age of their child if they are small in size and that this may be one reason for late weaning – that small children are not seen as old enough or 'ready' for complementary foods. If this is true for the current sample, smaller children in the control areas may have had their true age underestimated and their height-for-age overestimated. HAZ is probably the least accurate of all the nutrition indicators in the control areas because of extra measurement difficulties associated with measuring children lying down, especially younger children 'curling up' during measurement, in combination with less accurate dates of birth.

The women's groups and underweight

Underweight is a composite indicator of stunting and wasting and was significantly worse in the intervention areas than in the control, and consistently so between listwise, sibling-adjusted and multiple imputation models. Again, the larger SD in the control areas indicates less accurate child dates of birth than in the intervention areas, possibly biasing mothers towards underestimation of age if they appeared small, and resulting in overestimation of weight-for-age (Patel et al. 2012). This is in contrast to the intervention group for whom WAZ was likely to be the most accurate indicator, with digital weight recordings taken three times and accurate dates of birth, which is reflected in the comparatively smaller SDs. Again, there may have been important baseline group differences that explain the apparent lack of impact and worse WAZ outcomes, and we may have measured children too soon post-intervention to see an impact.

Limitations of Cycle 2

Cycle 2 took a different form to the first cycle of women's groups, which could have reduced intervention effectiveness. Cycle 1 followed a participatory learning and action (PLA) cycle in four sequential stages of meetings over 24 months: discussing and prioritising problems, developing strategies, implementing strategies, and evaluating strategies. The main difference with Cycle 2 was that much of the PLA cycle was enacted within a single meeting. The prioritising of problems also did not take place at the group level; rather the maternal and child health issues that were raised by all groups at the end of cycle 1 were amassed and incorporated into a topic-driven manual covering a wide range of issues that may have lacked focus. Newer women's group members would have also missed out on the trust-building exercises and other important aspects of phase 1 of the PLA cycle. Overall, the content of cycle 2 became more prescriptive than in cycle 1 and edged closer to a health-education intervention and away from community mobilisation. The evidence suggests health education alone may have a limited impact on nutrition. Issues that may have been important to groups in Saraikela (known to have much better outcomes) may have been very different to issues prioritised in other districts and this could have diminished the feeling of ownership of the intervention and reduced group autonomy. In terms of strategy formation, it is questionable whether innovative strategies to address a complex problem such as undernutrition could be devised within a 2-hour meeting. Furthermore, because strategies were implemented immediately after each meeting instead of waiting until the community-wide meeting, this could have hampered the involvement and understanding of other community members. It also amounts to a larger number of total strategies, which could have been more difficult to manage.

The contrast between the format of cycles 1 and 2 is important to understand the effectiveness of the intervention, but it is not fair to compare their outcomes directly. The levels of evidence are different because the randomised controlled trial allowed cause-effect attribution whereas the current study is cross-sectional and hypothesis generating. Secondly, the issues being tackled by the two cycles were very different (i.e. neonatal mortality versus malnutrition). The former may be more amenable to discrete behaviour change over a relatively short time (28 days), such as wrapping newborn infants to reduce hypothermia risk, and has the potential to make a large impact on outcomes without increasing household expenditure (unlike some standard feeding and hygiene recommendations). Although nearly 40% of under-five deaths occur in the neonatal period (Lawn et al. 2005), to reduce undernutrition in children 8 weeks to 3 years is arguably more complex, with on-going and continually changing dietary requirements, high risks of infection particularly after the period of exclusive breastfeeding and a greater range of behaviours necessary to promote child health (such as hand washing, child feeding, care-seeking, immunisations) that get increasingly complex beyond the neonatal phase. A recent analysis of National Family Health Survey data indicated that much of stunting has already taken place at birth, highlighting that behaviours to address undernutrition span a far wider time period and represent a more complex pathway than for neonatal mortality (Mamidi et al. 2011). In the following chapter I will attempt to unpick which of these behaviours appear to have been affected by the women's groups, and which may require a greater focus in refinements of cycle 2.

Lack of reliable birth weight data

I had hoped to be able to establish conclusively whether there were differences between exposure groups for birth weight, and whether there were a higher proportion of low birth weight survivors in the intervention group than the control, explaining the lack of impact of the women's groups. However, actual birth weight was available in only a minority of cases, and the data that were recorded had a higher than expected frequency of clinical thresholds used to define low birth weight and seemed unreliable. The proxy variable for low birth weight - perceived size at birth – did reveal that a greater proportion of intervention mothers perceived their children as smaller than average at birth compared to the control group. But, women answering in this category also tended to have taller children in both the intervention and control groups. As a low birth weight measure this is counterintuitive and may be measuring greater maternal concern about child health. Measurement issues will be considered in greater detail in chapter 9.

5.7 Conclusion

There is no evidence of a positive association between participation in women's groups and improved child anthropometric outcomes. This may be due to measurement issues. Despite considerable efforts to minimise bias and error in the selection and measurement of children these elements cannot be completely ruled out, particularly in younger children who are more difficult to measure, and a true effect could have been masked. It is also possible that we measured children too early in the post-intervention period to see an effect, or the effect was masked by pre-existing baseline anthropometric differences that favoured the control group. The <6 months intervention group had lower levels of wasting although we were underpowered to test this formally. Mothers of the youngest children would have been exposed to the intervention in pregnancy and perhaps the intervention could be more effective if mothers were targeted earlier (i.e. in early pregnancy) to impact upon early undernutrition through reduced low birth weight. Even with altered methods and intervention content it is doubtful that women's groups alone would be sufficient to tackle undernutrition. Chronic and acute undernutrition has many driving factors and women's groups are not a magic bullet to tackle these complex issues. They do have the potential to benefit important health behaviours, and this will be explored in the following chapter.

Chapter 6

Associations between intervention exposure and health behaviours

6.1 Chapter overview

In this chapter I explore whether intervention exposure was associated with the secondary outcomes I touched upon in chapter 3 (the rationale for the thesis). These outcomes include self-reported health and nutrition behaviours and other indicators that are on the pathway to improved child growth and that the women's groups could have influenced. Specifically, I have considered self-reported health and nutrition behaviours relating to: pregnancy, infant and young child feeding, the prevention and management of childhood illnesses, hygiene and sanitation, and growth monitoring. Health indicators include proxy measures of low birth weight, child morbidity and maternal physical and mental health. I have provided a rationale for testing the effect of the intervention on each outcome before presenting the model results. We also collected additional data on these topics that were not formally tested for exposure group effects, but which provide additional contextual detail in the text.

I followed the same analysis stages as for the previous chapter. Firstly, I explored univariate associations between exposure group and each outcome in Generalised Estimating Equation linear or logistic regression models (GEE). In a second step I assessed the combined association of exposure group and each socio-demographic variable previously identified as significantly different between intervention and control groups. Any socio-demographic variable significant at $p<0.10$ was included in an initial GEE regression model testing the association of exposure group with each outcome. I then used backwards, stepwise methods to eliminate socio-demographic variables that did not substantially improve model fit.

When I had obtained the most parsimonious listwise model (i.e. cases with missing data excluded) I re-ran the model twice: firstly in a dataset with one randomly selected child from each sibling pair removed (to ensure there was no influence of 'double-counting' mothers' responses on the outcome), and secondly in a multiply imputed dataset with missing predictor values replaced with their predicted values. The results of these additional models and listwise models including the associations of socio-demographic predictors are located in the appendices.

6.2 Pregnancy-related behaviours

The rationale and details for the self-reported pregnancy behaviour models are presented in Table 6.1. These outcomes were addressed by all or a majority of women's groups during cycle 1. Results of the final models are presented in Table 6.2. The full final models including all predictor estimates, and the results of multiple imputation and sibling-adjusted models are located in appendices 6.1-6.6.

Table 6.1 Rationale and details for self-reported pregnancy behaviour models

Model	Outcome	Binary categorisation	Sample	Pathway to improved child growth
1	Quantity of food eaten in pregnancy	Ate less versus the same/more than before pregnancy	Full sample	Maternal anaemia reduction (via maintained/increased food intake→ reduced low birth weight)
2	Birth spacing adequacy	Interval (last two pregnancies): >2 versus ≤2 years	≥2previous pregnancies	Maternal anaemia reduction → reduced low birth weight
3	Iron tablet intake during pregnancy[1]	iron tablets in pregnancy (yes/no)	Full sample	Maternal anaemia reduction in pregnancy→ reduced low birth weight
4	Attendance for antenatal care	Attended for antenatal care (yes/no)	Full sample	Maternal anaemia reduction and improved breastfeeding → reduced low birth weight and improved child growth. 152/244 groups promoted antenatal care (including anaemia prevention and breastfeeding promotion)
5	Kitchen gardens to increase maternal iron intake	Grows fruit/vegetables for consumption in garden/plot (yes/no)	Full sample	Maternal anaemia reduction → reduced low birth weight: 46/244 groups promoted kitchen gardens as a strategy to reduce maternal anaemia during pregnancy
6	Age at marriage (proxy for early pregnancy)	Age marriage (<18 versus ≥18 years)	Primigravidas	Marriage >18 years → reduced low birth weight and prematurity, helps interrupt intergenerational cycle of undernutrition via reduced maternal stunting. 109/244 groups developed campaigns against early marriage

[1]the government supply of iron tablets was interrupted several times during 2008-2010 in the intervention areas

Model results

A far higher proportion of women reported eating the same amount or more food than usual during their pregnancy compared to women in the control areas (69.0%% and 34.9%). This was significant in the adjusted model where women in the intervention areas were over four times more likely to report this behaviour compared to those in the control areas. This strong association was also found in the multiple imputation dataset (AOR=4.364, 95%CI 2.383-7.991) and the sibling-adjusted dataset (AOR=4.441, 95%CI 2.419-8.154).

Adequate birth spacing was more common in the intervention areas compared to the control

(86.5% versus 75.7%). In the adjusted model women in the intervention group were 2.5 times more likely to space their pregnancies by at least 24 months. A similar effect was observed in the multiple imputation model (AOR=2.459, 95%CI 1.577-3.835) and the sibling-adjusted model (AOR=2.379, 95%CI 1.526-3.708).

The proportion of women reporting iron tablet intake during pregnancy was similar between groups, and was quite high at ≥81.9%; there was no significant exposure group effect for this outcome in the adjusted model. The effect remained non-significant in the multiple imputed dataset (AOR=1.311, 95%CI 0.851-2.021) and the sibling-adjusted dataset (AOR=1.240, 95%CI 0.786-1.958). Ekjut field staff reported that there had been an interruption of the iron tablet supply in the intervention clusters during 2008-2010 which may have influenced this finding.

Self-reported attendance for antenatal care was more common in the intervention areas than the control (about three-quarters reported at least one visit), although this was not significant in the adjusted model, the multiple imputation models (AOR=1.644, 95%CI 0.807-3.349) or the sibling-adjusted model (AOR=1.746, 95%CI 0.837-3.639). Postnatal care was less commonly reported in both groups (intervention 33.7%; control 31.3%); I did not test for an intervention effect for this outcome as women's groups did not appear to have focused on this aspect of pregnancy care.

A higher proportion of women in the intervention areas reported getting married when they were at least 18 years of age (as opposed to under 18) compared to the control group (83.3% versus 73.5%), but this was not significant in adjusted models. The association remained non-significant in multiple imputation models (AOR=1.890, 95%CI 0.720-4.960) and the sibling-adjusted model (AOR=1.448 95%CI 0.536-3.910). Kitchen gardens were more commonly reported in the control areas than the intervention areas (17.3% versus 15.2%) although this was not significant in any of the final models (multiple imputation model: AOR=0.901, 95%CI 0.453-1.792; sibling-adjusted model: AOR=0.928, 95%CI 0.475-1.813).

Table 6.2 Associations between intervention exposure and self-reported pregnancy behaviours, adjusted for socio-demographic variables (0=control, 1=intervention)

Outcome	Intervention % (n)	Control % (n)	Total % (n)	Unadjusted OR (95%CI)	Adjusted OR (95%CI)
1. Food intake in pregnancy: the same or more than before[1]	69.0 (934/1354)	34.9 (777/2224)	47.8 (1711/3578)	4.141 (2.154-7.962)	4.391 (2.386-8.080)
2. Adequate birth spacing: ≥2 years between pregnancies[2]	86.5 (281/325)	75.7 (293/387)	80.6 (574/712)	2.049 (1.175-3.571)	2.459 (1.577-3.835)
3. Iron tablets taken in pregnancy[3]	83.7 (1509/1802)	81.9 (1820/2222)	82.7 (3329/4024)	1.138 (0.727-1.781)	1.266 (0.803-1.998)
4. Attendance for antenatal care[4]	75.9 (1368/1802)	69.9 (1554/2224)	72.6 (2922/4026)	1.359 (0.647-2.855)	1.741 (0.836-3.629)
5. Kitchen garden: food grown for own consumption[5]	15.2 (274/1804)	17.3 (384/2226)	16.3 (658/4030)	0.859 (0.405-1.823)	0.936 (0.481-1.820)
6. Age at marriage: ≥18 years [6]	83.3 (60/72)	73.5 (1086/1478)	73.9 (1146/1550)	1.805 (0.688-4.732)	1.529 (0.572-4.087)

[1]Adjusted for: socio-economic status and social group
[3]Adjusted for: religion
[3]Adjusted for: socio-economic status, relationship to household head, maternal age
[4]Adjusted for: socio-economic status, maternal education, relationship to household head, religion, maternal age
[5]Adjusted for: socio-economic status, maternal education, relationship to household head
[6]Adjusted for: maternal age

6.3 Breastfeeding and young child feeding indicators

The WHO has defined eight core and seven optional infant and young child feeding indicators which are shown in full in Appendices 6.7-6.9 along with additional breastfeeding characteristics (World Health Organisation 2009). I thought it was plausible that the groups could have impacted on five of the WHO indicators (early initiation of breastfeeding, exclusive breastfeeding under six-months, bottle-feeding, timeliness of weaning and minimum meal frequency), and pre-lacteal feeding. The rationale and details for these models are presented in Table 6.3 and model results are presented in Table 6.4. The full final models including all predictor estimates, and the results of multiple imputation and sibling-adjusted models are located in Appendices 6.10-6.15.

Table 6.3 Rationale and details for self-reported breastfeeding and young child feeding models

Model	Outcome	Binary categorisation	Sample	Pathway to improved child growth
1	Early initiation of breastfeeding	Baby put to breast within 1 hour of birth (yes/no)	Full sample	Child diarrhoea prevention/optimal growth. 178/244 groups requested Auxiliary Nurse Midwives to promote breastfeeding
2	Pre-lacteal feeds	What was the child given first when born? Breast milk or other	Full sample	Child diarrhoea prevention/optimal growth
3	Exclusive breastfeeding for 6 months	Children only received breast milk the previous day (yes/no)	Children 2.00-5.99 months	Child diarrhoea prevention/optimal growth. 178/244 groups requested Auxiliary Nurse Midwives to promote breastfeeding; exclusive breastfeeding for 6 months advised in cycle 2
4	Bottle-feeding	Ever fed anything from a bottle (yes/no)	Full sample	Diarrhoea prevention: women advised to abstain from bottle feeding and use a cup and spoon instead
5	Timeliness of weaning	Child received solid, semi-solid or soft food the previous day (yes/no)	6.00-8.99 months	Child nutrition/diet: age appropriate introduction of solid, semi-solid or soft food
6	Minimum meal frequency	Child fed the appropriate number of times for their age, including breast milk, the previous day (yes/no)	6.00-23.99 months	Child nutrition/diet: Guidance about feeding frequency from 6 months of age was given during women's groups

There was no clear rationale for testing intervention associations with the following breastfeeding indicators, but I have briefly described them here. Self-reports of continued breastfeeding at one year were very high in both groups (>93%), as were rates of 'ever breastfed' children (>98%) and continued breastfeeding at two years (>82%). According to maternal report more than two-thirds of children received 'age appropriate breastfeeding' (exclusive breastfeeding <6 months and breast milk plus complementary food for ≥6 months) and this was similar between groups. 'Predominant breastfeeding' which allows a restricted range of other liquids for children <6 months was higher in the intervention areas (87.2%) than the control areas (75.6%). Median duration of breastfeeding went beyond 35.99 months in the intervention group and was 30.89 months in the control areas. Overall this highlights that self-reported breastfeeding behaviours were positive in both groups. The only measure of slight concern was colostrum discarding: this was reported by more than a fifth of women in the control areas and 5% in the intervention areas, although there is a lot of missing data in the intervention group due to a change in the surveillance questionnaire.

There was also no clear rationale to test for group differences for the following child feeding indicators, but I have briefly described them here to provide a contrast with the largely positive breastfeeding indicators. Minimum dietary diversity (maternal reports of consumption of ≥4 food groups in the previous 24 hours) was very low across groups at <10%. This is partially accounted for by the low proportion of children who had been introduced to other foods in the 6.00-8.99 month group and shows a positive relationship with child age. Minimum acceptable diet, derived from dietary diversity and minimum meal frequency, and depends on whether the child has been introduced to complementary foods, was lower amongst breastfed children in the intervention group than the control (62.0% versus 67.2%). Again this indicator was positively related to child age, with >83% achieving a minimally acceptable diet in the 18.00-23.99 age group. However, this indicator was strikingly low amongst non-breastfed children 6.00-23.99 months (0%-3.3%). Consumption of iron-rich foods appeared to be low across exposure groups, even in the oldest age group (<15%).

Model results

Self-reported early initiation and exclusive breastfeeding until 6 months were both higher in the intervention areas than the control areas (71.7% versus 64.2% and 71.2% versus 67.0% respectively). The introduction of soft, semi-solid and soft foods in children 6.00-8.99

months appeared low at ≤45%. Maternally reported minimum meal frequency for breastfed children was higher in the control group than the intervention (67.0% versus 61.4%). The same pattern was seen for non-breastfed children, although far fewer of these children in either exposure group met the criteria compared to breastfed counterparts. Reported bottle-feeding was higher in the intervention group than the control, consistently across age groups. Milk feeding frequency for non-breastfed children was low in both exposure groups (6.3%-7.2%). Self-reported pre-lacteal feeding was more common in the control areas than in the intervention areas (10.7% versus 7.7%) and most commonly included honey/honey water, goat's/cow's milk or sugar/sugar water. There were no significant associations of intervention exposure with any of these outcomes; this remained the case when the final models were re-run in the multiple imputed dataset and the sibling-adjusted dataset.

Table 6.4 The association between intervention exposure and maternally reported infant and young child feeding practices, adjusted for socio-demographic variables (0=control, 1=intervention)

Outcome	Intervention % (n)	Control % (n)	Total % (n)	Unadjusted OR (95%CI)	Adjusted OR (95%CI)
1. Early initiation of breastfeeding[1]	71.7 (1295/1805)	64.2 (1430/2226)	67.6 (2725/4031)	1.413 (0.580-3.442)	1.410 (0.585-3.394)
2. Pre-lacteal feeding[2]	7.8 (140/1799)	10.8 (238/2200)	9.5 (378/3999)	0.696 (0.302-1.603)	0.665 (0.292-1.512)
3. Exclusive breastfeeding (children under six months) [3]	71.2 (89/125)	67.0 (132/197)	68.6 (221/322)	1.217 (0.620-2.390)	1.246 (0.669-2.318)
4. Any bottle-feeding[4]	16.7 (301/1805)	11.3 (251/2226)	13.7 (552/4031)	1.575 (0.854-2.903)	1.463 (0.841-2.545)
5. Introduction of solid, semi-solid or soft foods (6.00-8.99 months)[5]	42.0 (170/390)	45.0 (94/209)	43.6 (170/390)	0.886 (0.504-1.557)	1.161 (0.638-2.112)
6. Minimum feeding frequency (6.00-23.99 months)[6]	61.4 (603/982)	67.0 (732/1092)	64.4 (1335/2074)	0.782 (0.490-1.250)	0.770 (0.483-1.229)

[1]Adjusted for: maternal education, relationship to household head, social group
[3]Adjusted for: socio-economic status, social group
[3]Adjusted for: Income group
[4]Adjusted for: socio-economic status, relationship to household head, maternal age, season of measurement
[5]Adjusted for: socio-economic status
[6]Adjusted for: socio-economic status, maternal age

6.4 Prevention and management of childhood illnesses

This section includes a description of the immunisation status of children, and home care practices and treatment seeking for cough, fever and diarrhoea (fully presented in appendices 6.16-6.19). A selection of these indicators was identified as potentially influenced by women's groups and formally tested for an association: Table 6.5 describes the rationale for each of these models and Table 6.6 presents the association of exposure group with each outcome in adjusted models. Appendices 6.20-6.25 show all predictor associations with each outcome, and results from multiple imputed and sibling-adjusted datasets.

Table 6.5 Rationale and details for the prevention and management of childhood illnesses models

Model	Outcome	Binary categorisation	Sample	Pathway to improved child growth
1	Feeding frequency during diarrhoea/ fever/cough	Child fed the same/ more than usual versus less/stopped food or breastfeeding	Children with diarrhoea/fever and/or cough in last 14 days	Diarrhoea management. 178/244 groups requested Auxiliary Nurse Midwives to promote breastfeeding
2	Quantity of liquids given during diarrhoea /fever/cough	Child given the same/more than usual versus less/no liquids	Children with diarrhoea/fever and/or cough in last 14 days	Diarrhoea management
3	Use of oral rehydration solution for diarrhoea	Child with diarrhoea in last 14 days received oral rehydration solution (yes/no)	Children with diarrhoea in last 14 days	Diarrhoea management
4	Treatment seeking for suspected acute respiratory infection	Treatment seeking from formal healthcare provider for cough and atypical breathing (yes/no)	Child cough AND faster breathing than usual/breathing difficulties	Acute respiratory infection management: mothers taught to recognise signs (e.g. count/listen to breaths to assess breathing difficulty) and seek formal treatment
5	Measles vaccination uptake	Did the child receive a vaccination against measles? (yes/no)	9.00-35.99 months	Measles prevention
6	Routine de-worming	Did the child receive a drug to get rid of intestinal worms? (last 6 months) (yes/no)	12.00-35.99 months	Worm prevention/management

Immunisations and vitamin A (12.00-23.99 months)

During data collection, growth monitors were asked to collect immunisation data from children's vaccination cards where possible. In 66% of cases vaccination cards were available, and the remainder were based on maternal report. A far greater proportion of children with vaccination cards appeared to be fully immunised compared to those where maternal report was used (79.4% versus 44.1%) and this effect was similar across exposure groups. A greater proportion of children from the intervention areas were fully immunised compared to the control. Full immunisation included BCG, measles and three doses of DPT and Polio (71.9% versus 62.7%). More children from intervention areas received vitamin A solution (72.9% versus 58.8%). The full table reporting immunisation schedule completion in intervention and control areas is located in appendix 6.16.

Advice and treatment-seeking for diarrhoea, fever and cough

About half of respondents said they had sought advice on how to manage child diarrhoea, and this was slightly higher in the intervention group than the control (54.4% versus 47.7%), a similar pattern was seen for advice seeking about child fever. Sources of advice varied, however the Anganwadi worker was one of the most commonly accessed people (intervention 13.1%; control 28.0%) aside from 'other' which covered a range of formal and informal sources. Ekjut women's group members were approached for advice in 5-10% of cases in the intervention areas.

Around one-third of women said they had sought advice for child cough, which was considerably lower than for fever and diarrhoea and this was similar between exposure groups. Again, advice sources varied. With regards to treatment seeking, fewer women attended primary health centres, sub-centres or government hospitals compared to private facilities or informal treatment sources. Prevalence of child diarrhoea, fever and cough as well as home management and associated healthcare seeking variables by exposure group are presented in appendices 6.17-6.19.

Model results

Data on home-care practices showed that a greater proportion of children were reportedly given the same or more than usual to eat and drink in the intervention areas during diarrhoea, fever and cough compared to the control group, but this was not significant in adjusted models. However, the association was approaching significance in the multiple imputation and sibling-adjusted datasets (AOR=1.946, 95%CI 0.982-3.855 and AOR=1.988, 95%CI 0.979-4.037 respectively).

In terms of home-based treatment for diarrhoea, more women reported using oral rehydration solution in the intervention areas than the control (43.4% versus 37.9%). A slightly higher proportion also said they had sought treatment for complicated child cough, and reported routine deworming, but none of these effects were significant in adjusted models. One positive finding is that children in the intervention areas were more than twice as likely to have received their measles vaccination as children in the control areas (using vaccination card data where possible); this was also observed in multiple imputation models (AOR=1.987, 95%CI 1.076-3.666) and sibling-adjusted models (AOR=1.999, 95%CI 1.076-3.714).

Table 6.6 The association between intervention exposure and the prevention and management of childhood illnesses, adjusted for socio-demographic variables (0=control, 1=intervention)

Outcome	Intervention % (n)	Control % (n)	Total % (n)	Unadjusted OR (95%CI)	Adjusted OR (95%CI)
1. Fed the child the same or more than usual during diarrhoea, fever and/or cough (previous 14 days)[1]	52.3 (383/732)	36.3 (411/1133)	42.6 (794/1865)	1.928 (0.942-3.946)	1.965 (0.970-3.979)
2. Gave the child the same or more than usual the amount of liquids diarrhoea, fever and/or cough (previous 14 days)[2]	66.5 (242/364)	58.9 (300/509)	62.1 (542/873)	1.382 (0.582-3.281)	1.364 (0.653-2.849)
3. Gave the child oral rehydration solution during diarrhoea (previous 14 days)[1]	43.8 (158/361)	37.9 (193/509)	40.3 (351/870)	1.274 (0.529-3.072)	1.310 (0.648-2.648)
4. Sought treatment from a formal healthcare provider for child cough with abnormal/laboured breathing (previous 14 days)[3]	57.0 (170/298)	55.9 (245/438)	56.4 (415/736)	1.046 (0.336-3.259)	1.505 (0.545-4.161)
5. Child immunised against measles (9.00-35.99 months)[4]	76.0 (1131/1488)	65.4 (1176/621)	70.2 (2307/3285)	1.673 (0.898-3.115)	2.019 (1.089-3.743)
6.Child received routine de-worming in the last 6 months (12.00-35.99 months)[5]	27.0 (343/1270)	23.9 (375/1572)	25.3 (718/2842)	1.181 (0.506-2.758)	1.043 (0.440-2.469)

[1]Adjusted for: socio-economic status, religion
[3]Adjusted for: socio-economic status, religion, maternal education, income group
[3]Adjusted for: socio-economic status, social group
[4]Adjusted for: socio-economic status, social group, relationship to household head, maternal age
[5]Adjusted for: socio-economic status, relationship to household head, religion

6.5 Hygiene and sanitation

This section includes a description of the health environment, hand washing and water treatment behaviours (all hygiene and sanitation indicators measured in the survey are presented by exposure group in appendix 6.26). I tested for intervention associations with a selection of these outcomes; the rationale for testing these models is presented in Table 6.7.

Open-ended questions about the occasions when soap was used for hand washing were coded to gauge levels of positive hand washing practices for five key occasions: before preparing food, before feeding a child, after defecation, after cleaning up a child who has defecated, before eating. Two of these outcomes had insufficient numbers of cases in the response category to allow testing: hand washing with soap before preparing food had fewer than 10 cases in the control group (0.4%) and hand washing with soap before feeding a child had only 15 cases in the intervention group (0.8%) and 30 in the control (1.3%). Babyak (2004) advises that a minimum of 10 cases per level of each predictor are required in logistic regression to ensure model stability.

The results of the final models are presented in Table 6.8; full final models including all predictors, and multiple imputation and sibling-adjusted models are presented in appendices 6.27-6.30.

Table 6.7 Rationale and details for hand washing and water treatment models

Model	Outcome	Binary categorisation	Sample	Pathway to improved child growth
1	Hand washing with soap: after defecation	Soap/other cleansing agent used for hand washing after defecation (yes/no)	Full sample	Diarrhoea and worm/infection prevention
2	Hand washing with soap: after cleaning a child who has defecated	Soap/other cleansing agent used for hand washing after cleaning up after a child who has defecated (yes/no)	Full sample	Diarrhoea and worm/infection prevention
3	Hand washing with soap: before eating	Soap/other cleansing agent used before eating (yes/no)	Full sample	Diarrhoea and worm/infection prevention
4	Treatment of drinking water	Physical or chemical treatment of drinking water (yes/no)	Full sample	Diarrhoea and worm prevention: women were advised to boil and cool water before drinking

Health environment

Nearly two-thirds of respondents were classed as having an insufficient living area (>3 people per sleeping room) although no data were available on the size of rooms used for sleeping (United Nations 2011). The majority of participants reported using solid cooking fuels and cooked over an open fire (≥97%). Most respondents cooked in the main living area (intervention=72.3%, control=62.8%), about a quarter of participants cooked in a separate room and the remaining minority cooked outside. More than a third of respondents in both groups did not have access to safe drinking water and for up to 10% of people the time taken to reach and return from drinking water sources exceeded 30 minutes (intervention 6.3% control 9.7%) (United Nations 2011). More than 99% of respondents reported open defecation and >97% throw child faeces 'outside' (<2% used a latrine).

Open-ended survey questions asked what people use to wash their hands: the most common response was plain water (intervention=68.2%; control=87.2%). More than a third of intervention participants (35.6%) reported using soap or another cleansing agent (including mud, soap or ash) compared to 9.4% in the control areas.

Model results: hand washing and drinking water treatment

Women in the intervention areas were more than five times as likely to report hand washing with soap after defecation than women in the control areas in adjusted models (unadjusted percentages were 40.4% and 14.3% respectively). The same effect was observed in multiple imputation and sibling-adjusted models (AOR=5.234, 95%CI 1.940-14.119 and AOR=5.340, 95%CI 1.778-16.042 respectively).

Exposure to the intervention was also associated with a nearly 12 fold increase in self-reported hand washing with soap after cleaning up a child who had defecated compared to control areas (unadjusted percentages: intervention=30.9%; control=6.4%). This effect weakened slightly in the multiple imputation model (AOR=9.752, 95%CI 4.411-21.559) and to a lesser extent in the sibling-adjusted model (AOR=11.591, 95%CI 5.183-25.921) but remained highly significant.

Conversely, intervention exposure was associated with a 75.7% reduced likelihood of reporting hand washing with soap before eating in the adjusted model (unadjusted percentages: intervention=28.1%; control=54.7%). This result was similar in multiple imputation and sibling-adjusted models (AOR=0.240, 95%CI 0.095-0.607 and AOR=0.246, 95%CI 0.097-0.621 respectively).

Nearly double the percentage of intervention participants reported treating their drinking water (physical and/or chemical treatment; 36.3%) compared to respondents in control areas (19.1%). This was highly significant in adjusted models: women in intervention areas were more than 4 times as likely to report treating their drinking water as women from control areas. This effect remained highly significant in multiple imputation (AOR=0.240, 95%CI 0.095-0.607) and sibling-adjusted models (AOR=0.246, 95%CI 0.097-0.621).

Table 6.8 The association of intervention exposure with self-reported hand washing and treatment of drinking water, adjusted for socio-demographic variables (0=control, 1=intervention)

Outcome	Intervention % (n)	Control % (n)	Total % (n)	Unadjusted OR (95%CI)	Adjusted OR (95%CI)
1. Hand washing with soap after defecation[1]	41.2 (729/1769)	14.3 (319/2225)	26.2 (1048/3994)	4.188 (1.717-10.214)	5.354 (1.801-15.915)
2. Hand washing with soap after cleaning a child who has defecated[2]	31.5 (558/1769)	6.4 (143/2225)	17.6 (701/3994)	6.709 (2.875-15.656)	11.696 (5.268-25.969)
3. Hand washing with soap: before eating[3]	28.7 (507/1769)	54.7 (1218/2225)	43.2 (1725/3994)	0.322 (0.119-0.930)	0.243 (0.096-0.613)
4. Treatment of drinking water[4]	36.6 (655/1790)	19.1 (425/2221)	26.9 (1080/4011)	2.439 (0.904-6.578)	4.363 (1.631-11.671)

[1]Adjusted for: socio-economic status, maternal education, social group, season of measurement, income group, relationship to household head, religion, maternal age
[2]Adjusted for: socio-economic status, maternal education, social group, income group, relationship to household head, religion, maternal age
[3]Adjusted for: socio-economic status, social group, religion
[4]Adjusted for: socio-economic status, maternal education, social group, season of measurement, income group, maternal age

6.6 Provision and uptake of health and nutrition services

This section includes a description of women's self-reported access to higher-level health services, receipt of Integrated Child Development Service entitlements, and awareness of child underweight (these variables are presented in full by exposure group in appendix 6.31). There was only a rationale to test two of these variables for an association with the intervention: growth monitoring by the Anganwadi worker, and maternal awareness of child underweight (Table 6.9). Model findings are presented in Table 6.10. The full final models with all predictor associations, along with results from multiple imputation and sibling-adjusted models are presented in appendices 6.32-6.33.

Table 6.9 Rationale and details for models assessing maternal awareness of child underweight and reported use of growth monitoring services

Model	Outcome	Binary categorisation	Sample	Pathway to improved child growth
1	Growth monitoring by the AWW	Was the child's growth monitored at least once/month (yes/no)	Full sample	Child growth monitoring/case-finding for undernutrition; growth chart was discussed/AWWs approached for growth monitoring
2	Maternal awareness of child underweight	Mother correctly perceives child as underweight	Children with WAZ <-2	Child growth monitoring/case-finding for undernutrition: women's groups used the road to health card and weight for age to monitor child growth; awareness is a precursor to behaviour change

Access to higher-level health services

Double the percentage of women in the intervention areas reported having access to a community fund in case of serious illness (32.9%) than the control group (15.0%). About a third of respondents were within 5 Kilometres of a government or private health facility (intervention=34.3%, control=31.3%), more than a third were 5-10 Kilometres away (intervention=38.5%, control 42.3%), and about a quarter were >10 Kilometres away. The majority of respondents perceived the care they received at government of private health facilities as fair to very good.

Integrated Child Development Service entitlements

According to maternal report more than 80% of all children ≥6 months had received their monthly food ration entitlement. A similar proportion of mothers with children <6 months reported receiving a monthly food ration in the intervention areas (82.4%) but this was slightly lower in control areas (71.0%). About two-thirds of children reportedly had their growth monitored monthly by the Anganwadi worker, although nearly a fifth were not measured at all in the control areas (18.9%) compared to 13.6% in the intervention areas. Of those who were weighed, two-thirds (64.4%) of mothers reported that they were given feedback afterwards in the intervention areas compared to 40% in the control. There was no association between exposure group and reported uptake/provision of growth monitoring services in the adjusted model. Similarly, the multiple imputation (AOR=0.922, 95%CI 0.634-1.341) and sibling-adjusted models showed no significant association (AOR=0.919, 95%CI 0.441-1.917).

Maternal awareness of child underweight

More than three quarters of women perceived their children to be 'about the right weight', although this was more common in the control than the intervention areas (75.1% versus 88.9%). Of the children with a weight-for-age Z-score of <-2.00, more than a quarter of mothers in the intervention areas correctly identified that their child was underweight (27.4%), compared to 12.1% in the control areas, and this was significant in the adjusted models. This finding was confirmed in the multiple imputation and sibling adjusted models (AOR=3.026, 95%CI 1.587-5.768 and AOR=2.971, 95%CI 1.558-5.664 respectively). Around a quarter of women had sought care specifically because they thought their child was underweight and this was slightly higher in the intervention than the control areas (28.8% versus 24.6%).

Table 6.10 The association of intervention exposure with maternal awareness of child underweight and reported use of growth monitoring services, adjusted for socio-demographic variables (0=control, 1=intervention)

Outcome	Intervention % (n)	Control % (n)	Total % (n)	Unadjusted OR (95%CI)	Adjusted OR (95%CI)
1. Monthly growth monitoring by the AWW [1]	64.3 (1139/1772)	66.4 (1467/2211)	65.4 (2606/3983)	0.913 (0.434-1.919)	0.923 (0.443-1.923)
2. Maternal awareness of child underweight [2,3]	27.4 (348/1269)	12.1 (170/1402)	19.4 (518/2671)	2.738 (1.174-6.386)	3.027 (1.593-5.755)

[1]Adjusted for: season of measurement, social group, religion
[2]Adjusted for: socio-economic status, relationship to household head, religion
[3]Includes children with weight-for-age Z-scores <-2.00

6.7 Maternal and child health indicators

In this section I have described perinatal characteristics, childhood illnesses and maternal diet and health. Full data for these survey variables are presented by exposure group in appendices 6.34-6.36. Maternal reports of the prevalence of child diarrhoea, fever and cough in the last 14 days are presented in appendices 6.17-6.19.

Table 6.11 details the specific models I tested for exposure group associations with maternal and child health indicators. I had intended to test the association between exposure group and perceived prematurity (≤37 weeks perceived gestation), however there were too few cases in the response categories in both groups (2.9%) for the model to be viable. The final listwise models for this section are presented in Table 6.12. The full final models with all relevant socio-demographic predictors and results from multiple imputation and sibling-adjusted models are located in appendices 6.37-6.43.

Table 6.11 Rationale and details for perceived low birth weight, prematurity, recent childhood illness and maternal health models

Model	Outcome	Binary categorisation	Sample	Pathway to improved child growth
Maternal perceptions of low birth weight and prematurity				
1	Perceived size at birth	Did the mother perceive her child to be smaller than average versus average/larger than average at birth?	Full sample	Low birth weight reduction (proxy measure) via anaemia reduction strategies and dietary advice for pregnant women, and women's group campaigns against early marriage
2	Perceived prematurity	Did the mother perceive that her child was born early versus on time/late?	Full sample	Prematurity reduction (proxy measure) via anaemia reduction strategies and dietary advice for pregnant women, and campaigns against early marriage)
Child infections (last 14 days)				
3	Diarrhoea	Does the child suffer from repeated attacks of diarrhoea? (yes/no)	Full sample	Diarrhoea reduction
4	Fever	Does the child suffer from repeated attacks of fever? (yes/no)	Full sample	Infection prevention (e.g. malaria and other infection prevention behaviours; immunisations
5	Cough	Does the child suffer from repeated attacks of cough? (yes/no)	Full sample	Infection prevention (e.g. malaria and other infection prevention behaviours; immunisations; danger signs for acute respiratory infection
Maternal health				
6	Maternal psychological distress	Did the woman score >15 on the Kessler-10 scale? (yes/no)	Full sample	Improved maternal mental health -> improved caring and feeding practices. A beneficial effect of the groups was observed in the trial for the neonatal period
7	Maternal Body Mass Index	n/a – continuous variable	Excludes pregnant women	Reduced maternal underweight -> better pregnancy outcomes, and signifies adequacy of household diet. The women's groups focused on the importance of improving maternal diet through increased quality and quantity of intake

Perinatal characteristics

There were equal proportions of males and females between exposure groups (intervention males=50.2%, control males=50.8%). There were equal proportions of children born in the three seasons across exposure groups. Nearly a third of children were born 4th or later in relation to their other siblings (intervention=31.9%; control=31.2%). More than three quarters of all respondents reported home births. Delivery at a government facility was slightly more common in the intervention areas (17.7%) than the control areas (14.0%) and ≥96.8% of these births were normal vaginal deliveries.

On average children in intervention areas were 31g heavier at birth than children in the control areas. However, birth weight is not routinely collected in the study areas and was only available for a quarter of children. The quality of this data is also dubious with a strong preference for birth weights that correspond to clinical thresholds. As such, we relied upon proxy measures of birth weight – perceived size at birth (smaller than average, average or larger than average) and two measures of prematurity: whether the child was born early, on time or late, and a second question asking the mother to estimate the number of months gestation she was when she gave birth (<37 weeks was considered premature).

The majority of mothers estimated that their children were born at full gestation, and a very low percentage thought their children was born 'early' (≤3.7%). Double the proportion of women in the intervention areas felt their child was smaller than average size at birth (35.0%) than in the control group (17.3%). A slightly greater proportion of women in the control areas felt their child was larger than average at birth (7.4%) compared to the intervention areas (0.2%), although most women reported that their child was 'average' size at birth. None of these outcomes were significantly associated with intervention exposure in adjusted models, and remained non-significant in multiple imputation and sibling-adjusted models.

Childhood illnesses

According to maternal report more than a fifth of children had suffered with diarrhoea in the previous 14 days and this was marginally higher in the control (22.9%) than the intervention areas (20.1%); of these cases, 15.9% and 18.1% reportedly had blood in their stool respectively. Fever in the last 14 days was commonly reported overall, although it was slightly lower in the intervention areas (21.2%) than the control (28.0%). More than a quarter of mothers reported that their children had suffered with a cough in the previous 14 days and this was similar between groups (intervention=25.7%, control=28.5%). In about two-thirds of these cases cough was reportedly accompanied by atypical breathing (breathing faster than usual/short rapid breaths or difficulty breathing). There was no intervention association for any of these outcomes in the final listwise model, or in the multiple imputation or sibling-adjusted models.

According to maternal report 23.8% of children 6-35 months in the intervention areas and 30.5% in the control areas had been ill at least three times in the previous six months. In the <6 month group the frequency of illnesses since birth was lower than for older children: intervention=8.8%, control=10.1%. Repeated diarrhoea infection was reported for more than a quarter of children and was slightly more common in the intervention areas than the control (29.7% versus 25.3%). More than a third of children had reportedly experienced repeated fevers and this was more common in the control group than the intervention (39.9% versus 33.2%). Maternal report indicated that just under a third of children experienced repeated coughs and this was very similar between groups.

Maternal diet and health

Mean maternal Body Mass Index (BMI) was 18.5 in both groups (excluding pregnant women), which is at the threshold for underweight. There was no significant association with exposure group in adjusted listwise, multiple imputed or sibling-adjusted models. More than 50% of women were classed as underweight (BMI <18.5): intervention=52.9% and control=54.2%. 6.0% of women in the intervention areas and 6.4% in the control areas were severely underweight (BMI <16.0).

Most women reported that they had eaten at least three small or main meals in the previous 24 hours. However, a substantial minority said they had eaten two meals or fewer (intervention 40%; control 44.2%), although quantities were unknown. The profile of different food groups reportedly consumed in the last 24 hours was similar between exposure groups. Almost all respondents reported eating grains/roots/tubers and around three quarters had consumed vitamin A rich fruit and vegetables; a third had eaten legumes/nuts and a quarter of women had eaten other fruit and vegetables. Flesh foods were less commonly reported (~17%); eggs and other dairy products were very uncommon (≤2.3%). About half of women reported consuming 0-2 food groups, and just over a third said they had consumed three (intervention 34.2%; control 38.1%) in the previous 24 hours.

More than a quarter of women in both groups reported a non-pregnancy related physical health problem serious enough to affect their work and daily activities within the last three months, lasting for 5-8 days; the majority of these were due to illness rather than injury. The Kessler-10 self-reported measure of psychological distress identified most women as scoring in the ‘none/mild’ category (intervention= 91.9%; control=88.0%) (Kessler et al. 2002). A higher proportion of women in control areas were moderately distressed compared to the intervention group (11.9% versus 7.4%) and very few women scored in the severe category in either group (0.1-0.3%), although this difference was not significant in any of the final models. Consultations with health professionals about psychological distress were rare.

Table 6.12 The association between intervention exposure and other maternal and child health indicators, adjusted for socio-demographic variables (0=control, 1=intervention)

Outcome	Intervention % (n) or mean (SD)	Control % (n) or mean (SD)	Total % (n) or mean (SD)	Unadjusted β/OR (95%CI)	Adjusted β/OR (95%CI)
1. Mother perceived child to be average or larger than average size at birth[1]	65.0 (1172/1803)	82.7 (1840/2224)	74.8 (3012/4027)	0.388 (0.114-1.315)	0.313 (0.087-1.127)
2. Mother perceived child to be born early[2]	3.7 (66/1803)	3.1 (69/2219)	3.4 (135/4022)	1.184 (0.637-2.201)	1.327 (0.710-2.480)
3. Child suffered with diarrhoea in the previous 14 days[3]	20.2 (364/1804)	22.9 (509/2223)	21.7 (873/4027)	0.851 (0.455-1.593)	0.828 (0.506-1.354)
4. Child suffered with a fever in the previous 14 days[4]	21.2 (383/1804)	28.0 (622/2223)	25.0 (1005/4027)	0.694 (0.370-1.300)	0.659 (0.389-1.119)
5. Child suffered with a cough in the previous 14 days[4]	25.7 (463/1805)	28.5 (634/2223)	27.2 (1097/4028)	0.865 (0.456-1.640)	0.799 (0.439-1.455)
7. Maternal Body Mass Index[4]	18.52 (1.82)	18.51 (1.85)	18.52 (1.83)	0.006 (-0.191-0.203)	-0.019 (-0.229-0.191)
6. Mother was experiencing psychological distress (K10 >15)[5]	7.7 (139/1797)	12.0 (267/2225)	10.1 (406/4022)	0.615 (0.211-1.795)	0.477 (0.161-1.415)

[1]Adjusted for: socio-economic status, season of measurement, religion, social group, maternal age
[2]Adjusted for: income group
[3]Adjusted for: socio-economic status, religion, social group
[4]Adjusted for: SES, religion, maternal education, maternal age, social group, relationship to household head
[5]Adjusted for: socio-economic status

6.8 Discussion

The results indicate that women's groups have the potential to make positive impacts on several behaviours that are important for improved child growth outcomes. These include self-reports of maintained or increased dietary intake during pregnancy, better birth spacing, greater uptake of measles vaccinations, increased awareness of child underweight, and a borderline effect of maintained or increased food provision for children during illnesses measured through maternal report. Very large positive associations were also observed for self-reported hygiene and sanitation behaviours, including treatment of drinking water and hand washing with soap after defecation and after cleaning up a child who had defecated. The hand washing effect was not consistent though: self-reported hand washing with soap before eating was significantly less likely in the intervention group than the control, although the association was much weaker than for the other hand washing models.

Areas with apparently no association with the intervention despite related women's group action included: self-reported iron tablet intake in pregnancy, antenatal care, kitchen gardens, age at marriage, infant and young child feeding behaviours, use of oral rehydration solution for child diarrhoea, treatment seeking for complicated cough, routine deworming and growth monitoring. There was no apparent impact on any of the additional health indicators measured in the survey: maternally reported 14 day prevalence of child diarrhoea, fever and cough, perceived size at birth and prematurity, maternal BMI and maternal psychological distress.

Pregnancy behaviours

One positive finding from my analyses indicates that women in the intervention areas were more than four times as likely to eat the same or more than they did before pregnancy compared to women from the control areas (measured through self-report). This was emphasised in both cycle 1 and 2 so the prolonged exposure to this advice and resulting strategies may explain this finding. There is general consensus that women should modestly increase their calorie intake during pregnancy in the region of 240 extra calories in the second trimester, and 452 in the third (LINKAGES 2004). Advice also varies by the preconception nutritional status of the mother, for example the Indian Council of Medical Research recommends 150 extra calories for a 55kg woman in her first trimester, then 350 additional calories in the second and third (Indian Council of Medical Research 2010).

Despite this guidance, research from India has identified the practice of 'eating down' during pregnancy. A study in rural Karnakata observed a decline in calorie intake during pregnancy, which was particularly pronounced in the second and third trimesters (Hutter 1996) and a more recent study in rural North India identified a mean daily intake of 1541.36 calories in the second trimester of pregnancy, which is far lower than the recommended 2500 calories for rural non-pregnant women (Gautam et al. 2008). There is widespread belief that not only does food monopolise the baby's growing and moving space but that intake should be limited to avoid having a large baby and a potentially obstructed labour (Costello and Osrin 2003;Nag 1994); both of these attitudes were expressed by caregivers we met during growth monitor training.

Although I could find no evidence that healthy weight gain during pregnancy causes obstructed labour, the WHO collaborative study found that reduced maternal weight gain during the 5th and 7th months of pregnancy was strongly related to intrauterine growth restriction (Kelly et al. 1996). Conversely, one review concluded that the benefit of increased protein and energy intake during pregnancy on foetal growth was unclear (Kramer and Kakuma 2010). There is a huge burden of intrauterine growth restriction in India, and even mildly affected children are at a greater risk of undernutrition, morbidity and mortality in early life (Black et al. 2008). Intrauterine growth restriction has multiple causal factors and increasing weight gain in pregnancy is unlikely to be a panacea, but could lessen the problem. Restricted diets in pregnancy also have health implications for women including the exacerbation of anaemia, particularly if restrictions of iron-rich food co-exist (Nag 1994).

Birth spacing

Women in the intervention areas were 2.5 times more likely to space their pregnancies by at least 24 months compared to women in the control areas. Whilst this is encouraging, a substantial minority of women's group participants we surveyed (13.5%) spaced their pregnancies by less than 24 months. This compares unfavourably with the 8% estimated in the NFHS-3 for Jharkhand and Orissa (Government of India 2006). Our data are closer to the DLHS-3 survey for Jharkhand, which identified a 14.2% unmet need for birth spacing, although their Orissa estimate is lower than ours at 8.7% (Ministry of Health and Family Welfare 2010).

One recent review concluded that there was inconsistent evidence that birth spacing affects child nutritional outcomes (Bhutta et al. 2008). One further review found that although birth intervals ≥36 months were associated with a 10-15% reduction in child stunting, this did not apply across populations and there was concern about residual confounding (Dewey and Cohen 2007). In terms of maternal outcomes, again associations with birth spacing were mixed which may relate to breastfeeding status: Dewey and colleagues (2007) argue that it is the recuperative non-lactating interval that is important, rather than the birth interval per se which does not take account of the energy requirements of breastfeeding. This is relevant to the current sample where women continue breastfeeding well beyond two years.

It is difficult to know how important these two findings are for maternal and child nutrition. Our measure of diet in pregnancy is self-reported and does not provide quantitative calorie intake information and only tells us a woman's dietary intake relative to before pregnancy. The dietary data we have suggests that pre-pregnancy diet was probably inadequate and is reflected in low maternal BMIs. Nevertheless, I think there is reason to be optimistic that the potentially harmful cultural practice of 'eating down' during pregnancy seems to be reduced as a result of the intervention. This may be an aggravating factor for intrauterine growth restriction and maternal anaemia (albeit one of many). It also illustrates the potential for behaviour change around eating behaviours, which could be applied in a more focused way to improve maternal and child diets.

Although there is inconsistent evidence that birth spacing is important for child growth, there is stronger evidence for improved maternal outcomes, which are important to interrupt the intergenerational cycle of undernutrition (Bhutta et al. 2008). Increased birth spacing also has other important functions, such as reducing the burden of childcare on women and on household resources. A number of women's groups focused on improving maternal diet in pregnancy, many as part of anaemia reduction strategies during Cycle 1, but also through additional guidance during Cycle 2. Group strategies included awareness-raising to improve dietary quantity and quality during pregnancy (particularly to increase iron intake e.g. through kitchen gardens), campaigns against early pregnancy, and the promotion of antenatal care, iron tablets and adequate birth spacing. In future work, women's groups might want to consider the length of the non-breastfeeding interval between pregnancies to ensure ample time for women to recover from the demands of pregnancy and breastfeeding, although it is possible that breastfeeding is used as an informal method of family planning.

Infant and young child feeding indicators

There was no significant impact of women's groups on any of the maternally reported infant and young child feeding indicators tested. Reported early initiation and exclusive breastfeeding under 6 months were higher, and pre-lacteal feeding was lower in the intervention areas compared to the control but not significantly. Our data for these three indicators compares favourably to the NFHS-3 estimates for Jharkhand and Orissa (e.g. more than two-thirds of women in our survey reported early initiation of breastfeeding, compared to 10% and 55% in the NFHS-3 for Jharkhand and Orissa) (Ministry of Health and Family Welfare 2006). There are important differences between the surveys that could explain this: our recall period was shorter (children under-three as opposed to under-five years) and our sample was not representative at the state-level. The NFHS-3 was also five years earlier than our survey, and could be indicative of improvements on these indicators, although such a dramatic effect seems unlikely.

Reported bottle-feeding was unexpectedly higher in the intervention areas than the control, although was not particularly common. This increases the risk of diarrhoea and other health problems, especially if breast milk substitute or other fluids have been given early (i.e. before 4 months) (Black et al. 2008;Weisstaub and Uauy 2012;World Health Organisation 2008a). Maternal reports indicated that less than half of children 6-8 months had started receiving complementary foods, which is worse than the 55% reported in the NFHS-3 (Patel et al. 2012). Anecdotal information from Ekjut staff has highlighted the influence of naming ceremonies on the timing of weaning. These often occur at 7 months of age and because hosting the celebration may be costly, it is sometimes further delayed to enable saving, although this is one factor amongst many that influences weaning decisions.

The high reported levels of late weaning should also be considered alongside the fact that a third of children aged 6-35 months were reportedly not receiving the minimum meal frequency, which may suggest low food availability. These latter two indicators may be posing a greater risk to child health than the breastfeeding indicators, which appear reasonable. Late weaning increases the risk of anaemia, stunting and wasting when children are in a period of greater nutritional need than can be provided by breast milk alone, and the low proportion of children reportedly receiving the minimum meal frequency indicates a likely protein-energy deficit (De Onis 2008;Dewey and Adu-Afarwuah 2008;World Health Organisation 2001a). It is questionable as to how much behaviour change would be possible to improve these indicators as they may reflect broader food insecurity. Given ideal environmental conditions, a behaviour change intervention with women's groups to increase feeding frequency and to ensure children are weaned in a timely fashion could have an effect, but against a back drop of low income and high food prices it is not surprising that late weaning is so common and feeding frequency appears to be inadequate for so many children.

Prevention and management of childhood illnesses

All six indicators in this section were more favourable in the intervention group than the control although only one was significant and one borderline significant in the final models. Children aged 12.00-23.99 months in the intervention areas were more than twice as likely to have received their measles vaccination as children from control areas using a mixture of vaccination card and maternal report data. More than three quarters of children were vaccinated against measles in the intervention areas (76.0%), which compares favourably with the NFHS-3 data for Jharkhand (47.6%) and Orissa (66.5%) (Ministry of Health and Family Welfare 2006).

UNICEF has identified India as one of several South East Asian countries needing focused strategies for 'accelerated and sustained' reduction in measles mortality (UNICEF India 2013). This highly infectious respiratory illness is a leading cause of diarrhoeal deaths and improving vaccination uptake is one component of the WHO/UNICEF seven-point strategy to prevent the estimated 9 million diarrhoea deaths per year (World Health Organisation and UNICEF 2009). Household overcrowding which is common in the study areas increases the risk of infections via respiratory droplets where severely malnourished and younger children are at a greater risk of infection, and prolonged illness (Savitha et al. 2007). Several meetings during cycle 2 identified measles as a key cause of diarrhoea and stressed the importance of measles vaccination to prevent acute respiratory infection through a local story about a child who developed a severe infection.

One limitation of this finding is the reliance upon caregiver reports for vaccination status in about a third of cases. There was little difference in vaccination card availability between exposure groups though (intervention=67.7% and control=64.5%) and this does not suggest any bias towards over-reporting by women's group members. One paper based on the NFHS-3 suggests there may be significantly higher reported rates of completed immunisation schedules for 'vaccination card seen' versus 'vaccination card not seen' and the authors assume that cards are more accurate than maternal recall (Chandran et al. 2011). Even where vaccination cards were available, the experience of some Ekjut staff members is of inappropriate completion of vaccination cards by some Anganwadi workers. Future work could cross-check vaccination cards against caregiver recall, as well as vaccination coverage recorded at the district and block levels.

Nutritional management during childhood illnesses

Maternal self-reports of feeding the same or more than usual during child diarrhoea, fever or cough were more common in the intervention areas than the control (more than half compared to just over a third), and this was borderline significant. This is a higher percentage than reported in the NFHS-3 for Jharkhand (22.7%) and Orissa (49.3%) (Government of India 2006). This finding has important implications for child health, where nutritional management is important during both the illness and recovery phases (Lanata and Black 2008). Previous guidance was to withhold food during diarrhoea in case it exacerbated the problem. However, one study found that this resulted in weight deficits compared to children given a full strength diet, and the effect persisted beyond two weeks of observation (Brown et al. 1988). Current WHO guidance is to continue breastfeeding or general feeding as normal and this is included in the WHO/UNICEF diarrhoea reduction strategy to reduce severity and duration (World Health Organisation and UNICEF 2009).

The amount of liquids reportedly given during child illnesses and the reported use of oral rehydration solution for diarrhoea were greater in the intervention group than the control, although not statistically significant. The provision of liquids during illness is important to prevent dehydration and should continue to feature in women's groups as a nutritional management strategy. The use of oral rehydration solution is a central component of the WHO diarrhoea strategy and includes advocating for the use of appropriate fluids in the home if low osmolality sachets are unavailable (World Health Organisation and UNICEF 2009). The use of oral rehydration solution was much higher in the intervention areas at 43.8% than reported in the NFHS-3 for children under-five in Jharkhand and Orissa (17.3% and 39.8%) (Government of India 2006). Women's groups were taught how to make oral rehydration solution at home and were made aware that the Anganwadi worker should provide ready-made sachets, and how they should be used. Although low osmolality sachets may be more effective at managing diarrhoea, home treatment is an acceptable alternative (World Health Organisation and UNICEF 2009). We may have underestimated the use of homemade oral rehydration solution in the survey. We used a modified version of the NFHS-3 question options and homemade solution was not included (although free-text was allowed in the 'other' category, few people responded).

Routine de-worming

Maternal reports of routine de-worming, although higher in the intervention areas, were not significant different. Worms are highly prevalent in the study areas and are associated with child nutritional outcomes (Awasthi et al. 2008;Hall et al. 2008). Our measure used the same recall period as the NFHS-3 to find out whether children had received a drug to get rid of intestinal worms in the past six months. This measures routine bi-annual deworming which may not be adequate given the high burden in the study areas, and for which the WHO recommends tri-annual presumptive treatment (World Health Organisation 2012). Anecdotes from Ekjut staff include local children being turned away for worm treatment by Anganwadi workers or Auxiliary Nurse Midwives after being incorrectly told they were not eligible until age three. Although I have tested this indicator as a self-reported behaviour change outcome it is equally a measure of primary healthcare provision.

Treatment-seeking for suspected ARI

Maternally reported treatment seeking from formal health care providers for suspected acute respiratory infection (defined as cough and faster breathing than normal, short rapid breaths or difficulty breathing) was marginally more common in the intervention than control areas (57.0% versus 55.9%) but was not significant. The NFHS-3 used a similar definition (cough and short, rapid breathing) and found comparatively better treatment-seeking for children under-five in Jharkhand (67.0%) and Orissa (76.5%) than in our sample (Government of India 2006).

In Cycle 2 women's groups were taught to recognise the signs of acute respiratory infection, including increased respiratory rate, laboured breathing and in-drawing of accessory muscles. It is disappointing that there seems to be no women's group association with this outcome. As with the uptake of deworming, not accessing treatment for suspected acute respiratory infection may reflect supply-side problems, difficulties accessing care or limited household finances. The randomised controlled trial of cycle 1 showed a reduction in care-seeking delays for labour complications, which is partly attributed to the use of emergency drills and funds being made available to transport women to formal healthcare providers (Tripathy et al. 2010). The same principle could be applied here, and although it would be a more directive approach, it could be an agreeable suggestion, particularly if women are aware of the imminent mortality risk for children exhibiting these danger signs.

Hygiene and sanitation

Encouraging results were observed for several self-reported hygiene and sanitation behaviours, including significantly greater levels of drinking water treatment and hand washing with soap after defecation or cleaning up a child after defecation.

Self-reported treatment of drinking water included physical methods such as boiling and chemical treatment such as the addition of chlorine. Women's groups explored these methods during the Cycle 2 meeting about child diarrhoea. Treatment of drinking water was reportedly practised by more than a third of intervention participants compared to less than a fifth of women in the control areas. This is an important finding in a context where more than a third of respondents reported not being able to access clean drinking water. Whilst this is positive, water treatment is only one of several water and sanitation components crucial to reduce the burden of ill health observed in the study areas. Improved water quantity and quality, including treatment and safe storage of household water could reduce diarrhoea by 47% (Fewtrell et al. 2005). Improved water storage practices could be a worthy additional focus of the women's groups given the widespread unhygienic environmental conditions that could contaminate drinking water.

Intervention participants were far more likely to report hand washing with soap after defecation and after cleaning up a child who had defecated, although they were less likely to report hand washing before eating than women in the control areas. One meeting in Cycle 2 highlighted key hand washing occasions requiring soap within a local story about the prevention of worms; the diarrhoea prevention meeting also emphasised cleanliness as a prevention measure. The promotion of hand washing with soap is one of 13 priority direct interventions identified by the Scaling up Nutrition movement (Scaling Up Nutrition 2010). Hand washing is also integral to the WHO/UNICEF seven-point strategy to reduce diarrhoea, which is estimated to have the potential to reduce diarrhoeal mortality by 40% (World Health Organisation and UNICEF 2009).

The water treatment and hand washing models are generally encouraging. Although there was a negative result for self-reported hand washing before eating, relatively little input appears to have made significant improvements to other self-reported hand washing and water treatment variables in the intervention areas. There are limitations to the hand washing models, for example we had to rely on self-reported behaviours, we did not measure how consistently women washed their hands, how effectively, or the longevity of this apparent women's group impact. There is also the issue of what people used to wash their hands. Soap is ideal, but there may also be scope to include materials such as ash and mud, provided they are safely stored to avoid faecal contamination (Bloomfield and Nath 2009). This is explored in greater detail in the next chapter.

Reviews of hand washing interventions have noted an influence of water supply on the uptake of hand washing messages where easy access to plentiful and clean water sources encourages hand washing and other beneficial hygiene practices (Curtis et al. 2000). The women's groups could maximise their impact on water and sanitation indicators by engaging with community stakeholders and aiming for representation on Village Health Nutrition and Sanitation Committees to achieve more comprehensive community-level sanitation improvements and to advocate for improved quality and quantity of water supplies.

Access to health and nutrition services

According to maternal reports about two thirds of all children had received growth monitoring from the Anganwadi worker in the previous month, and this was very similar between groups. According to the 'conscientisation' principles that underpin the women's groups, increased awareness of citizen entitlements and the factors driving inequities and poverty in a community can lead to positive social change (Freire 2005). Women's group members had been made aware of the 'road to health' card in Cycle 2 and were versed in the Anganwadi's growth monitoring responsibilities; several groups also had active Anganwadi members. Thus, it is plausible that women's groups could have been galvanised to demand better quality health services, reflected in a better functioning growth monitoring programme, but this was not borne out in the analysis.

Conscientisation is an amorphous concept and would vary considerably across women's groups, and may not have been captured by this measure. There are other questions about the adequacy of our growth monitoring measure. Although it measures maternal reports of monthly growth monitoring expected of the Anganwadi worker, and is quite high at around two-thirds for both groups, this monitoring period may not be sufficient for early identification of growth faltering. The NFHS-3 reports any growth monitoring in the last 12 months, for which just 23.9% of children under-five years from tribal communities in Jharkhand received growth monitoring, although this figure was higher for Orissa at 61.1% (Government of India 2006). These NFHS-3 data do not provide a meaningful description of the functioning of growth monitoring services, and this frequency of measurement would not identify early growth faltering and would limit the effectiveness of case-finding for severe malnutrition.

Maternal perception of child underweight

Mothers of underweight children in the intervention areas were significantly more likely to correctly identify their child as underweight than counterparts in the control areas. The majority of women in both groups perceived their child as 'about the right weight'. During Cycle 2 two meetings focused specifically on the identification of malnutrition in children, and included plotting children's weight-for-age on locally used growth charts. This is an important finding because awareness of child weight status is a precursor to behaviour change towards better feeding and caring practices to reduce malnutrition (Kumar et al. 2010b).

Research from high-income countries with a high burden of obesity has identified a shift in social norms where larger children are perceived as 'about right' in terms of weight-status (Baughcum et al. 2000;Hager et al. 2012;He and Evans 2007). It is possible that the same shift has occurred in the study areas, where underweight children are the norm and are perceived as a healthy weight. Theories of behaviour change assert that awareness of a problem is necessary before meaningful behaviour change can occur (Kumar et al. 2010b;World Bank 2009). This finding suggests that women's groups may have increased awareness about undernutrition and this could in turn increase motivation to improve caring and feeding practices. However, there is an ethical issue of placing all the responsibility about child underweight upon caregivers, which may actually be better considered as government failures to respond to the health and nutritional needs of vulnerable members of the population, much of which is beyond the power of the individual.

Other health indicators

None of the additional health indicators measured in the survey showed a positive association with intervention exposure.

Proxy measures of low birth weight and prematurity

Women's group participants were more likely to perceive their child as smaller than average at birth than women from the control areas. Although this effect was not significant it may be capturing some baseline differences in child nutritional status between intervention and control groups, which could be an artefact of the neonatal mortality trial (as discussed in the previous chapter). However, this is only a proxy maternally reported measure of birth weight as opposed to actual birth weight, and there is some doubt over the reliability of the measure as children in the 'smaller than average' category were significantly taller when measured in the nutrition survey.

I thought it was possible that women's groups could have prevented some of the premature births associated with malaria and anaemia in pregnancy and early conception (before 18 years of age) (Black et al. 2008;Kumar et al. 2007;Rao et al. 2011). The data (again using a proxy maternally reported measure) do not support this hypothesis, but there could have been a greater proportion of surviving premature babies in the women's group sample as an artefact of the cycle 1 intervention.

Overall, the proportion of women who felt their child was smaller than average at birth (17.3%-35.0%) was much larger than those who thought their child was born early (<4%). If these proxy measures are in any way accurate, this could reflect a greater burden of small-for- gestational-age children than premature births. This would require further investigation with validated, more objective measures.

Child morbidity in the last 14 days

Although maternal reported child diarrhoea, fever and cough in the last 14 days were slightly lower in the intervention areas than the control, none of these associations were significant. The women's groups had dedicated several meetings to diarrhoea prevention and management during both cycles, and also to the prevention and management of malaria, which is a common cause of fever in the study areas. Cough and complications of cough had received some attention in cycle 2, although comparatively less than the other two illnesses.

It is disappointing that there was no apparent impact on child diarrhoea, but in some ways it is not surprising given the multitude of environmental risks that exist. Open defecation and unsafe child faeces disposal were almost universal in the sample and are of major public health concern. Although improvements to some self-reported hand washing behaviours were observed they may not have been consistent or effective. There are many other routes to diarrhoeal infection such as measles (World Health Organisation and UNICEF 2009), and whilst there was a positive intervention association with measles vaccination, a sizeable proportion of children remained unimmunised; vulnerability to measles infection would also be higher because of the huge burden of undernutrition. Similarly, although maternal reports of care-seeking for child diarrhoea was slightly higher in the intervention areas a substantial minority reported no care seeking, and reported use of oral rehydration solution to mitigate the duration and severity of diarrhoea was low.

Recent estimates show a very high prevalence of malaria in Jharkhand and Orissa (Dhingra et al. 2010). The process evaluation of cycle 1 and detail about cycle 2 activities indicate that communities with Ekjut women's groups were highly motivated to reduce malaria infection e.g. through removal of stagnant water pools in the community and the use of bednets (Rath et al. 2010). Unfortunately we do not have data about the use of bednets in the control areas and we only have a non-specific maternally reported measure of fever. Although fever was approaching significance in terms of a reduction in the intervention group, it would not be fair to suggest that the women's groups reduced malaria transmission considering the measures we have available. Fever may be indicative of other non-malarial infections as well. It would be interesting to measure malaria more precisely in future work and to take into account the impact of using bednets.

Maternal physical and mental health

Mean maternal BMI was nearly identical between exposure groups and was on the threshold for underweight (BMI=18.5); more than 50% of women were below this value. Low weight-for-height in adults is a marker for inadequate diet and can be an indicator of food insecurity (Food and Agriculture Organisation 2008). The women we spoke to during the focus group discussion (detailed in Chapter 8) painted a bleak picture of food security in the area and this may be compromising the effect of women's group activities promoting maternal nutrition.

Our self-reported measure of maternal psychological distress was suggestive of lower distress in the intervention areas, but was not statistically lower than control areas (7.7% versus 12.0%) although it is possible we were underpowered to detect an effect. Levels of distress in the intervention areas were similar to a study of 3000 non-pregnant women in Goa that identified a 6.6% prevalence of common mental disorders using the Revised Clinical Interview Schedule (Patel 2006). The control areas of the current study show much higher levels of distress than this, and although we used a different measure (the Kessler-10) a recent study suggests the two measures are equivalent in their ability to identify common mental disorders (Patel et al. 2008).

Predictors of common mental disorders in Indian women include poverty, low income and limited autonomy and lack of social support amongst many other factors (Patel 2006). The study areas are particularly underserved compared to most other regions of India and are likely to have greater levels of poverty than those in the Goa study. The control areas of the present study do not have women's groups, which have been shown to increase autonomy and social support and may provide some protection against the development of common mental disorders, and this could explain the elevated levels of distress observed in the control group (Montalvao et al. 2011;Tripathy et al. 2010).

There is a growing body of evidence linking maternal mental health and child anthropometric status (Stewart 2007;Surkan et al. 2011). The lower levels of distress in the intervention areas compared to the control, although not statistically significant, could be protective against undernutrition for some children. Women's groups did not specifically attempt to reduce distress but evidence from the trial of Cycle 1 suggests this was a beneficial by-product from increased levels of social support and autonomy and improved perinatal health outcomes. In the following chapter on the determinants of undernutrition I will explore whether maternal psychological distress was associated with child anthropometric status in the control areas. It should be noted however that this is a cross-sectional study and there could be reverse causality whereby poor child nutrition and environmental stressors are driving maternal distress.

Other limitations

One important limitation of these analyses is that I have assumed the outcomes were amenable to individual or community-level behaviour change through the women's group intervention. The study areas are characterised by high levels of food insecurity, a fragile primary healthcare system and extreme poverty, and it may be that these factors are over-riding the beneficial influences of the women's groups. Supply-side failures are a clear limiting factor for the impact of the women's groups, for example women were encouraged to take iron tablets during pregnancy, but the government supply was sporadic for two years of the data surveillance (Nirmala Nair, personal communication, January 2010).

These analyses were intended to be exploratory, but some of our measures could be improved in subsequent research. For example, we could attempt to differentiate between general fever and malaria by collecting data on specific symptoms to assess whether women's groups have contributed to a reduction in malaria infection. Similarly, with assessment of self-reported hand washing practices, we could measure the longevity of hand washing behaviours with simple follow-up surveys, and include a measure of consistency of hand washing. Reliance upon self-reported behaviours is a limitation of some of these models. Due to time and financial constraints it would not have been possible to include in-depth observations (e.g. of hand washing), follow-up surveys (e.g. for more reliable assessment of dietary intake) or a greater number of objective measures (such as blood tests for anaemia). However it should be acknowledged that social desirability and self-reporting errors could have played a role in some of the models I tested, and that there is often a discrepancy between levels of self-reported and actual behaviour. This could partially explain why there were no positive associations between women's groups and child anthropometry despite some of the positive findings observed in these behavioural models.

In future studies it would be pertinent to assess the influence of sibling-to-sibling care on child health outcomes. One further measure could be developed to determine whether 'conscientisation' (the development of a critical consciousness) (Freire 2005) has increased as a result of women's groups, and whether this is linked to supply-side improvements and greater accountability of community stakeholders, although this could be a longer-term process.

There are some limitations to the particular version of Cycle 2 under scrutiny here, which I discussed in detail in the previous chapter. These mostly refer to changes in the format of the meeting cycle, the lack of group-level prioritising of problems, and the limited time available to devise strategies and consult the wider community to garner additional support for strategy implementation. The cross-sectional nature of the study also means that we cannot definitely attribute the positive differences we observed for some indicators to the women's groups as they may be due to pre-existing baseline differences or other biases.

6.9 Conclusion

The women's groups have demonstrated their potential to impact upon key self-reported water and sanitation indicators, the care of pregnant women (including better birth spacing), child immunisation uptake and maternally reported child caring practices during illness. In a newer, more focused version of Cycle 2 the women's groups could aim for a more comprehensive impact on water and sanitation indicators, particularly to improve community-wide sanitation and to find alternatives to the near universal practices of open defecation and unsafe child faeces disposal. It is important to note that there was no relation between women's groups and maternally reported child fever, cough and diarrhoea. Reducing morbidity will be central to improving child nutritional status. Women's groups could further focus on increasing the use of oral rehydration solution to manage diarrhoea and continue to improve hand-washing practices. The barriers to improved nutrition are not solely behavioural. The study areas are afflicted with high levels of food insecurity and many supply-side failures, including an underperforming health system. Unless these issues are addressed in parallel to behaviour change activities, the impact of women's groups on nutrition and key health indicators is likely to be limited.

In the next chapter I will identify the strongest determinants of child undernutrition in the control areas. This will identify further opportunities for women's groups, as well as barriers to behaviour change and improved child growth outcomes.

Chapter 7

Determinants of undernutrition

7.1 Chapter overview

The purpose of this chapter was to identify the strongest determinants of stunting, wasting, underweight and mid-to-upper-arm circumference amongst 6-23 month old children. The findings are exploratory and hypothesis generating, and could be useful to optimise future nutrition interventions in the study area. The results could also be used for advocacy for the participating communities, particularly if risk factors are identified that are not amenable to behaviour change and require government input (such as strengthening social security programmes to increase food security). The findings from this chapter could also inform the work of local Village Health and Sanitation Committees and the Integrated Child Development Services at the block, Panchayat, and village levels. These analyses were limited to the control group as there may have been confounding and effect modification of determinants in the intervention group.

7.2 Selection of candidate predictors

I used the UNICEF conceptual framework to guide my selection of potential determinants of undernutrition, and to aid interpretation of the final models (UNICEF 1990;UNICEF 1998). As stated in chapter 1, the UNICEF framework arranges the determinants of undernutrition hierarchically from the most distal basic causes (e.g. poverty, governance), to underlying causes (e.g. care of mothers, child caring practices, health services), to the most immediate determinants (dietary intake and disease). In line with the principles underpinning the framework I considered a wide range of possible determinants to enable the development of a context-specific plan of action to improve child nutrition in the study areas.

The specific variables I considered are detailed in Table 7.1. The same variables were generally considered for all four anthropometric outcomes, except where there was no theoretical justification or if the variable was already adjusted for in the outcome (e.g. age and height-for-age Z-score). I included maternal reports of child chronic cough, fever and diarrhoea as underlying determinants, although they could also be considered as immediate determinants. Other predictors fitted into multiple levels of the framework (e.g. immunisations reflect child-care practices and health services) but for simplicity I assigned them to a single category. Categorical predictors required a minimum of 30-40 cases per level, based on statistical advice.

Table 7.1 Potential determinants of undernutrition for consideration in univariate models

Determinant category	Variable
Age and sex	Parental age, child age (months), sex
Basic causes	Socioeconomic quintile, income group, maternal education, father's education, social group, religion, district, relationship to household head
Underlying causes	
Household shocks	Household shocks in the last 12 months: major household health problem, disease epidemic, crop failure/drought/drop in production, damage to houses or crops
Care of mothers	Parity, birth spacing, self-reported anaemia and malaria in pregnancy, food intake during pregnancy, iron tablet consumption during pregnancy, maternal BMI, non-pregnancy related illness/injury in the last three months, psychological distress (last 4 weeks),
Child caring factors	Early initiation of breastfeeding, pre-lacteal feeds, bottle-feeding, colostrum discarding, BCG, DPT and Polio immunisations, feeding and treatment seeking during childhood illness, use of oral rehydration solution for child diarrhoea, birth order
Underlying child health issues	Repeated attacks of diarrhoea, fever and cough
Health environment and services	Place of delivery, antenatal and postnatal visits, growth monitoring and food ration provision through the Anganwadi Centre, sufficient living area (≤ people per sleeping room), cooking location (main living area, separate room or outdoors), season of birth, treatment of drinking water, source of drinking water, accessibility of drinking water (≤30 minutes), disposal of children's faeces, use of a hand washing agent (soap/ash/mud), occasions when cleansing agent is used for hand washing (before preparing food/feeding a child/eating, after defecation/cleaning up a child who has defecated)
Immediate causes	
Dietary intake/breastfeeding (previous 24 hours)	Predominant breastfeeding, age-appropriate breastfeeding, minimum dietary diversity (≥4 food groups), minimum meal frequency (breastfed children twice/day if 6-8 months, thrice/day if 9-23 months, non-breastfed children four times/day), consumption of iron-rich foods
Child morbidity (last 14 days)	Fever, cough or diarrhoea; cough severity (no cough, uncomplicated cough, cough with atypical breathing); diarrhoeal severity (no diarrhoea, uncomplicated diarrhoea, bloody diarrhoea)

There was potential for multicollinearity between the model predictors (i.e. at least two variables may have been strongly related). One limitation of multicollinearity is that parameter estimates may not reflect the unique contribution of the predictor in explaining variance in the outcome. However, a degree of collinearity might be expected here because nutritional outcomes involve complex interdependent causal pathways with overlapping and synergistic effects. For example, variables such as socio-economic status, income group and maternal education may explain some overlapping variance in the outcomes, but could also have independent effects. A study of 42 DHS surveys from developing countries highlighted strong independent effects of purchasing power parity (derived from Gross Domestic Product), maternal education and household wealth on child stunting and underweight, in addition to overlapping variance (Boyle et al. 2006). Another study found independent effects of household income and maternal education on risk of prolonged diarrhoea (Moore et al. 2010).

I attempted to minimise multicollinearity amongst the predictors through assessment of correlations: I excluded one of each pair of variables with r=>0.9, and considered excluding variables with r=>0.7. I also used SPSS (version 19) to check other collinearity diagnostics, specifically Tolerance and the Variance Inflation Factor. Here I excluded variables causing Tolerance values of <0.2 and Variance Inflation Factors >10, based on published guidance (Field 2009). If two variables shared common data (e.g. maternal BMI and maternal height), I did not include both.

7.3 Analysis stages

Stage 1: I used Generalised Estimation Equation models (GEE) to assess the univariate association of each potential determinant with each outcome, retaining those with p<0.10. I made further exclusion decisions based on assessment of multicollinearity. All univariate associations are reported in appendices 7.1 to 7.4.

Stage 2: All predictors carried forward from stage one were entered simultaneously into GEE multiple linear regression models. I eliminated least significant variables according to their p-value in a backward, stepwise manner using a threshold of p≤0.1 for inclusion. I included additional forward steps in-between to check whether previously eliminated variables had become significant in later models.

Stage 3: I explored interactions between selected variables that were retained in the final model if there were theoretical reasons to suspect potential combined effects on the outcome.

Stage 4: I ran the models with two variations. First, I randomly selected one child per sibling pair and repeated the backward elimination steps to check whether the same final model was achieved (there were 16-18 sibling pairs, depending on the outcome, and large differences between models were not expected). Secondly, missing data were accounted for using multiple imputation (using the same process as for chapters 5 and 6). Here missing data were replaced with predicted values in 20 new versions of the original dataset. Again I used backwards elimination to assess any changes to the final model using the pooled results from the imputed datasets. These are also reported in appendices 7.1 to 7.4.

7.4 Determinants of stunting in children 6.00-23.99 months (height-for-age Z-score)

Univariate associations

'Basic' causes of undernutrition that were univariably associated with height-for-age Z-score (HAZ) at p<0.10 included: socioeconomic quintile, income group, and parental education, which were all positively associated. HAZ scores in Saraikela district compared favourably to those in West Singhbhum, and the children of respondents belonging to Scheduled Castes or Other Backward Class groups had significantly higher HAZ scores than those from Scheduled Tribes. Parental age was negatively associated with HAZ, but relationship to household head was not associated.

'Underlying' causes relating to child-care that were positively associated with HAZ included BCG and DPT immunisations and beneficial caring practices during diarrhoea, fever and cough. The strongest association was seen for birth order: children born fourth or later in relation to their siblings had HAZ scores nearly half an SD unit lower than first born children (β=-0.446, p<0.001). None of the early breastfeeding indicators (colostrum discarding, pre-lacteal feeding, early initiation of breastfeeding) or bottle-feeding were associated with HAZ. Repeated diarrhoeal infection was strongly and negatively related to HAZ (β=-0.343, p=0.001), but repeated attacks of fever and cough were not.

Significant variables related to the care of mothers included parity: child HAZ scores were nearly 0.3 z-scores lower if mothers had ≥4 children compared to one child (β=-0.296, p=0.029). Adequate birth spacing (≥24 months) was strongly positively related to child HAZ compared to <24 months (β=0.464, p=0.012), maternal BMI was also positively related (β=0.070, p<0.006). Self-reported anaemia in pregnancy and non-pregnancy illness or injury in the previous three months were negatively related to HAZ (β=-0.280, p=0.033 and β=-0.229, p=0.045 respectively) but food intake during pregnancy was not, although this could be due to the crudeness of our measure.

Significant 'health environment and services' variables included delivery location: mothers giving birth at government and private facilities had children with higher HAZ scores compared to home births (β=0.228, p=0.011 and β=0.590, p=0.001 respectively). Also positively associated were: cooking in a separate room or outside compared to the main living area, having ≤3 people sharing a sleeping room, treating drinking water, being born in the rainy season as opposed to winter, using a hand washing agent (soap, ash or mud), hand washing with soap in particular situations and the sum score for hand washing occasions. Time taken to collect drinking water, food rations, growth monitoring and household shocks showed no association with HAZ.

'Immediate' causes included minimum dietary diversity, which was linked to substantially higher HAZ scores (β=0.496, p=0.009). Minimum meal frequency, iron-rich food consumption, predominant and age-appropriate breastfeeding were not associated. Diarrhoea in the last 14 days was negatively associated with HAZ, but fever and cough were not.

Further variable selection and multicollinearity assessment

I chose to include hand washing score (the sum of five key hand washing occasions where soap is used) over individual instances of hand washing because there were too few cases in the response categories of discrete hand washing variables (e.g. n=16, hand washing before feeding a child) potentially causing model instability. Several variables reflecting child-care practices during illness were constructed using common information and as treatment-seeking showed the strongest association it was retained over the other variables. Mothers' and fathers' age were strongly inter-correlated at 0.799; I excluded fathers' age because maternal factors may be more influential for child growth. I entered the remaining variables into a multiple linear regression model to check the collinearity diagnostics: all tolerances were >0.2 and Variance Inflation Factors were <10.

Final variables for inclusion in the backward stepwise models were: maternal age, socioeconomic quintile, income group, maternal education, father's education, district, social group, BCG and DPT vaccinations, treatment seeking from formal healthcare providers during diarrhoea, fever and cough, birth order, birth spacing, parity, self-reported anaemia during pregnancy, non-pregnancy illness or injury in the last three months, maternal BMI, cooking location, delivery location, sufficient living area, season of birth, treatment of drinking water, use of hand washing agent, child minimum dietary diversity, repeated diarrhoeal episodes, and diarrhoea in the last 14 days.

The final model predictors following the backward stepwise procedure are presented by position in the UNICEF conceptual framework in Table 7.2.

Table 7.2 Final model estimates for determinants of height-for-age z-score in children 6.00-23.99 months in the control areas (n=1227)

Position in framework	Predictor		% (n) or mean (SD)	Unadjusted β (95%CI)	P-value	Adjusted β(95%CI)	P-value
Basic causes	Income group:				0.007		0.048
	Lowest		82.7 (1015)	1			
	Middle		12.9 (158)	0.343 (0.073-0.612)	0.013	0.272 (0.047-0.497)	0.018
	Highest		4.4 (54)	0.547 (0.163-0.931)	0.005	0.301 (-0.113-0.714)	0.154
Underlying causes	Birth order:				<0.001		0.001
	First born		28.0 (344)	1			
	2nd born		23.6 (289)	0.057 (-0.155-0.269)	0.599	-0.026 (-0.261-0.209)	0.828
	3rd born		17.8 (219)	-0.103 (-0.428-0.223)	0.537	-0.136 (-0.474-0.202)	0.432
	≥4th born		30.6 (375)	-0.446 (-0.668- -0.224)	<0.001	-0.420 (-0.683- -0.157)	0.002
	Birth spacing:				0.005		0.053
	<24 months		14.8 (181)	1			
	≥24 months		39.8 (488)	0.464 (0.101-0.826)	0.012	0.409 (0.077-0.740)	0.016
	n/a first child/Don't Know		45.5 (558)	0.452 (0.172-0.731)	0.002	0.232 (-0.088-0.552)	0.156
	Self-reported anaemia in pregnancy:	No	81.4 (999)	1			
		Yes	18.6 (228)	-0.280 (-0.539- -0.022)	0.033	-0.190 (-0.420-0.040)	0.106
	Maternal Body Mass Index		18.45 (1.84)	0.070 (0.020-0.120)	0.006	0.068 (0.011-0.124)	0.018
	Cooking location:				<0.001		<0.001
	In the house/main living area		62.6 (768)	1			
	In a separate room		31.4 (385)	0.268 (0.015-0.521)	0.038	0.097 (-0.146-0.341)	0.433
	Outdoors		6.0 (74)	0.823 (0.476-1.171)	<0.001	0.730 (0.365-1.094)	<0.001
	Season of birth:				0.026		0.081
	Winter		20.9 (257)	1			
	Summer		37.2 (457)	0.043 (-0.206-0.292)	0.733	0.028 (-0.235-0.291)	0.837
	Rainy		41.8 (513)	0.285 (0.035-0.535)	0.025	0.247 (-0.029-0.523)	0.079
	Hand washing agent:	None	80.2 (984)	1			
		Ash/mud/soap	19.8 (243)	0.438 (0.197-0.678)	<0.001	0.347 (0.133-0.561)	0.001
	Repeated diarrhoea[1]:	No	70.2 (861)	1			

		Yes	28.4 (348)	-0.343 (-0.551- -0.135)	0.001	-0.191 (-0.338- -0.043)	0.011
Immediate causes	Minimum dietary diversity:	No	94.6 (1161)	1			
	(≥4 food groups previous day)	Yes	5.4 (66)	0.496 (0.126-0.865)	0.009	0.303 (-0.064-0.670)	0.106

[1] 1.5% cases missing (n=18)

Summary of results

Income was the only basic determinant of HAZ remaining in the final model (p=0.048): children from the middle group had HAZ-scores 0.272 SD units higher than the lower group. The effect was borderline significant for the higher versus lower income group (p=0.154). Underlying predictors of HAZ included a strong effect of birth order where children born 4th or later had HAZ-scores 0.420 units lower than first-born children (p=0.002). Three underlying predictors related to care of mothers: ≥24 months birth spacing was associated with higher HAZ-scores (0.409 SDs) than counterparts with <24 months spacing (p=0.016). A one unit change in maternal BMI was associated with a small increase in HAZ-score (β=0.068, p=0.018) and self-reported anaemia in pregnancy was borderline for inclusion (β=0.190, p=0.108).

The strongest predictor from the 'health and environment and services' category was cooking location: cooking outdoors as opposed to the main living area was equivalent to an increase of 0.730 SD units (p<0.001). Use of a hand washing agent (soap/ash/mud) compared to no cleanser was strongly and positively linked to HAZ (0.347, p=0.001) and being born in the rainy season as opposed to winter had a modest positive association: β=0.247, p=0.079. Repeated diarrhoea was strongly and negatively associated with HAZ (β=-0.191, 95%CI -0.388- -0.043, p=0.011). The single immediate determinant of HAZ in the final model was minimum dietary diversity, which was borderline for inclusion (p=0.106).

Interactions

I tested the significance of interactions between the following predictors in simple models: hand washing agent with repeated diarrhoeal episodes, season of birth with repeated diarrhoeal episodes, season of birth with dietary diversity, and birth order with repeated diarrhoeal episodes. None of these interactions were significant.

Model variations

I obtained the same final model using the dataset with one of each sibling-pair randomly removed, although the order of backwards elimination was different. The effect of income group became stronger, and the highest income group became significant compared to the lowest (β=0.331, p=0.091). 12.6% of cases in the initial model (i.e. those included in the first stage of backward elimination) were missing (154/1227). The vast majority of missing data were accounted for by maternal age (n=95) and socioeconomic status (n=34), and these were imputed in the multiple imputation dataset. The final model using this dataset differed slightly from the final listwise model because maternal age and education were retained. Specifically, mothers with secondary and ≥higher secondary education had children with significantly higher HAZ-scores than mothers with no schooling (β=0.177, p=0.004 and β=0.559, p=0.014 respectively); there was no effect of primary school versus no schooling. Birth order, season of birth, and minimum dietary diversity were excluded.

7.5 Determinants of wasting in children 6.00-23.99 months (weight-for-height Z-score)

Univariate associations

Child age was modestly and positively associated with WHZ (β=0.022, p=0.021) and parental age was modestly and negatively associated (mothers' age β=-0.043, fathers' age β=-0.025, both p<0.001).

'Basic' predictors were socioeconomic quintile, where the upper two quintiles compared to the lowest were associated with significantly higher WHZ-scores. This difference was particularly pronounced for the highest compared to the lowest quintile (β=0.732, p<0.001). Children of mothers' with ≥secondary schooling had WAZ-scores 0.439-0.665 SD units higher than those with no schooling (p≤0.001); again there was no effect of primary schooling. Fathers' ≥higher secondary versus no education was also associated with WHZ but the effect was weaker than for maternal education (β=0.361, p<0.001). Children from the highest income group had significantly higher WHZ-scores compared to the lowest (β=0.281, p=0.002) and children from Other Backwards Class had WHZ-scores nearly 0.5 SD units higher than children from tribal groups (β=0.460, p<0.001). Children from Saraikela district had WHZ-scores 0.637 SD units higher than those from West Singhbhum (p<0.001).

Underlying predictors included two 'household shock' variables: damage to houses or crops by elephants (β=-0.279, p=0.063) and experience of any major household shock in the last 12 months (crop failure/drought/reduced production, disease epidemic, major household health problem, damage to houses or crops by elephants, natural calamities/disasters), β=-0.208, p=0.064. Protective child-care practices for WHZ were early initiation of breastfeeding (β=0.295, p=0.004) and, unexpectedly, colostrum discarding (although this was only borderline significant; β=0.218, p=0.094). Bottle-feeding, pre-lacteal feeding, and vaccinations were not related to WHZ. Positive feeding practices and treatment-seeking during childhood illnesses were positively related to WHZ (β=0.307, p=0.009 and β=0.276, p=0.036 respectively). Again birth order (≥4th versus first-born) was a strong risk factor for wasting (β=-0.496, p<0.001).

Significant maternal health variables that were negatively associated with child WHZ were parity (≥4 children; β=-0.197, p=0.097) self-reported anaemia in pregnancy (β=-0.398, p<0.001), psychological distress in the last 4 weeks (Kessler-10 score >15; β-0.555 p<0.001) and non-pregnancy physical injury or illnesses in the last three months (-0.194 p=0.019); birth spacing was not related to WHZ. Iron tablet intake in pregnancy and maternal BMI were both positively related to WHZ (β=0.072, p<0.001).

Protective 'health environment and service' factors for WHZ-scores were: delivery at a private hospital versus at home (β=0.441, p=0.001), ≥1 antenatal care visit (β=0.295, p=0.001), sufficient living area (β=0.342, p<0.001), and improved sources of drinking water (β=0.385, p<0.001). Treatment of drinking water, use of a hand washing agent, using soap to wash hands after defecation or cleaning up a child who had defecated and hand washing score, postnatal visits and delivery in government hospitals were also protective, associations were weaker. Repeated bouts of fever, cough and particularly diarrhoea (β=-0.400, p<0.001) were strongly and negatively associated with WHZ-scores.

Immediate predictors of WHZ were dietary diversity (β=0.388, p=0.003), meal frequency (β=0.140, p=0.056) and consumption of iron-rich foods the previous day (β=0.313, p=0.002). Diarrhoea and fever in the last 14 days were strongly and negatively associated with WHZ (β-0.468 and β-0.314 respectively, p<0.001). I also considered diarrhoea severity, in terms of whether there was blood present. This showed a worsening of WHZ-scores with increasing severity from β=-0.445, p<0.001 to β=-0.596, p<0.001. Cough in the last 14 days was not linked to wasting when used as a yes/no variable, but when severity was considered (cough and atypical breathing) there was a modest negative association with WHZ compared to no cough (β-0.216, p=0.071), but not for uncomplicated cough versus no cough (β=-0.089, p=0.189).

Further variable selection and multicollinearity assessment

Both household shock variables contained common information so I selected the more inclusive composite variable including 'any shock' in the last 12 months. Child care practices during recent child illness were highly correlated and shared information with diarrhoea, fever and cough in the last 14 days so I chose to exclude these care-practices from this analysis. There were two possible iron tablet variables to include in the backwards elimination models: yes/no (β=0.197, p=0.050) and quantity (≥50 tablets compared to no tablets β=0.220, p=0.010 and <50 tablets versus no tablets β=0.125, 0.349). I selected the latter because it had a stronger association and p-value. Again I chose hand washing score over discrete hand washing occasions. As before, parental age was highly correlated and I excluded fathers' age because of a possible stronger maternal influence over child growth. Other high correlations were: hand washing score and district (-0.778), hand washing score and parity (0.730), and maternal age and birth order (0.728). Collinearity diagnostics did not flag these as problematic in terms of Variance Inflation Factor (all <10) or tolerance (all >0.2).

Final variables for inclusion in backward stepwise models were: child age (months), maternal age, socio-economic status, income group, mothers' and fathers' education, district, social group, birth order, colostrum discarding, early initiation of breastfeeding, repeated fever diarrhoea and cough, parity, self-reported anaemia in pregnancy, non-pregnancy illness/injury (last three months), psychological distress, maternal BMI, delivery location, sufficiency of living area, treatment of drinking water, antenatal and postnatal care, use of a hand washing agent, source of drinking water, hand washing score, any household shock (last 12 months), dietary diversity, consumption of iron-rich foods and meal frequency, and child diarrhoea and cough severity, and fever in the last 14 days.

The final model highlighting the strongest predictors of WHZ-score is presented in Table 7.3.

Summary of results

Maternal age was negatively associated with WHZ (β=-0.026, p=0.001) and maternal secondary education was positively associated compared to no schooling, equivalent to a 0.226 WHZ-score increase; ≥higher secondary versus no schooling was not significant. Children living in Saraikela and Keonjhar districts had significantly higher WHZ-scores than children in West Singhbhum (β=0.425, p<0.001 and β=0.292, p=0.007 respectively).

Early initiation of breastfeeding appeared protective against wasting (β=0.202, p=0.014) whereas repeated episodes of child cough was a moderate risk factor (β=-0.236, p=0.001). For every unit increase in maternal BMI there was a modest predicted increase of 0.064 in WHZ-score (p<0.001) whilst self-reported anaemia in pregnancy was linked to a 0.183 decrease in WHZ (p=0.020). Maternal psychological distress was a borderline risk factor, but was just outside the significance threshold and was excluded. Beneficial health environment and service factors were: use of an improved drinking water source equivalent to a 0.189 SD increase compared to unimproved sources, use of a hand washing agent and ≤3 people per sleeping room (β=0.134, p=0.050 and 0.118, p=0.014 respectively).

Child consumption of iron-rich foods was linked to a moderate increase in WHZ of β=0.276 (p<0.001) whilst fever in the last 14 days was associated with lower WHZ (β=0.196, p=0.024). There was a sharp decrease in WHZ-scores as diarrhoea severity increased from β=-0.291 to β=-0.443 (p≤0.002).

Interactions

I explored the following interactions in simple models: sufficiency of living area with repeated cough, drinking water source with diarrhoeal severity (last 14 days), maternal education with use of hand washing agent, maternal education with early initiation of breastfeeding, district with fever (last 14 days), and maternal education with child iron consumption. The only significant interaction was maternal education with hand washing agent (p=0.041). This showed that child WHZ-score was 0.568 SD units higher if mothers used a hand washing agent and were educated to ≥secondary level compared to non-schooled women not using a hand washing agent (p=0.009).

Model variations

The sibling-adjusted dataset produced the same final model described above and the magnitudes of associations were very similar. The multiple imputation dataset identified many of the same WHZ predictors as the original dataset although maternal education was not retained. Three additional predictors were also identified: belonging to the OBC group was associated with a 0.227 increase in WHZ compared to Tribal groups (p=0.010), delivery at a government hospital was linked to higher WHZ-scores compared to home births (β=0.180, p=0.030) and maternal psychological distress was linked to a 0.235 SD unit reduction in WHZ compared to non-distressed women (p=0.051). Otherwise, the predictors and sizes of associations were generally similar in this model compared to the other models.

Table 7.3 Final model estimates for determinants of weight-for-height Z-score in children 6.00-23.99 months in the control areas (n=1244)

Position in framework	Predictor	% (n) or mean (SD)	Unadjusted β (95%CI)	P-value	Adjusted β(95%CI)	P-value
Age and sex variables	Maternal age (years)[1]	26.38 (5.20)	-0.043 (-0.057- -0.029)	<0.001	-0.026 (-0.041- -0.011)	0.001
Basic causes	Maternal education			<0.001		0.002
	No schooling	68.4 (851)	1		1	
	Primary school	3.9 (49)	0.104 (-0.223-0.432)	0.532	0.021 (-0.296-0.339)	0.895
	Secondary school	24.9 (310)	0.439 (0.310-0.567)	<0.001	0.226 (0.101-0.351)	<0.001
	≥Higher secondary	2.7 (34)	0.665 (0.267-1.062)	0.001	0.266 (-0.148-0.680)	0.208
	District			<0.001		<0.001
	West Singhbhum	35.5 (441)	1		1	
	Saraikela	32.1 (399)	0.637 (0.417-0.857)	<0.001	0.425 (0.215-0.635)	<0.001
	Keonjhar	32.5 (404)	0.148 (-0.069-0.366)	0.156	0.292 (0.079-0.506)	0.007
Underlying causes	Self-reported anaemia in pregnancy: No	81.7 (1016)				
	Yes	18.3 (228)	-0.398 (-0.571- -0.226)	<0.001	-0.183 (-0.337- -0.029)	0.020
	Maternal Body Mass Index	18.47 (1.84)	0.072 (0.046-0.099)	<0.001	0.064 (0.034-0.095)	<0.001
	Sufficient living area[2]: >3 people/sleeping room	57.1 (710)				
	≤3 people/sleeping room	42.8 (533)	0.342 (0.206-0.478)	<0.001	0.118 (0.024-0.212)	0.014
	Source of drinking water[2]: Unimproved	37.7 (469)				
	Improved	62.2 (774)	0.385 (0.221-0.550)	<0.001	0.189 (0.088-0.291)	<0.001
	Hand washing agent: None	80.0 (995)				
	Ash/mud/soap	20.0 (249)	0.261 (0.058-0.464)	0.012	0.134 (0.000-0.269)	0.050
	Early initiation of breastfeeding: No	37.5 (467)				
	(within one hour) Yes	62.5 (777)	0.295 (0.097-0.494)	0.004	0.202 (0.041-0.363)	0.014
	Repeated episodes of cough[3]: No	68.9 (845)				
	Yes	31.1 (381)	-0.104 (-0.319-0.112)	0.344	-0.236 (-0.374- -0.098)	0.001
Immediate causes	Diarrhoeal severity (last 14 days)[4]			<0.001		<0.001
	No diarrhoea	74.2 (921)	1		1	
	Diarrhoea, no blood	22.0 (273)	-0.445 (-0.637- -0.254)	<0.001	-0.291 (-0.480- -0.103)	0.002
	Diarrhoea, blood present	3.9 (48)	-0.596 (-0.832 - -0.359)	<0.001	-0.443 (-0.667- -0.220)	<0.001

Fever (last 14 days)[4]	No	71.3 (885)				
	Yes	28.7 (357)	-0.314 (-0.490- -0.138)	<0.001	-0.196 (-0.366- -0.026)	0.024
Iron-rich food (last 24 hours):	No	90.9 (1131)				
	Yes	9.1 (113)	0.313 (0.115-0.512)	0.002	0.276 (0.122-0.430)	<0.001

[1]7.6% missing from maternal age (n=95)
[2]0.1% missing from living area and drinking water source (n=1)
[3]1.4% missing from repeated episodes of cough (n=18)
[4]0.2% missing from fever and diarrhoea in the last 14 days (n=2)

7.6 Determinants of underweight in children 6.00-23.99 months (weight-for-age Z-score)

Univariate associations

Socio-economic status showed a graded increase in WAZ-scores with increasing quintile compared to the lowest quintile. The WAZ-score difference between the highest and lowest quintiles was large (β=0.827 p<0.001) as was the difference between the highest and lowest income groups (β=0.616, p<0.001). Maternal ≥secondary level education compared to no schooling was associated with 0.537-0.921 higher WAZ-scores (p<0.001); a similar but less pronounced association was seen for fathers' education. Children from Saraikela district were significantly heavier for their age compared to children in West Singhbhum (β=0.533, p<0.001) as were children belonging to OBC groups compared to Tribal groups (β=0.452, p<0.001). Older parental age was significantly associated with underweight but religion was not.

Underlying univariate risk factors for underweight were: damage to houses or crops by elephants in the last 12 months (β=-0.295, p=0.078), birth order (4^{th} or later compared to first-born siblings; β=0.284, p=0.002), self-reported anaemia in pregnancy (β=-0.407, p<0.001), repeated episodes of diarrhoea (β=-0.492, p<0.001), and to a lesser extent repeated fevers. Protective univariate factors were full DPT and Polio immunisations (β=0.220, p=0.056 and β=0.272, p=0.007 respectively), positive feeding practices and treatment-seeking during childhood illnesses (β=0.340, p=0.006 and β=0.442, p=0.003 respectively), higher maternal BMI (β=0.098, p<0.001), and colostrum discarding which was an unexpected finding (β=0.263, p=0.076). Early initiation of breastfeeding, pre-lacteal feeds and bottle feeding were not associated with WAZ-scores.

Several 'health environment and service' factors were positively associated with WAZ, including: antenatal and postnatal visits (β=0.241, p=0.036 and β=0.200, p=0.025), being born in the rainy season as opposed to the winter (β=0.257, p=0.052), sufficient living area (β=0.315, p<0.001), treatment of drinking water (β =0.344, p<0.001), improved drinking water source (β=0.326, p=0.003), use of a hand washing agent (β=0.478, p<0.001), several discrete occasions when soap is used for hand washing and their sum score (β=0.255, p=0.034), and cooking in a separate room or outside compared to the main living area (β=0.359, p=0.002 and β=0.379, p=0.027 respectively).

Immediate protective factors for WAZ included: minimum dietary diversity and consumption of iron-rich foods (β=0.524, p<0.001 and β=0.413, p=0.001 respectively); minimum meal frequency was modestly associated (β=0.148, p=0.017). Age-appropriate breastfeeding was not associated with WAZ-score. Immediate risk factors were: predominant breastfeeding (β=-0.308, p=0.003) and child diarrhoea, fever and cough in the last 14 days. WAZ dramatically decreased with increasing diarrhoea severity compared to no diarrhoea: β=-0.397 for non-severe diarrhoea to β=-0.604 for bloody diarrhoea (p<0.001).

Further variable selection and multicollinearity assessment

Parental age was highly inter-correlated and I excluded fathers' age as before. Feeding frequency and treatment-seeking for child fever, cough and diarrhoea in the last 14 days were significantly correlated and shared information with the 14 day child morbidity indicators. I chose to prioritise the morbidity indicators over their associated caring practices to minimise collinearity in the model, whilst acknowledging that caring practices are extremely important. I included hand washing score over discrete hand washing variables because it captures more behaviours and there were insufficient cases for some individual hand washing variables. Both 14-day diarrhoea variables (binary and severity) were significantly associated with WAZ, but diarrhoea severity had a stronger Wald value and provided additional health information so was selected for further analysis. Most correlations between the remaining predictors were <0.7 and all Variance Inflation Factors and tolerance values were >0.2.

Variables for inclusion in the backwards, stepwise model were: mothers' age, parental education, socioeconomic quintile, income group, district, social group, damage to houses or crops by elephants (last 12 months), birth order, colostrum discarding, Polio and DPT vaccinations, antenatal and postnatal care, self-reported anaemia in pregnancy, maternal Body Mass Index, delivery location, cooking location, hand washing score, use of a hand washing agent, treatment of drinking water, use of an improved drinking water source, season of birth, sufficiency of living area, repeated fever, diarrhoea and cough, predominant breastfeeding, dietary diversity, meal frequency, iron-rich foods, and diarrhoea and cough severity and fever in the last 14 days.

The results of the final adjusted listwise model are presented in Table 7.4.

Summary of results

Maternal secondary education was protective against child underweight compared to no schooling and was associated with 0.225-0.349 higher WAZ-scores. Socioeconomic quintile was significant overall (p=0.032): the second and third quintiles were associated with higher WAZ-scores compared to the lowest quintile although the highest two quintiles were not. There was a modest overall effect of increasing income group with increasing WAZ-score (p=0.051). Children from Saraikela district had WAZ-scores 0.347 SD units higher than those from West Singhbhum (p<0.001).

Underlying risk factors for underweight included a strong effect of birth order: (being born ≥4th was associated with WAZ-scores 0.377 lower than first-born children; p<0.001) and self-reported anaemia in pregnancy which was moderately associated (β=-0.201, p=0.065). Repeated episodes of cough and diarrhoea were also significantly and negatively related to WAZ (β=-0.196, p=0.001 and β=-0.185, p=0.012 respectively). Underlying protective factors were higher maternal BMI (β=0.083, p<0.001), and the use of a hand washing agent which was equivalent to a 0.356 WAZ-score increase. Borderline significant were season of birth (being born in the rainy season rather than the winter was protective; β=0.248, p=0.116) and delivery at a private hospital compared to at home (β=0.154, p=0.109).

Immediate determinants of underweight were predominant breastfeeding, which was associated with a 0.199 reduction in WAZ-score (p=0.075). Bloody diarrhoea in the last 14 days was also linked to a 0.364 reduction in WAZ-score compared to no diarrhoea (p=0.008) and uncomplicated diarrhoea compared to no diarrhoea was borderline significant (β=-0.165, p=0.121). Consumption of iron-rich foods appeared strongly protective for WAZ: β=0.374, p=0.003.

Interactions

I explored interactions between: maternal education*hand washing agent, birth order*repeated cough, birth order*repeated diarrhoea, birth order*diarrhoea severity (last 14 days), predominant breastfeeding*season of birth, predominant breastfeeding*maternal education, predominant breastfeeding*income. There was a marginal interaction between birth order and diarrhoea severity in the last 14 days whereby WAZ-scores were worse for third born children with uncomplicated diarrhoea than first born children with no diarrhoea (p=0.091). There was a marginal interaction between maternal education and hand washing agent (overall p=0.153) showing that women educated to at least higher secondary level and who used a hand washing agent had children with WAZ-scores 0.502 SD units higher than non-schooled women not using a hand washing agent (p=0.022).

Model variations

Analysis using the sibling-adjusted dataset led to the same final model as above and predictor associations were of a similar magnitude. The multiple imputation dataset yielded a similar model, although income and season of birth were not retained. In this model, delivery at a government hospital or private facility compared to at home became a stronger determinant: β=0.130, p=0.075 and β=0.151, p=0.083 respectively. The association of repeated diarrhoea with WAZ also became stronger (β=-0.203, p=0.008), whilst child dietary iron intake became weaker although remained highly significant (β=0.340, p=0.005).

Table 7.4 Final model estimates for determinants of weight-for-age Z-score in children 6.00-23.99 months in the control areas (n=1265)

Position in framework	Predictor		% (n) or mean (SD)	Unadjusted β (95%CI)	P-value	Adjusted β(95%CI)	P-value
Basic causes	Maternal education				<0.001		0.013
		No schooling	68. 9 (871)	1		1	
		Primary school	3.9 (49)	0.191 (-0.067-0.449)	0.147	0.131 (-0.117-0.379)	0.300
		Secondary school	24.6 (311)	0.537 (0.359-0.716)	<0.001	0.225 (0.063-0.388)	0.006
		≥Higher secondary	2.7 (34)	0.921 (0.453-1.388)	<0.001	0.349 (-0.036-0.734)	0.076
	Socio-economic quintile[1]:				<0.001		0.032
		Lowest	20.1 (247)	1		1	
		Second lowest	12.4 (152)	0.322 (0.042-0.603)	0.024	0.219 (-0.013-0.451)	0.064
		Middle	22.0 (270)	0.331 (0.026-0.635)	0.033	0.182 (0.007-0.357)	0.041
		Second highest	19.9 (245)	0.594 (0.248-0.939)	0.001	0.191 (-0.060-0.442)	0.135
		Highest	25.7 (316)	0.827 (0.511-1.144)	<0.001	0.109 (-0.189-0.407)	0.474
	Income group:				<0.001		0.051
		Lowest	82.8 (1048)	1		1	
		Middle	12.7 (161)	0.224 (-0.013-0.461)	0.064	0.347 (0.161-0.532)	0.112
		Highest	4.4 (56)	0.616 (0.355-0.878)	<0.001	0.155 (-0.036-0.347)	0.155
	District				<0.001		0.001
		West Singhbhum	35.7 (451)	1		1	
		Saraikela	31.9 (403)	0.533 (0.365-0.700)	<0.001	0.347 (0.161-0.532)	<0.001
		Keonjhar	32.5 (411)	0.042 (-0.323-0.407)	0.822	0.188 (-0.098-0.473)	0.198
Underlying causes	Season of birth:				0.015		<0.001
		Winter	21.2 (268)	1		1	
		Summer	37.1 (469)	0.058 (-0.149-0.265)	0.583	-0.008 (-0.232-0.216)	0.944
		Rainy	41.7 (528)	0.257 (-0.003-0.518)	0.052	0.248 (-0.061-0.558)	0.116
	Self-reported anaemia in pregnancy:	No	18.3 (231)	1		1	
		Yes	81.7 (1034)	-0.407 (-0.611- -0.203)	<0.001	-0.201 (-0.414-0.012)	0.065
	Birth order:				<0.001		<0.001
		First born	27.7 (351)	1		1	

		2nd born	24.1 (305)	0.012 (-0.161-0.186)	0.888	-0.002 (-0.152-0.149)	0.984
		3rd born	18.0 (228)	-0.149 (-0.437-0.139)	0.310	-0.065 (-0.342-0.213)	0.648
		≥4th born	30.1 (381)	-0.581 (-0.808- -0.354)	<0.001	-0.377 (-0.570- -0.184)	<0.001
	Place of delivery				<0.001		0.070
		Home/providers home/other	77.5 (981)	1		1	
		Government facility	16.9 (214)	0.272 (0.061-0.483)	0.012	0.095 (-0.047-0.237)	0.190
		Private facility	5.5 (70)	0.685 (0.465-0.904)	<0.001	0.154 (-0.034-0.341)	0.109
	Maternal Body Mass Index		18.46 (1.85)	0.098 (0.064-0.133)	<0.001	0.083 (0.043-0.123)	<0.001
	Hand washing agent:	None	80.2 (1014)	1		1	
		Ash/mud/soap	19.8 (251)	0.478 (0.236-0.721)	<0.001	0.356 (0.223-0.490)	<0.001
	Repeated episodes of cough[2]:	No	68.8 (858)	1		1	
		Yes	31.2 (389)	-0.233 (-0.429- -0.037)	0.020	-0.196 (-0.311- -0.081)	0.001
	Repeated episodes of diarrhoea[2]:	No	71.5 (892)	1		1	
		Yes	28.5 (355)	-0.492 (-0.670- -0.315)	<0.001	-0.185 (-0.329- -0.041)	0.012
Immediate causes	Diarrhoeal severity (last 14 days)[3]				<0.001		0.001
		No diarrhoea	74.0 (934)	1		1	
		Diarrhoea, no blood	22.2 (280)	-0.397 (-0.591- -0.204)	<0.001	-0.165 (-0.373-0.044)	0.121
		Diarrhoea, blood present	3.9 (49)	-0.604 (-0.867- -0.341)	<0.001	-0.364 (-0.632- -0.096)	0.008
	Consumption of iron-rich food:	No	90.8 (1149)	1		1	
	(previous 24 hours)	Yes	9.2 (116)	0.413 (0.168-0.659)	0.001	0.374 (0.131-0.617)	0.003
	Predominant breastfeeding:	No	84.6 (1070)	1		1	
		Yes	15.4 (195)	-0.308 (-0.509- -0.107)	0.003	-0.199 (-0.419-0.020)	0.075

[1]2.8% cases missing from socioeconomic status (n=35)
[2]1.4% cases missing from repeated cough and diarrhoea episodes (n=18)
[3]0.2% cases missing from diarrhoea in the last 14 days (n=2)

7.7 Determinants of mid-upper-arm circumference in children 6.00-23.99 months (cm)

Univariate associations

Child age was modestly and positively associated with mid-to-upper-arm circumference (MUAC) (β=0.022, p<0.001) and parental age was negatively related (mothers' age β=-0.034, fathers' age β=-0.020, p<0.001). Females had MUAC scores 0.296 centimetres lower than male counterparts (p<0.001). Socioeconomic quintile was positively associated with MUAC, particularly for the highest quintile versus the lowest (β=0.656, p<0.001). A similar effect was seen for the highest income group versus the lowest (β=0.683, p<0.001). The effect was even stronger for maternal education where children of women educated to at least secondary level had MUAC scores 0.462-0.761 SD units higher than women with no schooling (p<0.001); fathers' education was significant but only for ≥higher secondary compared to no schooling (β=0.454, p<0.001). Children from Saraikela district, Hindus and children from OBC groups had significantly higher MUAC scores compared to West Singhbhum district, Sarnas (a Ho tribal religion, common in Jharkhand) and children from Tribal groups.

Underlying variables that were positively associated with MUAC included BCG, Polio and DPT immunisations, treatment-seeking during childhood illnesses, colostrum discarding, cooking outdoors (versus the main house), being born in the rainy season versus winter, and use of soap for key hand washing occasions. Strong positive associations were observed for: adequate birth spacing (β=0.303, p<0.001), intake of ≥50 iron tablets in pregnancy versus none (β=0.281, p=0.023), delivery at a government (β=0.273, p=0.002) or private hospital (β=0.656, p<0.001) compared to at home, antenatal visits (β=0.336, p<0.001), sufficient living area (β=0.325, p<0.001), treatment and use of improved drinking water sources (0.335, p=0.026 and β=0.233, p=0.003) and use of a hand washing agent (β=0.500, p<0.001).

Negatively associated with MUAC were: self-reported anaemia in pregnancy (β=-0.323, p=0.034), psychological distress (β=-0.302, p=0.088) and birth order (third-born versus first-born children β=-0.233, p=0.031; ≥4th born versus first-born children β=-0.550, p<0.001). Repeated attacks of fever, diarrhoea and cough were also negatively associated with MUAC, particularly diarrhoea (β=-0.450, p<0.001). Early initiation of breastfeeding, bottle feeding, pre-lacteal feeds, household shocks, food rations and growth monitoring by the Anganwadi workers were not associated with MUAC.

Of the immediate determinants, minimum dietary diversity, minimum meal frequency and consumption of iron rich food were positively related to MUAC (β=0.431, p<0.001, β=0.102, p=0.088 and β=0.277, p=0.005 respectively); age appropriate breastfeeding was not associated. Predominant breastfeeding was negatively associated with MUAC (β=-0.239, p=0.005) as were the 14 day child morbidity variables, particularly diarrhoea and cough.

Further variable selection and multicollinearity assessment

I prioritised mothers' age over fathers' age to minimise collinearity. I also excluded treatment-seeking during childhood illnesses due to likely collinearity with the 14 day morbidity variables. Both iron tablet variables were significant but I prioritised the quantity variable because it was more strongly associated with MUAC than the binary version. This variable showed no apparent benefit of consuming <50 tablets compared to none (β=0.066, p=0.461) but ≥50 tablets was positively associated with MUAC (β=0.281, p=0.023). Hand washing with soap before feeding a child was excluded because there were only n=16 cases in the response category, potentially causing model instability. Both 14-day diarrhoea variables were significant but the yes/no version was stronger than the severity variable which I excluded. Cough severity in the last 14 days was more strongly associated than the binary version which was excluded. Correlations between the remaining variables were generally <0.7 and tolerance and Variance Inflation Factors did not indicate a collinearity problem.

Included in backward stepwise models were: child age (months), sex, maternal age, parental education, socioeconomic quintile, income group, religion, social group, colostrum discarding, birth order, BCG, DPT and Polio immunisations, antenatal care, self-reported anaemia and quantity of iron tablets in pregnancy, maternal BMI, birth spacing, psychological distress, district, delivery location, cooking location, hand washing with soap after defecation and after cleaning up a child who has defecated, drinking water treatment, use of a hand washing agent, season of birth, drinking water source, sufficient living area, repeated cough, fever and diarrhoea, predominant breastfeeding, dietary diversity, meal frequency, consumption of iron-rich foods, diarrhoea, fever and cough severity in the last 14 days.

The results of the final adjusted listwise model of MUAC determinants are shown in Table 7.5.

Summary of results

Child age and sex were both significantly related to MUAC in adjusted models. The child age association was small (β=0.012, p=0.005), but the effect of sex was larger where girls' MUAC scores were 0.282 centimetres lower than boys' (p<0.001). Fathers' education appeared important: MUAC scores were marginally higher if fathers had completed primary school (β=0.147, p=0.098), and moderately higher if fathers had ≥secondary education compared to no schooling (β=0.223, p<0.001). Children from middle and higher income groups also had higher MUAC scores than children from the lowest group, equivalent to 0.170-0.193 cm. Children from Saraikela and Keonjhar districts had MUAC scores ≥0.372cm higher than children from West Singhbhum; children from OBC groups also had significantly higher MUAC scores than children from Tribal communities (β=0.345, p<0.001).

Two underlying factors were negatively related to MUAC: third-born versus first-born children was borderline significant (β=-0.158, p=0.111), and ≥4th born versus first-born was highly significant (β=-0.360, p<0.001); repeated cough was linked to a 0.209cm lower MUAC measurement compared to those without repeated cough (p=0.001). A modest positive association was observed between maternal BMI and MUAC (β=0.063, p<0.001); stronger positive associations were identified for adequate birth spacing (β=0.238, p<0.001) and use of a hand washing agent (β=0.390, p<0.001).

The strongest immediate determinants of MUAC were consumption of iron-rich foods which was positively associated (β=0.283, p=0.008) and diarrhoea in the last 14 days which was negatively associated (β=-0.276, p<0.001). Fever and cough with atypical breathing showed moderate negative associations with MUAC (β=-0.186, p=0.007 and β=-0.177, p=0.022 respectively).

Interactions

I explored the following interactions: sex*iron-rich foods, district*birth spacing, district*hand washing agent, district*iron-rich foods, birth order*iron-rich foods, birth order*repeated cough, birth order*diarrhoea (last 14 days), birth order*fever, birth order*cough severity (last 14 days), child age*iron-rich foods. The only significant interaction was between child age and iron consumption which showed older children were more likely to have consumed iron-rich foods (p<0.001).

Model variations

Re-running the analyses in the sibling-adjusted model led to the same final model as above, with some small differences in the sizes of associations. Fathers' education weakened slightly (although remained highly significant; ≥higher secondary versus no schooling $\beta=0.212$, $p<0.001$). The effect of income group became stronger for middle and higher income groups compared to the lowest ($\beta=0.183$, $p=0.003$ and $\beta=0.221$, $p=0.007$ respectively). The effect of birth spacing weakened, although remained marginally significant ($\beta=0.212$, $p=0.080$) and the effect of consuming iron-rich foods strengthened ($\beta=0.315$, $p=0.003$). The multiple imputation model also showed a weakening of fathers' education for ≥higher secondary versus no schooling ($\beta=0.189$, $p=0.006$). Two additional variables were retained in this model: delivery in a government facility compared to at home ($\beta=0.124$, $p=0.056$) and sufficient living area ($\beta=0.085$, $p=0.084$) which were both modestly and positively associated with MUAC.

Table 7.5 Final model estimates for determinants of mid-upper-arm circumference in children 6.00-23.99 months in the control areas (n=1273)

Position in framework	Predictor		% (n) or mean (SD)	Unadjusted β (95%CI)	P-value	Adjusted β(95%CI)	P-value
Age and sex variables	Child age (months)		14.98 (5.20)	0.022 (0.014-0.030)	<0.001	0.012 (0.004-0.020)	0.005
	Sex	Male	50.2 (634)			1	
		Female	49.8 (634)	-0.296 (-0.436- -0.156)	<0.001	-0.282 (-0.390- -0.173)	<0.001
Basic causes	Father's education				<0.001		0.002
		No schooling	42.6 (542)	1		1	
		Primary school	15.2 (194)	0.157 (-0.061-0.376)	0.159	0.147 (-0.027-0.320)	0.098
		Secondary school	13.6 (173)	0.134 (-0.069-0.338)	0.196	0.136 (-0.054-0.327)	0.161
		≥Higher secondary	28.6 (364)	0.454 (0.325-0.582)	<0.001	0.223 (0.108-0.358)	<0.001
	Income group:				<0.001		0.001
		Lowest	82.8 (1054)	1		1	
		Middle	12.7 (162)	0.270 (0.023-0.517)	0.032	0.170 (0.049-0.291)	0.006
		Highest	4.5 (57)	0.683 (0.443-0.922)	<0.001	0.193 (0.030-0.356)	0.021
	District				0.001		0.001
		West Singhbhum	35.6 (453)	1		1	
		Saraikela	31.7 (404)	0.536 (0.255-0.817)	<0.001	0.375 (0.139-0.611)	0.002
		Keonjhar	32.7 (416)	0.203 (-0.099-0.505)	0.188	0.372 (0.164-0.580)	<0.001
	Social group[1]				<0.001		<0.001
		Scheduled Tribe	77.9 (989)	1		1	
		Scheduled Caste	2.3 (29)	0.260 (-0.229-0.748)	0.297	0.088 (-0.590-0.766)	0.799
		Other Backward Class	17.3 (220)	0.590 (0.401-0.779)	<0.001	0.345 (0.204-0.487)	<0.001
		Other group	2.5 (32)	0.397 (-0.198-0.991)	0.191	0.068 (-0.495-0.630)	0.813
Underlying causes	Birth spacing:				<0.001		0.001
		<24 months	14.7 (187)	1		1	
		≥24 months	39.8 (507)	0.303 (0.173-0.434)	<0.001	0.238 (0.109-0.368)	<0.001
		n/a first child/Don't Know	45.5 (579)	0.504 (0.345-0.663)	<0.001	0.171 (-0.012-0.355)	0.068
	Birth order:				<0.001		<0.001
		First born	27.7 (353)	1		1	

	2nd born		24.0 (305)	-0.036 (-0.191-0.119)	0.650	-0.065 (-0.240-0.110)	0.466
	3rd born		18.0 (229)	-0.233 (-0.444- -0.022)	0.031	-0.158 (-0.353-0.037)	0.111
	≥4th born		30.3 (386)	-0.550 (-0.678- -0.423)	<0.001	-0.360 (-0.497-- -0.222)	<0.001
	Maternal Body Mass Index		18.46 (1.84)	0.098 (0.064-0.133)	<0.001	0.063 (0.036-0.090)	<0.001
	Hand washing agent:	None	80.2 (1021)	1		1	
		Ash/mud/soap	19.8 (252)	0.500 (0.259-0.741)	<0.001	0.390 (0.226-0.554)	<0.001
	Repeated episodes of cough[2]:	No	68.6 (861)	1		1	
		Yes	31.4 (394)	-0.267 (-0.475- -0.060)	0.011	-0.209 (-0.332- -0.086)	0.001
Immediate causes	Consumption of iron-rich food:	No	90.8 (1156)	1		1	
	(last 24 hours)	Yes	9.2 (117)	0.277 (0.084-0.470)	0.005	0.283 (0.075-0.491)	0.008
	Diarrhoea (last 14 days)[3]:	No	73.7 (937)	1		1	
		Yes	26.3 (334)	-0.428 (-0.598- -0.257)	<0.001	-0.276 (-0.413- -0.139)	<0.001
	Fever (last 14 days) [3]:	No	71.0 (904)	1		1	
		Yes	28.8 (367)	-0.291 (-0.475- -0.106)	0.002	-0.186 (-0.321- -0.051)	0.007
	Cough severity (last 14 days)[3]				0.001		0.002
	No cough		71.0 (902)	1		1	
	Cough, normal breathing		9.1 (116)	0.015 (-0.283-0.312)	0.923	0.071 (-0.119-0.261)	0.463
	Cough with atypical breathing		19.9 (253)	-0.426 (-0.679- -0.172)	0.001	-0.177 (-0.329- -0.025)	0.022

[1]0.2% (n=3) missing from social group
[2]1.4% (n=18) missing from repeated cough
[3]0.2% (n=2) missing from diarrhoea, fever and cough (last 14 days)

7.8 Discussion

Basic determinants

Maternal education to secondary level and beyond was strongly protective against undernutrition. Interestingly no effect was observed for primary-schooling compared to no schooling, and this is consistent with a recent study from India that included Jharkhand and Orissa, and a cross-sectional study of children from tribal groups in rural Maharastra (Bhagowalia et al. 2012;Meshram et al. 2012a). The added benefits of secondary compared to primary school education (e.g. for numeracy, problem-solving, self-efficacy and greater employability) may benefit maternal and child health in countless ways, including positive health-behaviours. For example, in this analysis there was a multiplicative benefit of hand washing with higher maternal education for child weight-for-height Z-score, which could reflect a deeper understanding of when, how and why hand washing is beneficial.

Socioeconomic status (based on assets, maternal literacy and fuel-type) was related to underweight, and income group was linked to all outcomes except wasting. Income in this study may better represent disposable income to buy food and other essentials than socioeconomic status. One cross-sectional survey of children <36 months in Andhra Pradesh also identified low wealth group as a risk factor for undernutrition (Meshram et al. 2010). Although a further study from Eastern India observed a weak income gradient in undernutrition, with only children from the richest wealth group deriving significant benefits (<5% of cases in this study). The authors noted that small increases in income may not lead to substantial reductions in undernutrition without additional gains in health and education (Bhagowalia et al. 2012).

District and social group were important determinants of undernutrition: unsurprisingly, children from OBC groups tended to have better nutritional outcomes than children from tribal groups. Numerous studies using National Family Health Survey data (NFHS) highlight considerable health inequalities by social group (Arnold et al. 2009;Mathew 2012;Van de Poel and Speybroeck 2009). People from Tribal groups are known to be amongst the most underserved in India with poorer access to quality education and health services, higher levels of poverty and correspondingly worse health outcomes than other groups (Ghosh 2012;Subramanian et al. 2006). Living in Saraikela or Keonjhar districts as opposed to West Singhbhum was linked to lower levels of undernutrition; this effect was particularly pronounced for Saraikela. Government district-level data from 2007/8 support this finding, highlighting disparities in access to services from electricity to family planning, all favouring Saraikela with the worst access seen for West Singhbhum (Ministry of Health and Family Welfare 2010).

Girls had substantially lower MUAC scores than boys. A cross-sectional survey in West Bengal also found lower MUAC measurements in girls under-five which the authors attribute to sexual dimorphism in fat deposition (Mandal and Bose 2009). This sex-effect contrasts with our findings for weight-for-height and stunting where boys tended to fare worse (data not shown), which matches findings of other nutrition surveys from around the world (Khawaja et al. 2008;Marcoux 2002;Wamani et al. 2007).

Underlying determinants: health environment and services

Improved drinking water sources lowered the risk of wasting in this study. More than a third of respondents relied upon unsafe drinking water (37.7%, n=469) which is likely to be one of the main drivers of diarrhoea and other infections. This is similar to findings from recent district-level health surveys in the study areas (Ministry of Health and Family Welfare 2010) and one analysis of the NFHS-3 which found lower quality drinking water was associated with higher levels of wasting (Arnold et al. 2009). Two recent systematic reviews and meta-analyses of interventions to improve drinking water sources suggest this could reduce the risk of diarrhoea by 11%-17% (Cairncross et al. 2010;Fewtrell et al. 2005).

Hand washing with a cleansing agent was strongly protective for child anthropometric outcomes. Several systematic reviews have highlighted the potential of hand washing to reduce diarrhoea by 40-48% (Cairncross et al. 2010;Fewtrell et al. 2005;World Health Organisation and UNICEF 2009). Another review suggested that hand washing also reduces the risk of viral and bacterial pneumonia (Luby et al. 2005). Intestinal worms are highly prevalent in the study areas and epidemiological studies have established a link between worm infection and child undernutrition (Awasthi et al. 2008;Hall et al. 2008). Worms are frequently transferred through the faecal-oral route which would be disrupted with good hand washing practices. One recent cross-sectional survey in rural Andhra Pradesh identified not using soap for hand washing as one of the strongest predictors of stunting in children <36 months (Meshram et al. 2010).

Cooking outdoors rather than the main living area appeared strongly protective against stunting. The most likely explanation is that cooking outdoors reduces exposure to harmful indoor air pollutants from the burning of biomass fuels. The use of biomass fuels for cooking was high at >87%, and the vast majority cooked over an open fire (>85%). Cooking tasks often fall to women in the study areas exposing them, their unborn children and young children in their care to biomass fuel smoke more than other family members (Bruce et al. 2000;Duflo et al. 2008). Epidemiological studies have linked indoor air pollution from biofuels to child stunting. NFHS-1 data (1998-9) showed that severe stunting was 84% higher in biofuel burning households and child anaemia prevalence was significantly higher compared to households using cleaner fuels, after adjusting for tobacco smoke, maternal education, nutrition and recent illness (Mishra and Retherford 2007). Similarly, Demographic and Health surveys from seven developing countries found biofuel exposure was linked to HAZ-scores 0.13 lower than for non-biofuel households, after confounder adjustment (Kyu et al. 2009).

One possible mechanism is that indoor air pollution increases the risk of acute respiratory infections, which can lead to stunting (Bruce et al. 2000). There is also consistent epidemiological evidence that indoor air pollution can cause low birth weight (Bruce et al. 2000). A cohort study from South India measured children from birth to 6 months at two-week intervals and identified a 49% increased risk of low birth weight and a 30% higher risk of stunting at 6 months in households using wood and/or dung as their main household fuel compared to cleaner fuels (Tielsch et al. 2009). Much of this low birth weight may be attributable to intrauterine growth restriction: exposure to particulate matter and other noxious substances in pregnancy can increase the risk or exacerbate the problem in already vulnerable populations with high levels of maternal underweight and anaemia (Tielsch et al. 2009).

Being born in the winter was a significant risk factor for stunting and underweight compared to children born in the rainy season. This could be due to worsened intrauterine growth restriction and stunting in early life from the extra exposure of mothers and children to biofuel smoke to keep warm in the winter months (Bruce et al. 2000). There is also a seasonal peak in respiratory infections in winter that could contribute to stunting (Luby et al. 2005). Seasonal influences on child anthropometry are also attributed to differences in food availability. This could pose another risk for winter-born children: the point at which they should begin weaning (at 6 months) coincides with the pre-harvest period when food is more scarce, whereas for children born in the rainy season weaning coincides with a time of more plentiful food supply.

Sufficient living area (≤3 people per sleeping room) was protective against wasting and

MUAC, although fewer than half of respondents met this standard (United Nations 2011). Housing conditions are variable in the study areas and it is not uncommon for there to be a single main living area which is also used for sleeping. This may increase exposure to indoor air pollution (from heat and cooking sources), but if there are more than three people, it also increases the risk of cross-infections. One hospital-based study in Karnataka linked household overcrowding to significantly increased risk of acute lower respiratory tract infection, which the author attributed to greater ease of transmission of pathogens via respiratory droplets (Savitha et al. 2007).

Delivery in government or private hospitals (as opposed to home-births) was moderately protective against undernutrition. Institutional delivery provides an opportunity for post-natal care including encouragement of early breastfeeding initiation and caring practices, and identification and treatment of health problems in mothers and infants, both of which can improve health and subsequent nutritional outcomes (Campbell and Graham 2007;Mangasaryan et al. 2012).

Underlying determinants: care of mothers and other maternal factors

Maternal psychological distress was significantly associated with wasting when missing data were accounted for. 12.1% (n=154) of women were moderate-severely distressed which is very similar to previous research using the same scale in the same districts (Prost et al. 2012). One recent meta-analysis, although not including wasting as an outcome identified a 1.5-2.2 increased risk of underweight if mothers had depression or depressive symptoms (Surkan et al. 2011). Several Indian studies suggest that maternal depression is an independent risk factor for child growth (Anoop et al. 2004;Patel et al. 2003). Another review identified possible mechanisms for this effect including a lowered likelihood of seeking care, suboptimal infant and young child feeding practices and reduced quality of mother-child interactions (Stewart 2007). This author also acknowledged that there may be reverse causality where mothers become depressed because their child is undernourished, and which may be compounded by poor environmental conditions and limited household resources for improved health and nutrition (Stewart 2007).

Self-reported anaemia in pregnancy was significantly associated with undernutrition. Women were defined as anaemic in pregnancy if they recalled symptoms of 'anaemia', 'malnutrition' or 'weakness' (considered by Ekjut staff to represent local anaemia concepts). Self-reported anaemia levels were low (16.8%, n=374) compared to measured anaemia in the NFHS-3 (Orissa 73.8%, Jharkhand 85.0%; Ministry of Health and Family Welfare 2006).

Our measure probably underestimated true anaemia levels due to recall error and because many women would not have received a formal diagnosis. If we can assume that our measure was not particularly sensitive, a more accurate variable may have had an even stronger influence in the models. Our finding is supported by NFHS-1 data which showed moderate-severe anaemia was a significant risk factor for severe stunting (Mishra and Retherford 2007). One explanation for the link with child undernutrition is that anaemia increases the risk of low birth weight from prematurity (Lone et al. 2004). A recent meta-analysis also estimated that the risk of children being small-for-gestational age increased by 53% if women were moderate-to-severely anaemic in pregnancy (Kozuki et al. 2012). Maternal anaemia may result from poor dietary quality and intake, but may also be due to worm or malaria infection, and inadequate birth spacing (Kumar et al. 2007); indoor air pollution can also contribute to anaemia in adults, which seems a reasonable explanation in this context (World Health Organisation 2000;Zuskin et al. 2009).

Maternal BMI was modestly and positively related to all anthropometric outcomes. More than half of women were underweight in this sample, which is a known risk factor for intrauterine growth restriction and may account for more than half of low birth weight cases in South East Asia (Black et al. 2008). Maternal underweight can also affect child growth through reduced micronutrient content of breast milk, in particular vitamin A, which is important because infants have low stores at birth (Black et al. 2008). Low maternal BMI may also reflect poor dietary intake and adequacy, and generally low food availability, which could partly explain this association.

Older maternal age was a modest but consistent risk factor for undernutrition. Older women would have been less likely to be first-time mothers, and as such may have been exposed to risks associated with greater parity and inadequate birth spacing (such as anaemia). Children born later than their other siblings were at a greater risk of stunting in this sample. Larger family sizes can also strain household resources, the ability to provide adequate care for children, and increase the chances of having an insufficient living area.

Adequate birth spacing (≥24 months) appeared strongly beneficial for HAZ and MUAC. This is line with NFHS-2 data that identified birth spacing <24 months as a stunting risk (Som et al. 2007). Mechanisms include compromised nutrition for the first-born child via early interruption of breastfeeding, and for the second child a greater risk of low birth weight (Dewey and Cohen 2007;Som et al. 2007;Wendt et al. 2012). One review on this topic found the association between birth spacing and child growth was inconsistent: about half of the studies found a positive association where intervals of ≥36 months equated to reduced stunting risks of 10-50% (Dewey and Cohen 2007). The risks for maternal nutrition and anaemia were also mixed and studies varied in the extent to which they adjusted for obvious confounders, such as breastfeeding. The authors considered the 'recuperative' interval (when women are neither pregnant or breastfeeding) as potentially more relevant to maternal health than pregnancy or birth intervals (Dewey and Cohen 2007). A more recent meta-analysis relating inter-pregnancy interval to birth outcomes found intervals of <12 months significantly increased the risks of prematurity, low birth weight, still births and early neonatal deaths; they could not assess impact on mothers due to poor study quality (Wendt et al. 2012).

Underlying determinants: care of children

Inextricably linked to the above factors is birth order, which emerged as a strong risk factor for undernutrition, particularly for children born ≥4th compared to first-borns. This is consistent with NFHS data: in the NFHS-1 ≥3rd born children had a 1.26-1.56 greater risk of severe stunting (Mishra and Retherford 2007) and in the NFHS-3 there was an elevated risk for ≥6th born compared to first-born children (Arnold et al. 2009). Later birth order (and greater parity) is likely to stretch household resources and undermine the effectiveness of caring practices. In addition to addressing the unmet need for family planning in the study areas interventions to counteract the negative effects of later birth order might also want to address sibling-to-sibling care. Not only does this increase the likelihood of infections and sub-optimal feeding (as children may be less likely to understand these issues than adults), but child care responsibilities are a common reason for female siblings leaving education prematurely (Sengupta and Guha 2002). There has been a recent attempt to increase the availability of crèches to counteract this problem, and it may be incorporated into Integrated Child Development Service reforms (Indian Planning Commission 2011).

Early breastfeeding initiation (within one hour of birth) was moderately protective against wasting. It was practised by nearly two-thirds of women, which is higher than reported in the NFHS-3 for Jharkhand and Orissa (10.7-54.8%; Ministry of Health and Family Welfare 2006). Black et al (2008) estimate that suboptimal breastfeeding practices could account for 1.4 million annual child deaths and 44 million Disability Adjusted Life Years, many of which would be underpinned by malnutrition. One explanation for the association with wasting in this sample is that the variable captures positive effects of other breastfeeding behaviours (e.g. early initiation is known to predict successful breastfeeding establishment) (Edmond et al. 2006). However, one Ghanaian study showed that delayed initiation increased the risk of neonatal mortality after adjusting for later establishment of breastfeeding. The authors hypothesised that there are additional benefits of early breastfeeding including reduced hypothermia risk and colostrum in early milk that promotes gut maturation and provides immune protection against infection (Edmond et al. 2006).

Early breastfeeding initiation also reduces the possibility of pre-lacteal and bottle-feeding that can cause infections, interrupts exclusive breastfeeding, and in the case of non-human milk can damage gut function (Edmond et al. 2006). In this sample bottle-feeding and pre-lacteal feeding were not eligible for inclusion in backward stepwise models, but oddly, colostrum discarding (practiced by more than a fifth of women) was positively associated with WHZ-scores (although not retained in the final model). The survey question did not specify how much colostrum was discarded and it may have been a token amount, although this does not explain the apparently beneficial effect of 'throwing away the first milk'. Perhaps this question was measuring something else that represents attentiveness to newborns, it could be a chance effect, or it could reflect social desirability in responses linked to commonly held taboos about giving colostrum.

Underlying child health status

Repeated diarrhoea infection was negatively related to anthropometric status, particularly stunting and underweight. The association with stunting is consistent with previous studies. A multi-country longitudinal study identified a dose-response relationship between each day of diarrhoea in the first two years of life and stunting at 24 months, accounting for 18% of stunting (Checkley et al. 2008). A Brazilian cohort study from birth to 24 months also found that the duration of diarrhoeal episodes was important: 7-13 days significantly worsened HAZ-scores relative to acute episodes (<7 days) and prolonged episodes were linked to a doubled risk of developing persistent diarrhoea (≥14 days) in later childhood (Moore et al. 2010). Each day of diarrhoea effectively amounted to a day of missed opportunity for linear growth, and if prolonged, minimises the possibility for catch-up growth.

Nearly a third of children suffered from chronic or repeated coughs and this was moderately associated with undernutrition. Cough, although not attributable to a specific illness, may have captured children with infections of the respiratory tract. As mentioned previously, repeated coughs may partly result from exposure to indoor air pollutants from the burning of biomass fuels, as well as poor environmental conditions and suboptimal hand washing practices (Duflo et al. 2008;Luby et al. 2005).

Immediate determinants: dietary intake

Minimum child dietary diversity and consumption of iron-rich foods were protective against undernutrition. Just 5.4% of children had an adequately diverse diet (≥4 food groups the previous day) which is lower than the 15.2% reported in the NFHS-3 (Patel et al. 2012). Consumption of iron-rich foods was also low in this sample (<10%). This finding is more similar to the NFHS-3 data on child iron consumption which was 0-1.3% for children 6-8 months and 13.0-16.1% for children 18-23 months (Patel et al. 2012). Micronutrients are essential for growth and development in the first two years of life. From 6 months the majority of iron, zinc and Vitamin B6 are required from food, even with continued breastfeeding, and the proportion of energy, protein and essential fatty acids also increases (Dewey and Brown 2003). Animal source foods are important because they are rich in protein and micronutrients; a lack of these foods is a risk factor for stunting and iron-deficiency anaemia (Black et al. 2008). The very low dietary diversity and iron-intake is worrying and probably represents late weaning as well as a poor diet for those who have been introduced to complementary foods. It is worth noting that iron-rich foods may be prohibitively expensive for many respondents, or rejected for cultural or religious reasons.

Predominant breastfeeding was a risk factor for underweight (i.e. children received breastmilk and other fluids but not non-human milk, food-based fluids, or other foods) (World Health Organisation 2009). This represents late weaning onto solid, semi-solid and soft foods for 15.3% of children in this sample. There are many reasons influencing late weaning, as I have suggested previously. These include seasonal factors relating to food availability at the time of weaning, the perceived need for the child to be weaned depending on their size, and increasing food prices that could result in delaying the introduction of complementary foods in low income households (Holmes et al. 2008;Meshram et al. 2012b;Patel et al. 2012). The focus groups (reported in the next chapter) revealed that some women did not consider the age of their child when beginning weaning, instead focusing on behavioural cues such as walking before introducing food into the child's diet. In many cases this could occur well after the recommended 6 months of age (World Health Organisation 2011a). One NFHS-3 paper identified stunting as a determinant of late introduction of complementary foods in India and suggested that mothers of stunted children may not have felt their child was 'ready' for food because they were small in size (Patel et al. 2012).

Immediate determinants: Infection/illness

Diarrhoea in the last 14 days was a strong determinant of wasting, particularly if there was blood in the stool. This is consistent with two cross-sectional Indian studies of children under-three: one in Andhra Pradesh (Meshram et al. 2010), and the others in rural Maharastra that linked diarrhoea in the last 14 days to a two-fold increase in wasting (Meshram et al. 2012a). A third study from Uttar Pradesh identified a more than five-fold increased risk of wasting due to infection from measles, which is the leading cause of diarrhoea deaths globally (Sachdeva et al. 2010;World Health Organisation and UNICEF 2009). Bloody diarrhoea, also known as dysentery, is characterised by intestinal damage and loss of nutrients leading to weight loss. It is often caused by Shigella bacteria and undernourished children are particularly vulnerable to infection (World Health Organisation and UNICEF 2009). Children are also more prone to dehydration from diarrhoea because their kidneys are less able to conserve water than adults, they have higher metabolic requirements, and because water constitutes a greater proportion of their body weight (World Health Organisation and UNICEF 2009). Blood in the stool could also reflect parasitic infection in the form of hookworms, caused by anticoagulants secreted by the worms and are known to be a problem in the study areas (Awasthi et al. 2008;Hall et al. 2008).

Diarrhoea may have indirect effects on child growth in areas with pre-existing high mortality and prevalent undernutrition. Schmidt (2009) attributed 26% of acute lower respiratory infection cases to recent diarrhoea in a Ghanaian cohort with high baseline levels of undernutrition and mortality, but they did not observe this effect in a better nourished Brazilian cohort with low mortality. In other words, for particularly vulnerable populations there may be an additional pathway to undernutrition and death from diarrhoea via elevated respiratory infection risks (Schmidt et al. 2009). The authors suggest the mechanism could operate through acute micronutrient loss due to diarrhoea and subsequent immune system impairment, dehydration and immobilisation that creates a window for opportunistic infections. In this respect, extra efforts dedicated to diarrhoea reduction could also reduce incidence of acute respiratory infections in malnourished populations.

Fever in the last 14 days was moderately associated with wasting and lower MUAC scores. Generally, fever is associated with loss of appetite and increased energy demands which can culminate in weight loss (Wiskin et al. 2011). This finding is consistent with a cross-sectional study of children from tribal groups in rural Maharastra that observed a doubling of wasting risk (Meshram et al. 2012a). A study from Peru also found an impact of malaria on child nutritional status (Lee et al. 2012). This study assessed the comparative impacts of diagnosed malaria (Plasmodium Vivax), non-specific fever and diarrhoea on child growth and found a stronger weight and height deficit per malaria incident compared to each diarrhoea or fever event. However, because diarrhoea was ten times more common than malaria, the cumulative effect of diarrhoea resulted in a stronger overall impact on child growth (Lee et al. 2012).

'Fever' in this study may be capturing a variety of different health problems such as Dengue, Japanese encephalitis, Chikungunya, respiratory infections, and a range of febrile illnesses that particularly affect rural areas (Gupta and Guin 2010). One common reason for fever in the study areas is malaria. Orissa and Jharkhand are amongst a minority of 'high malaria' states, particularly the Plasmodium falciparum strain which is endemic in tribal forested areas (although P.vivax and P.malariae are also found) (Kumar et al. 2007). A study using verbal autopsies estimated far greater levels of malaria mortality in India than other epidemiological data (WHO or Black 2010) which they attribute to the fact that most malaria deaths (86%) occur outside of the health system without treatment opportunities or establishment of the cause of death (Dhingra et al. 2010); they estimate that up to a quarter of malaria deaths in India may occur in Orissa.

Recent child cough accompanied by atypical breathing in the last 14 days was associated with significantly lower MUAC scores. Nearly a third of children (29%) had a recent cough and 68.5% of these included breathing difficulties. This is almost identical to the prevalence reported in a previous study in rural Orissa (Duflo et al. 2008). As previously discussed, indoor air pollution may be playing an important role in development of acute respiratory infections, for which cough plus breathing problems is one proxy measure. An additional pathway to respiratory infection via diarrhoeal illness in malnourished population has also been discussed above (Schmidt et al. 2009). Finally, there are clear roles for other environmental stressors such as poor hand washing practices and suboptimal caring practices (e.g. associated with later birth order) in the development of cough and acute respiratory infections (Berman 1991;Luby et al. 2005).

7.9 Variable limitations

There was insufficient variability for many of the water, sanitation and hygiene measures and they could not be included in the analyses. For example, the majority of respondents practiced unsafe disposal of children's faeces (97.3% throw faeces outside), just 0.9% reported hand washing before preparing food and 99.2% reported open defecation. These are probably important determinants of undernutrition but are not represented here.

Other important variables were omitted from the survey. For example, we did not measure water storage, which is an important dimension of drinking water safety; it will be useful to consider this in future work. A common causal factor in undernutrition is environmental enteropathy for which only invasive measures are currently available. This would not have been appropriate for our survey although other researchers are working to identify urinary, faecal and blood-based markers which may be more acceptable (Humphrey 2009;Prendergast and Kelly 2012).

I allowed the inclusion of ash and mud as cleansing agents in the hand washing variable, but it is possible that these materials could have been contaminated and facilitated parasite transmission, especially given the high levels of open defecation (Bloomfield and Nath 2009). The main reason for including ash and mud were that the exclusive use of soap for hand washing was low (5.6%) and could have been influenced by cost. When I re-ran the final stunting model with respondents using soap only the association strengthened slightly (β=0.381 to β=0.347) although the estimate also became less precise. Whilst acknowledging that ash and mud may be less effective than soap for hand washing, they are preferable to using plain water (reported by >80%). They may also be a more pragmatic recommendation for the poorest households where soap is unaffordable. Minimising the contamination of ash and mud, and improving the mechanics and regularity of hand washing practices could be important components of interventions allowing the promotion of alternatives to soap.

Proxy measures: although there appears to be a strong protective influence of cooking outdoors on height-for-age my explanation that this is due to lowered exposure to indoor air pollution is speculative. We do not have data on other important facets of indoor air pollution such as length of exposure time, the extent to which fires and stoves are used inside for other reasons, tobacco use in the household or direct measurements of air quality, which could partially account for this finding. Paternal smoking has been linked to stunting in previous studies although the effect seems to be weaker than for the burning of biofuels (Kyu et al. 2009). I think this is an interesting finding, worthy of further investigation and more focused measurement.

The survey questions asking whether children suffered from repeated attacks of diarrhoea, fever and cough are limited because they do not quantify the duration or severity of episodes, rather they capture the mother's perception of whether these are recurring problems. In the case of recurrent diarrhoea, longitudinal studies have shown that the duration of previous diarrhoeal episodes are important, which if prolonged and/or persistent have more serious implications for child linear growth than shorter acute episodes (Checkley et al. 2008). It would not have been possible to collect detailed information about recurrent diarrhoea episodes because this was a cross-sectional survey. However, our general questions about recurrence of child illnesses still have value, and seem to capture something different to the 14-day morbidity variables which may only have short-term implications for nutritional status.

Community-based surveys that quantify the risks of undernutrition from morbidity data often rely upon caregiver reports or fieldworker assessments of a collection of symptoms likely to represent a particular illness. Whilst this is a practical way to collect large amounts of data to model nutritional risks, if there is no clear precedent in the literature as to how to define a particular illness it can result in inconsistent findings and excessive heterogeneity. Defining acute respiratory infections from a collection of symptoms seems to be problematic. In one study field workers were instructed to diagnose this if children had a fast breathing rate plus chest in drawing, nasal flaring or stridor, although cough was not a symptom (Schmidt et al. 2009); another study used fever and difficulty breathing (Tielsch et al. 2009). As in this study, Mishra (2007) and a hospital-based study (Savitha et al. 2007) used cough plus abnormal breathing as a proxy measure. Although I have referred to cough and abnormal breathing as potentially representing an acute respiratory infection it is clear that this is just a proxy measure, for which there is incomplete consensus in the literature.

Other limitations

It would have been interesting to explore determinants of undernutrition in children <6 months because this is often an overlooked age-group in nutrition research (Emergency Nutrition Network et al. 2010). However, the sample size was too small to construct a stable and comprehensive model for this group. I had also planned to report determinants in the 12.00-23.99 month age group because this would have allowed examination of the impact of full immunisation, deworming and Vitamin A given from 12 months. However an assessment of univariate associations with nutritional outcomes indicated considerable repetition with the models presented in this chapter.

A general limitation of these analyses includes the cross-sectional design, so although I talk about 'determinants' to describe factors that may be contributing to undernutrition, I cannot attribute causality. Indeed there may be causality in both directions for particular variables. Positive feedback between undernutrition and morbidities such as diarrhoea would be expected, and maternal psychological distress may be both a cause and a consequence of wasting. There may also be unmeasured confounding that accounts for some of the associations identified here and some collinearity amongst predictors meaning that parameter estimates might not be independent.

7.10 Conclusion

These analyses highlight a range of determinants and several possible pathways to stunting, wasting, underweight and low MUAC. These findings could be a useful basis for the development of a context-specific nutrition strategy for the study areas. Income generating activities could be useful to help households meet minimum dietary diversity requirements, in particular to purchase iron-rich foods. Improving access to secondary school education could be an important long-term strategy for child health. Strong district and social group disparities in undernutrition underline the importance of effective local health governance and the continued fight against discrimination towards people from tribal communities in terms of access to health services, employment and education.

There appears to be a clear and important role for hand washing interventions to improve nutrition, and a strong argument to prioritise the reduction of diarrhoea and dysentery. It is telling that several key water and sanitation indicators could not be included in the analyses because so few respondents reported safe practices, particularly around faeces disposal. Community-wide sanitation drives could also be an effective nutrition strategy. One unexpectedly strong determinant of height-for-age was cooking outdoors and suggests that great benefit may be gleaned from interventions to reduce exposure to indoor air pollution from the burning of biomass fuels. Finally, the health of children is inextricably linked to the health of mothers, particularly in pregnancy. There is a clear need for family-planning interventions to promote adequate birth spacing and increase the availability of contraception to reduce maternal anaemia and child stunting. These and other proposed interventions will be discussed in greater detail in the main discussion chapter.

In the following chapter I present my analyses of the focus group discussions. The chapter includes an exploration of caregiver perspectives about the determinants of child undernutrition, food security in the study areas, infant and young child feeding practices and hygiene behaviours.

Chapter 8

Focus Group Discussions

8.1 Introduction

The objectives of the focus group discussions were to find out about women's experiences of obtaining food for themselves and their families (and their coping strategies in times of shortage), whether there were seasonal differences in the types and availability of foods, to understand local feeding and hygiene practices, and to explore local understandings of child undernutrition. The focus groups also gave Ekjut staff an opportunity to engage with the communities comprising the new control clusters and to gain support for the later nutrition survey. Additionally, we used the focus groups to identify local foods that were commonly consumed in order to develop a food glossary. This facilitated the categorisation of responses to the 24-hour food frequency questionnaire we used in the nutrition survey.

In this chapter I present the methods and findings from the focus group discussions. I have also chosen to incorporate related quantitative content from the nutrition survey, specifically information about household shocks and livelihoods. The purpose of this triangulation of data is to provide balance and support for the qualitative findings.

8.2 Methods

Development of topic guide

We used the framework approach, developed by The National Centre for Social Research and detailed in the work of Pope and colleagues, and identified themes of interest to include in the topic guide (NATCEN 1980;Pope et al. 2000) (see appendix 8.1). Focus group themes sought to explore food security, hygiene practices, infant and young child feeding practices (based on WHO guidelines), and local understandings of undernutrition (World Health Organisation 2008b;World Health Organisation 2009).

The topic guide covered the following main themes and sub-themes:

1. Food availability and access
    a. Ways that people obtain food
    b. Challenges to getting food
    c. Seasonal foods
    d. Access to food markets
    e. Food prices
    f. Experience of and coping with food shortage
2. Local feeding and hygiene practices
    a. Food rituals and restrictions
    b. Weaning practices
    c. Typical food choices for children under-five
    d. Beliefs about feeding ill/thin children
    e. Food handling and hygiene
3. Local understandings of child undernutrition
    a. Perception of the scale of undernutrition locally
    b. Perceived causes of thin/small children
    c. Perceived actions required to resolve undernutrition
    d. Views on growth monitoring

Design, participants and data collection

Two senior members of Ekjut (including one trained sociologist, with experience in qualitative data collection) conducted six focus group discussions with mothers. Three focus groups were held in the women's group intervention clusters and three in the control clusters, with a total of two focus groups per district. We chose to carry out focus groups rather than in-depth interviews because this enabled us to collect data covering a broad range of perspectives in a short amount of time, about relatively non-contentious topics.

The sites for qualitative data collection were purposefully selected (convenience sampling). Ekjut staff were able to organise and recruit participants for the focus groups taking place in the intervention areas using existing contacts. Three growth monitors from the control areas (one per district) were asked to recruit participants and arrange the focus groups in their own clusters because Ekjut staff were new to those areas. The aim was to recruit mothers of young children, in order to elicit perspectives from caregivers. Clusters were chosen based on being located a relatively short distance from the district office where the focus group facilitators worked.

Focus group discussions were carried out in November 2009 when the nutrition survey was being developed. The number of participants present at each focus group ranged from 12 to 18 in West Singhbhum, 9 to 21 in Saraikela and was 18 in both the intervention and control clusters in Keonjhar. All focus groups included a mixture of people from different social groups. The West Singhbhum focus group comprised people from Other Backward Class and Scheduled Caste groups as well as women from the Ho tribal group. The Saraikela focus group included participants from Other Backward Class groups and the Santhal tribal group. The Keonjhar focus groups included Other Backward Class and Scheduled Caste groups and Scheduled Tribes that included people from the Juang community. The Anganwadi worker was present at the focus group discussion in the Keonjhar control cluster; I was also present although I did not contribute to or lead any of the discussion. As far as I am aware, there were no community-health workers present at the other focus groups.

Data were audio-recorded in both Keonjhar focus group discussions and in the West Singhbhum intervention cluster; field-notes were also taken. Although the intention was to audio-record all of the focus groups, due to an oversight only notes were available for the remaining three. The resulting qualitative data included three different languages: Hindi, Oriya and Ho. The transcripts and notes were translated and transcribed by two members of Ekjut staff.

Separate UCL ethical approval was sought for this study in addition to the ethical approval for the nutrition survey. Informed verbal consent to participate in the nutrition survey was sought from focus group respondents. The project identification number is: 2163/002.

8.3 Thematic analysis stages

The data analysis involved several stages.

Initially, the field-notes from the focus groups were discussed amongst those who were involved in managing the nutrition survey. The discussion was led by a qualitative research expert and included the focus group facilitators. Women's group facilitators were also called upon for their opinions at several points to clarify any issues that had arisen. The purpose of this stage was to share the issues emerging from the focus groups with the whole team and to provide input into the development of the nutrition survey; it also served as training in how to analyse qualitative data using a framework approach.

I and SR (one of the focus group facilitators) conducted the main analysis. We independently familiarised ourselves with the data (taking half of the transcripts and notes each) by reading and re-reading the documents. Then we annotated our notes and transcripts in Microsoft Word to help us identify the most salient issues that were emerging ('memoing') and to decide which portions of text belonged under which of the predefined themes in the topic guide ('indexing').

We then pasted segments of text under their appropriate headings and sub-headings to condense the data into a master sheet using Excel software (we also pasted the line numbers associated with each segment of text to enable linkage back to the original transcripts). We wrote summaries to express the essence of each group of quotes ('charting'). Finally, we discussed our coding decisions, the strongest themes we felt were emerging and how well our summaries described groups of data. We resolved any differences of opinion before combining our work into a single master sheet.

I continued with the remainder of the analysis. This involved: gauging how consistent the responses were within and between response categories, further review of emergent themes, identification of discrepant cases and possible reasons for these differences, and identification of rare or consensus opinions. I also searched for links between themes to identify an overall pattern to the data and to guide my presentation of narrative accounts. This process is known as mapping and interpretation (Pope et al. 2000).

In an additional final step I triangulated the findings with related quantitative data from the nutrition survey. Data triangulation has been defined as the use of more than one method to confirm a single theory (Risjord et al. 2001). Of particular relevance to the themes explored in the focus groups were quantitative data about livelihoods, household shocks and coping (this chapter, section 8.5), feeding and hygiene indicators (chapter 6) anthropometry of children and mothers (chapters 5 and 6) and some of the determinants of undernutrition (chapter 7).

8.4 Qualitative findings

Theme 1: Food access and availability

Four interwoven themes emerged concerning food access and availability: insecure livelihoods and low income, increasing food prices and food price volatility, pressure on environmental resources, and coping strategies in times of food shortage or reduced income.

Insecure livelihoods and low income

Many participants were subsistence farmers and relied upon rainfall to grow their crops. These participants expressed serious concern about the recent drought and the impact it was having on their income. They also mentioned lack of access to irrigation facilities and on-going water shortages as threats to their livelihoods. Not all respondents owned cultivable land and depended upon daily labour as their main source of income to buy food. However, there was no guarantee of year-round work and participants in half of the focus groups reported supplementing their income or household food supplies through government schemes. Extremely low income and unemployment were commonly cited factors for people not being able to afford seeds for their own cultivation or particular foods for their own consumption at the market.

Box 8.1 Insecure livelihoods and low income

"We face water shortage while doing agricultural activities. This year there was very little rainfall and so the paddy could not bloom and there was a crop failure, plants died because of lack of water…We do not have any irrigation facilities in our village, we have to depend upon rainfall" (Keonjhar intervention cluster)

"Those who have little cultivable land have a low (crop) production. If we have good rainfall and a good crop then we have enough to consume for about six months and buy for rest of the year. But if the rainfall is less or delayed like this year we have a crop failure and we have to buy for the entire year" (Keonjhar control cluster)

"We face seasonal problems, for example in the rainy season we don't get regular work and in the summer we are unable to work because of hot sunny days, and also staying in remote areas we do not get regular work" (West Singhbhum intervention cluster)

"If we are earning Rs.100 a day (£1.15) then we don't spend all the money the same day but save some for the next day with a feeling that we may not get work the next day" (West Singhbhum intervention cluster)

"Those who can afford vegetables buy them and others just eat with the help of salt. When we have money then only do we buy dal (lentils) or vegetables or else we do not buy. We only buy salt and chilli with the money we have and eat it with rice" (Keonjhar control cluster)

Increasing food prices and food price volatility

Recent increases in food prices were highlighted by all groups. Whilst some seasonal price fluctuations were expected, participants reported that in the last two years food costs had soared and were high in all seasons. Many people stated that, unlike before, they were now unable to afford key food items such as lentils and vegetables. Some people remarked that the value of items they were trying to sell had reduced, and this was negatively impacting on their income. They attributed this to the recent drought (in 2009), which meant crop production was late and diminished. In some instances high food prices forced people to choose between paying the transport fare to the market and their preferred staple food, while others could now only afford a single food item.

Box 8.2 Increasing food prices and food price volatility

"Nowadays prices are high all the time. The time has gone when we were getting vegetables for Rs.2 (2p) but now everything has become so expensive and prices even go up during the summer season." (West Singhbhum intervention cluster)

"We do not buy costlier things, we do not buy potato, we just go to the stream side and get 'benga saag'"[1] (Keonjhar control cluster)

"Now things are so expensive, if we sell one bunch of firewood then we can only buy some amount of rice grains. It has become so expensive that we have to choose between rice grains and potato" (Keonjhar intervention cluster)

"Food prices have gone up too much in the last 1-2 years. Now potato costs Rs.20 a kilo (23p), how will we buy, we cannot afford it. If we sell one bunch of firewood then we get rice grains and potato and we have no money left for the transport fare" (Keonjhar intervention cluster)

"The price of seeds is very expensive. When we buy them they are expensive but when we sell them the price becomes low. Because of water shortage we have late production and when we sell it the prices are low...Now all the different food items have an increase in price, we are very sad. How will we live, what will we buy and what will we eat?" (Keonjhar intervention cluster)

[1]'Benga saag' is Centella Asiatica, a herb found in wet areas (near streams) which contains zinc and other micronutrients

Pressure on environmental resources

Respondents were highly dependent on the physical environment, not just for cultivation, but as a source of wild food for sale and consumption. Many of these wild foods were seasonal. Although some people suggested these foods were in plentiful supply, others were concerned that their availability was reducing. This was attributed to unexpected changes in the climate, habitat destruction, interference from others and government activities. A serious problem raised by all groups was animal-human conflict over food.

Box 8.3 Pressure on environmental resources

"Some seasonal fruits such as mangoes have become less since 1-2 years. There was a lot of wind this year and because of this most of the mangoes fell off before getting ripe. This year the rain was late and so the paddy cultivation was reduced…Seasonal fruits like kendu, kodhei and dimri[1] are also less this year, even I did not have a taste of them this year." (Keonjhar intervention cluster)

"Earlier we used to get some fruits like kendu, chara koli (a type of berry) and many more like pita alu[2] which is grown underground, from the forest. But now the forest is destroyed due to shifting cultivation in the forests and hill. Now we get nothing from the jungle." (Keonjhar control cluster)

"Wild animals like elephants eat our paddy and they come when the paddy ripens. Bears come when maize ripens, and they come to eat maize." (Keonjhar intervention cluster)

"We were cultivating maize and other thing in the hills earlier, but now the government has planted trees and we cannot cultivate there." (Keonjhar control cluster)

"On rainy days, those who are nearby the forest collect more mushrooms and the rest of them have to buy from them." (Facilitator notes, West Singhbhum control cluster)

[1] 'Kendu', 'kodhei' and 'dimri' are summer fruits; Kendu is rich in vitamin A and its leaves are also used for making 'bidi' cigarettes
[2] 'Pita alu' is a type of potato

Coping strategies in times of food shortage or loss of income

People coped differently with the challenges associated with accessing food. Some people appeared prepared for the seasonal fluctuations in food availability, expecting that they would use their savings, borrow from a neighbour or migrate for work during particular seasons. For others, the increase in food prices and lack of employment had led to more extreme and less sustainable coping strategies. These included reducing the quantity and diversity of food intake and increased gathering of firewood to sell at the market to support their livelihoods.

Box 8.4 Coping strategies in times of food shortage or loss of income

"We have experienced food shortage in the summer and at that time we do some labour work. Sometimes we don't get work; at that point we use our savings for meeting our daily requirements." (West Singhbhum intervention cluster)

"Sometimes due to heavy rainfall or untimely rainfall we face crop failure and then we have to migrate to other places in search of work." (Keonjhar control cluster)

"We work outside to get money. We also work in others' fields. Men go to the mines to work. But we cannot work in the mines because it is very far." (Keonjhar control cluster)

"We will be having only rice and salt because the food we eat is so expensive that we cannot afford it." (Keonjhar intervention cluster)

"We live like that. We buy (food) and try to collect firewood more and more and sell it in the market to earn our living." (Keonjhar intervention cluster)

Theme 2: Local feeding and hygiene practices

Three clear themes concerning infant and young child feeding and hygiene practices emerged from the data: exclusive breastfeeding of infants as the norm but bottle-feeding as acceptable in the case of "insufficient milk", timely weaning as common but late weaning as equally widespread with uncertain quality of complementary foods, and evidence that suboptimal hand washing and hygiene practices were rife.

Exclusive breastfeeding the norm, bottle-feeding if "insufficient milk"

The majority of participants reported exclusive breastfeeding as the dominant behaviour for children less than six months of age. Pre-lacteal feeds (honey) at birth and early weaning (at 4-5 months) were mentioned in a minority of cases. Although exclusive breastfeeding was the norm in all groups, the concept of insufficient breast milk was widely reported, described in terms of "any difficulty feeding", "being unable to satisfy a baby's hunger" or having inadequate "milk production". Most groups considered this to be a rare problem for which the solution was to bottle-feed with breast milk substitute.

Box 8.5 Exclusive breastfeeding and "insufficient milk"

"We give breast milk only...we all give mother's milk" (West Singhbhum intervention cluster)

"Everyone gives only breast milk until 6 months of age" (Keonjhar control cluster)

"If the mother has any difficulty in feeding, or has died or has less amount of milk production, the baby is given other food" (Keonjhar control cluster)

"If the mother is unable to satisfy the baby's hunger then powdered milk is given to the baby" (Keonjhar intervention cluster)

"Some who do not have sufficient breast milk give amul (milk powder) water. But that is very rare" (Keonjhar intervention cluster)

Timely weaning was common but late weaning was widespread

Many participants reported weaning their children at an appropriate time (i.e. at six months) but late weaning (at 7-8 months) was equally common. Some reasons for late weaning were specific to some social groups, including the Mahto 'Muh-Juthi' festival held for infants at seven months and sex differences in weaning reported in one focus group by Other Backward Class participants (boys at five months, girls at seven months). Age of weaning was uncertain for women who used ambiguous cues such as excessive crying, but those using behaviours such as walking were probably weaning late. The content of complementary foods tended to be the same as what the parents ate but was prepared to be more palatable (i.e. soft). Considering the difficulties many women had accessing an adequately diverse diet for themselves (see theme 1) this raises doubt as to the quality of complementary foods for children. In a minority of cases these foods seemed to be restricted to rice-based items.

Box 8.6 Timeliness and quality of weaning foods

"After six months of age we give mother's milk and soft food prepared by us like rice-dal and vegetables." (West Singhbhum intervention cluster)

"We continue breastfeeding until the baby walks. We start giving food mostly during 7-8 months of age. When the baby sits crawls or walks and is able to hold the food, then only we start giving food." (Keonjhar intervention cluster)

"Children from six months to two years of age are given rice, rice flake powder, boiled vegetables. We give them whatever we eat, but in less quantity" (Keonjhar intervention cluster)

"We give only mother's milk and when it starts to walk we give them rice and rice cakes." (Juang community member, Keonjhar intervention cluster)

Suboptimal hand washing and hygiene practices

Suboptimal hand washing practices were near universal across groups, suggestive of a lack of knowledge about hand washing benefits and routes of diarrhoeal infection. Whilst several people mentioned hand washing before preparing food or feeding a child, when probed as to whether they used soap, people tended to report using plain water. Soap was rarely mentioned in the context of hand washing: one group said that soap was used if hands "looked dirty" otherwise people used plain water. A minority reported using ash or mud to wash their hands after defecation. There was a lack of consistency around washing children's hands. Descriptions of bottle hygiene were mixed, with good sterilisation practices reported for around half of respondents using this feeding method, whilst others "wash it with plain water" or "in boiled water twice a day".

Box 8.7 Suboptimal hand washing and hygiene practices

"We do not wash our hands before cooking rice, but while washing rice our hand automatically gets clean." (West Singhbhum intervention cluster)

"Yes, we wash our hand (before cooking)...we wash with plain water." (Keonjhar intervention cluster)

"If the baby is eating on his own we wash their hand after they finish their food." (Keonjhar control cluster)

"Sometimes we wash their hands (young children) and sometimes they just eat like that." (Keonjhar intervention cluster)

"We wash our hand with mud after defecation and after cleaning up the child." (Keonjhar control cluster)

"For those who use bottles it is washed with detergent powder and hot water. Detergent powder and hot water is put into the bottle and it is washed properly." (Keonjhar intervention cluster)

Theme 3: Local understandings of child undernutrition

Three inter-linked themes emerged from the data about local understandings of undernutrition: the perceived local burden of undernutrition and causal factors, the importance of functioning health services to improve child health, and women's own knowledge and capacity gaps as barriers to reducing undernutrition.

Perceived local burden and causes of undernutrition

There were mixed views across groups about the burden of malnutrition. In the majority of focus groups (four out of six), participants recognised it as a problem in their community but one Anganwadi worker in Keonjhar asserted that most children in her village were adequately nourished. Several participants reported knowing a particular child who was affected by undernutrition. The most commonly cited reasons for undernutrition were: illness and infection, late weaning and a poor diet, breastfeeding problems caused by inadequate birth spacing, and maternal dietary restrictions in the postnatal period.

Box 8.8 Perceived local burden of undernutrition

"In our village many children are thin but we do not know why they are thin. How can we know why children become thin, we parents are giving them food." (Keonjhar intervention cluster)

"We have very few children in grade 3 and 4 (severely malnourished). Children are mostly in grade1 (normal) and grade 2." (Anganwadi worker, Keonjhar control cluster)

Perceived local causes of undernutrition

"Some children have worms for which they are thin. Some cannot digest anything they eat and become thin, and some children fall ill repeatedly, which is why they become very thin." (Keonjhar intervention cluster)

"They (children) also become thin and weak because of fever, diarrhoea, vomiting. Children who are ill become thin. If the child is not properly fed, it becomes ill and thin. If other food is not given after six months then the child becomes thin." (Keonjhar control cluster)

"In some cases the mother is not able to lactate properly, as a result of which the child does not get the mother's milk properly. That is why the child is thin. Sometimes because of less spacing between children the child does not get proper breastfeeding." (West Singhbhum intervention cluster)

"We mothers are so weak, [and so] our child also becomes weak. After delivery until one month we have some food restrictions. But now it is changing. Still there are some in our village who are not allowed to eat everything…It is believed that there are certain foods, if the mother eats then the child will have diarrhoea, have convulsions and become weak, so we are given rice, dal and salt. There are also certain fruits like mangoes, and kendu which we do not take till the chid is one and half years old." (Keonjhar intervention cluster)

The importance of functioning health services

All groups viewed local health services as critical for child health, and medical solutions to undernutrition were seen as essential. Participants in two focus groups were extremely unhappy about the lack of Anganwadi Centre in their village, which was seen as a barrier to improved child growth; others appeared satisfied with the functioning of local health services (although in one case the Anganwadi worker was present and could have inhibited candid discussion).

Box 8.9 The importance of functioning health services

"Children are weighed in the Anganwadi centre and those who are thin are given medicines. So we should continue weighing and consult the Anganwadi worker for advice on taking care of our babies." (*Keonjhar control cluster)*

"After being weighed and measured by the Anganwadi worker they come to know that the baby is healthy or not. If the weight is decreasing then the Anganwadi worker suggests to mothers how to take care of the baby and feed them available foods" (Facilitator notes, West Singhbhum control cluster)

"We feel good about children being weighed and measured, but we do not get any suggestion from the Anganwadi worker. We are not aware of our children's weight, whether it's decreasing or increasing. We also don't know what we should feed to make them healthy or increase their weight" (West Singhbhum intervention cluster)

"In our village we do not have an Anganwadi centre nor do we have ASHA. If our child falls sick where will we go?" (Keonjhar intervention cluster)

"By weighing our baby we could know whether he is growing properly or not. We want to weigh our baby regularly but the Anganwadi worker does not come to our village regularly. She also does not come to give polio. Even the children do not receive timely immunisation, only because we do not have an Anganwadi centre." (Keonjhar intervention cluster)

Knowledge and capacity gaps as barriers to improving child nutrition

Whilst most participants recognised that improvements to children's diets were necessary to improve nutrition, some remarked on the difficulties of doing this due to income and time restrictions. Women identified a destructive cycle of increasing food prices, poverty, and a high workload which prevented them caring for and feeding their children in the way they wanted. Women also highlighted gaps in their own knowledge as a barrier to improving child nutrition. Participants had general queries about how to increase a child's weight and how to best care for children. Specific queries focused on breastfeeding, which foods young children should be given, how bottles should be sterilised and what should be done in the case of delayed language development. Some participants wanted to understand how to tackle undernutrition.

Box 8.10 Capacity gaps as barriers to improving child nutrition

"We can't do all what she (the Anganwadi worker) says. We go to work all the day and get less time to look after the baby." (Keonjhar control cluster)

"We do work all the time for our livelihood for which we cannot take care of our children and neglect their food. Can you suggest some things which will help us in taking care of our babies?" (Keonjhar intervention cluster)

"We need to give proper food like vegetables and pulses. But we are poor people, we earn every day and eat. How will we feed extra or special food? We are not earning much and now price of rice is Rs.14 per Kilogram (16p). To feed our babies we need money. If we are having money then only we feed milk or Horlicks." (West Singhbhum intervention cluster)

Knowledge gaps as barriers to improving child nutrition

"We do not know what to do (about child undernutrition).You make us understand what to do." (Keonjhar intervention cluster)

"We would like to know what food we should give to our children for better health." (Keonjhar intervention cluster)

"What to do if the mother is not able to lactate?" (Keonjhar intervention cluster)

8.5 Triangulation of qualitative findings with the nutrition survey

Theme 1: Food access and availability

Many of the narratives from the focus groups are echoed in the quantitative data about livelihoods, household shocks and coping collected during the nutrition survey (see Table 8.1). These data support the idea that many people do not have a secure livelihood, with more than two-thirds of respondents dependent upon daily paid labour, which many people described as unreliable. The main source of income for more than one-fifth of respondents was selling their own production, which brings with it other vulnerabilities, such as the effects of drought.

Nearly half of survey respondents (46.9%) had experienced a major household shock in the last 12 months, a sharp increase from 12% three years ago and 18% two years ago (data not shown) although recall bias may be a factor. The most common household shocks were: a major household health problem (46.4%), damage to houses or crops by elephants (42.3%) and droughts, crop failure or a drop in production (32.7%). Again, these shocks were highlighted in the focus groups where elephants posed a significant threat to livelihoods, and the recent drought had seriously undermined crop production.

There was also cross-over in household coping strategies reported in the nutrition survey and focus groups. In the survey ‘taking on extra work’ (50.6%), ‘getting a loan from a relative’ (43.9%), ‘buying food on credit’ (18.2%), ‘getting a loan from the bank or savings organisation’ (17.2%), and ‘migratory labour’ (14.2%) were the most common coping strategies. A substantial minority reported less sustainable strategies, such as selling cattle or land (up to 11% of cases) and sending children to relatives (8.3%). Together with the more distressing focus group narratives, such as people reducing their diet to rice and salt or having to depend upon the sale of firewood for income, these data strongly suggest that extreme food insecurity was endemic in the study areas. The fact that more than half of women were underweight (BMI <18.5, chapter 6) also supports this notion.

Table 8.1 Livelihoods, household shocks and coping: data collected during the nutrition survey		Intervention % (n)	Control % (n)	All % (n)
Main source of household income[1]	Daily paid labour	53.7 (970)	81.4 (1812)	69.0 (2782)
	Making items for sale (e.g. tailoring, bidis)	0.8 (14)	0.8 (18)	0.8 (32)
	Rented rickshaw, operating ox or push cart	0.1 (2)	0.0 (0)	0.1 (2)
	Making and selling alcohol	0.2 (4)	0.3 (6)	0.2 (10)
	Regular job	2.5 (45)	3.1 (69)	2.8 (114)
	Selling own production	36.2 (653)	11.8 (263)	22.7 (916)
	Selling own livestock	0.2 (3)	0.1 (3)	0.1 (6)
	Selling items from the wild	5.4 (97)	0.5 (12)	2.7 (109)
	Small scale trade	0.8 (15)	0.4 (10)	0.6 (25)
	Medium scale trade	0.1 (2)	0.2 (5)	0.2 (7)
	Large scale trade	0.0 (0)	1.2 (26)	0.6 (26)
Main way that Household obtains staple food[1]	Own production	50.7 (916)	50.9 (1132)	50.8 (2048)
	Purchased	42.8 (772)	46.5 (1035)	44.8 (1807)
	Barter, borrow, exchange for labour, gift	0.4 (7)	0.3 (6)	0.3 (13)
	Food aid/BPL card	6.0 (109)	2.4 (53)	4.0 (162)
Household shock (last 12 months)[1]	Yes	49.5 (893)	44.9 (999)	46.9 (1892)
	No	50.5 (911)	55.1 (1227)	53.1 (2138)
Type of household shock experienced (multi-option)[1,2]	Drought, crop failure, drop in production	27.4 (245)	37.4 (374)	32.7 (619)
	Disease epidemic	15.6 (139)	30.3 (303)	23.4 (442)
	Major household health problem (not above)	61.7 (551)	32.6 (326)	46.4 (877)
	Damage to houses or crops by elephants	41.1 (367)	43.4 (434)	42.3 (801)
	Natural calamities (floods, landslides)	5.3 (47)	0.7 (7)	2.9 (54)
Household coping strategies for household shocks in the last 3 years	Loan from bank / savings organisation	22.9 (208)	11.6 (108)	17.2 (316)
	Loan from landlord	6.1 (56)	4.7 (44)	5.4 (100)
	Loan from relative	48.7 (445)	39.1 (364)	43.9 (809)

(multi-option)	Loan from self-help group	1.1 (11)	0 (0)	0.5 (11)
	Use of own savings	3.1 (30)	0 (0)	1.5 (30)
	Buying food on credit	11.6 (106)	24.6 (229)	18.2 (335)
	Selling off cattle	9.5 (87)	7.4 (69)	8.5 (116)
	Selling off plot	4.7 (43)	0.4 (4)	2.5 (47)
	Selling firewood	0.2 (2)	0 (0)	0.1 (2)
	Mortgaging land/cattle/household items	3.1 (28)	0.3 (3)	1.7 (31)
	Migratory labour	18.1 (165)	10.3 (96)	14.2 (261)
	Sending children to stay with relatives	11.0 (100)	5.7 (53)	8.3 (153)
	Taking on extra work	33.3 (304)	67.5 (628)	50.6 (932)
	Other not specified/none given	7.2 (71)	10.6 (110)	9.0 (181)

[1]Data were missing for 0.1-0.3% of cases

[2]Denominator is participants saying they had experienced a household shock in the last 12 months

Theme 2: Local feeding and hygiene practices

The nutrition survey data generally support the idea expressed in the focus groups that exclusive breastfeeding was the norm and that bottle-feeding was rare and only practised in the event of "insufficient milk": the rate of exclusive breastfeeding was 67.6% and 14% of women reported that their child had been fed by a bottle sometime in their life (see chapter 6).

The widespread practice of late weaning emerging in the focus groups was also supported by the nutrition survey where 56.4% of children 6.00-8.99 months had not yet been introduced to solid, semi-solid or soft foods. Similarly the uncertainty around the quality of complementary foods in the focus groups should be considered against the quantitative findings: just 5.4% in the control areas had consumed ≥4 food groups and <10% iron-rich food the previous day. Although this is partly accounted for by late weaning, this has worrying implications for the dietary quality of young children (see chapter 6).

The poor hand washing practices identified in the focus groups are also strongly supported by the nutrition survey. In chapter 6 I identified that hand washing with soap before preparing food and before feeding a child was <2%, and in the control areas ≤14% of people washed hands with soap after defecation or cleaning up a child who had defecated.

Theme 3: Local understandings of child undernutrition

The majority of focus groups recognised undernutrition as a problem in their communities, but the quantitative data suggest the burden is worse than seems to have been verbally expressed. One focus group in particular may have been inhibited by the presence of the Anganwadi worker as she is entrusted with growth monitoring and acting upon growth faltering. Women in the focus groups identified fever and diarrhoea as important local causes of undernutrition and this is reflected in the quantitative data both in terms of the high prevalence of these problems, but also the fact that they emerged as predictors of child undernutrition in chapter 7.

Several focus group participants identified maternal factors such as diet, inadequate birth spacing and impaired breastfeeding as important causes of undernutrition. In the survey, one-fifth of women spaced their most recent pregnancies by <24 months and this also emerged as a risk factor for child nutrition in chapter 7. Maternal "weakness" was expressed as an issue for child nutrition in the focus groups and anaemia amongst women (often referred to locally as "weakness") was extremely high in the NFHS-3; self-reported anaemia during pregnancy also emerged as a consistent predictor of child nutritional outcomes in chapter 7.

There was divided opinion across the focus groups as to the quality of local Integrated Child Development Services, and this is also reflected in the survey data. On the one hand >80% of children in the survey had received a monthly take-home food ration as per their entitlement, on the other more than a fifth of children in the control areas had never had their growth monitored by the Angandwadi worker.

8.6 Discussion

Summary of main findings

The overriding feeling from the focus groups was one of extreme hardship when it came to procuring food. Women identified insecure livelihoods and low income, increasing food prices and diminishing natural resources as barriers to getting food. Strong statements were also made about the effects of drought and lack of irrigation, as well as concerns about animal-human conflict over food.

The way women coped with these problems varied, but some worrying strategies were discussed, such as the reduction of quantity and diversity of food, and having to depend “more and more” on the sale of items from the wild, including firewood, which is unsustainable in the longer-term. Women linked high workloads, increasing food prices and poverty as a destructive cycle of factors that prevented them caring for their children properly.

Late weaning was very common, and arguably this could be seen as a coping strategy: by lengthening the period of exclusive breastfeeding this limits pressure on household income to buy additional food. It will be important to monitor this situation, perhaps within the existing data surveillance system, or to lobby the government to assess changes in the proportion of households reporting major shocks, and the nature of coping strategies used to deal with these shocks, as a method to highlight deteriorations in food security.

Exclusive breastfeeding for infants under six months seemed to be the norm, although many groups also mentioned bottle-feeding in the case of insufficient milk supply. There is concern that perceptions of insufficient milk may be more common than would be expected. This suggests an opportunity for improving breastfeeding support, including counselling by Anganwadi workers and ASHAs and through women’s groups to minimise the use of bottle-feeding. This is particularly important in the study areas where there are limited facilities for hygienic bottle preparation and where breast milk substitute may be too costly given that incomes are so low.

The hand washing practices described by focus group participants were also concerning: soap was scarcely mentioned, neither were other hand washing agents such as ash and mud. This suggests limited understandings of faecal-oral contamination, and again, an opportunity for front-line health workers and women's groups as agents of change to improve community and household hygiene practices.

Triangulation with other data

The themes I identified in the qualitative data fit well with the quantitative nutrition survey data, echoing the focus groups in terms of a high prevalence of recent household shocks and some coping strategies that signified extreme food and livelihood insecurity. The qualitative and quantitative data on infant and young child feeding and hand washing practices also triangulated well and women highlighted many of the determinants of undernutrition that were identified in the quantitative analyses.

It is important to consider women's experiences of food price increases against official food price data for the same period. The Economic Times of India reported food inflation of 19.9% for 2009 where the price of potatoes and pulses alone increased by 136% and 40% respectively. These data are consistent with the experiences of focus group participants who reported being unable to afford potato or lentils which particularly affected people without cultivable land who buy all their food (BBC 2009;Economic Times of India 2009). A recent World Bank analysis estimated that because of increases in food prices in India during the second half of 2010 there was a net increase in the percentage of people living below the poverty line ($1.25 per day) of 0.77% (Ivanic et al. 2011).

Market trends over the last few years in India show that food price volatility can make small farmers extremely vulnerable if prices are lowered for even a short time (Food and Agriculture Organisation 2011). This was expressed by small farmers in the focus groups who felt that whilst they bought seeds for cultivation at a very high price, at the point of sales of their own crop the price was lower and was undermining their income, although this may also reflect the fact their production was late due to the drought.

Commentators suggest food price volatility is likely to be a long-term problem, exacerbated by climate change and increased 'weather shocks' such as drought (The Independent 2011).

Commentators also mention biofuel demand (which reduces particular foods available for consumption), higher fuel prices (including for food transport), increasing meat consumption (for which grain is needed to feed livestock) and particular trade policies that can erode the safety net associated with stockpiles in times of food shortage (Amadeo 2012). Others mention that stockpiling has been used as a deliberate strategy to create short-term food price hikes for profit, further complicating the situation, but where the poorest people are hardest hit in both cases. Market speculation is also an on-going influence over food prices and was one of the key drivers of the Global Food Crisis in 2008 (Pace et al. 2008).

What does this mean for child nutrition?

There appear to be a toxic mix of factors driving undernutrition in the study areas. Some of these risk factors would be amenable to behaviour change including hand washing and hygiene, for which women's groups could be a powerful platform. However, most of the risk factors identified here lie outside of the realm of women's groups.

Supply-side failures were identified by the focus group participants and are supported by the nutrition survey data, including patchy coverage of community-based health services, and inadequate government support for those with insecure livelihoods. This is also set within a broader context of hostile market forces where increasing food prices are causing the poorest people without cultivable land to reduce the quantity and diversity of their diet. Small farmers who are affected by drought and crop failure are also vulnerable to food price volatility where short-term drops in food prices mean they are at risk of losing their livelihoods completely. These factors are forcing a substantial minority of people to become totally dependent upon wild produce and the sale of natural resources such as firewood, which are unsustainable in the long-term.

The government can do more to limit these problems, for example they could make the National Rural Employment Guarantee scheme work better and be more inclusive of women with small children (Dreze 2010;Khera and Nayak 2009). They could also work to improve the coverage and quality of the Integrated Child Development Services. These issues are all under review with impending reforms to primary health services as well as a revised food security bill being debated in the Indian parliament (Indian Planning Commission 2011); a new cash transfer scheme for pregnant women (MAMATA) is also currently being introduced in Orissa (Government of Orissa 2011). These proposals and their implications will be discussed in greater detail in the following final chapter.

8.7 Limitations

There are a number of limitations to this work that should be acknowledged.

Firstly, there was a selection bias in the focus groups: locations closer to the office were chosen over more remote regions and in this respect participants may have been better off than those living in more difficult to reach areas who did not participate in the discussions.

In terms of data quality, half of the data from the focus groups were in note form and lacked the depth of an audio-recording. The notes could have been influenced by the facilitator's note-taking ability and interests in terms of what was included. In the case of people speaking simultaneously, it would have been difficult to capture all viewpoints, and the note-taking itself may have inhibited free discussion. There seems to have been a tendency to list food items that are sometimes eaten without giving an indication of how often they are actually consumed by mothers and children (this was also the case for the audio-recorded discussions). It is also possible that the note-taker did not understand all the languages being spoken, limiting the voices of particular groups. Both focus groups in Saraikela were in note form, and the views of people living in that district may have been under-represented.

Some of the focus groups were large and possibly difficult to moderate. Smaller groups would have been better, but we felt it was important to be inclusive. Due to the large group sizes it is possible that more sensitive issues such as acute household food insecurity were not discussed.

Although researcher bias is usually unavoidable, my presence at one of the focus groups could have influenced responses. Equally, the facilitators could have unintentionally influenced responses. There were clear social divisions at the group I attended, which was obvious from the seating arrangements, and some groups may have dominated the discussions. The presence of the Anganwadi worker at the Keonjhar control group discussion is also likely to have had an influence, and may have prevented people speaking openly about their experiences with local health services.

In terms of the focus groups that were audio-recorded and translated, I did not understand the languages spoken and could have missed important nuances, and it may not have been possible to translate these meaningfully. I also did not consider non-verbal communication to any great extent and may have lost some of the meaning to the discussion expressed through body-language.

It would have been useful to do further qualitative work with women's group participants as part of a broader process evaluation of cycle 2, similar to the process evaluation of the first cycle of groups (Rath et al. 2010). This could have helped us to understand how and why the intervention apparently affected some of the secondary outcomes (in chapter 6) but why there was no measurable difference in the primary outcome (chapter 5). It would have also been interesting to explore if and how women were empowered, as well as to enhance our understanding of how the development of a critical consciousness can lead to health improvements. Unfortunately the necessary time and resources were not available for this.

Finally, in terms of bias in the analyses, it is possible that preconceived ideas about the problems faced by community members influenced the themes that we chose as the most vivid and important. However, triangulation with the quantitative data and data on food prices supports the identification of these themes as salient.

8.8 Conclusion

The focus group discussions strongly suggest that food insecurity is rife in the study areas. A combination of insecure livelihoods, drought, and poverty amidst soaring food prices (without any apparent increase in income) are undermining the nutritional intake of community members and leading to unsustainable coping strategies. For food producers there is also a disparity between the cost at which they buy, and the price at which they can sell their produce, and this creates a further income and nutritional deficit. Poor hand washing and hygiene behaviours were common and add an additional layer of risk to child health and nutrition. Behaviour change activities have the potential to improve child health, but only with concurrent supply-side improvements and strengthened social and livelihood security measures.

In the next and final chapter I have drawn together the threads of the thesis to arrive at a conclusion about the potential of community mobilisation with women's groups to reduce child undernutrition in rural communities of Jharkhand and Orissa.

Chapter 9

Discussion

9.1 Introduction

The aim of this thesis was to explore the potential of community mobilisation with women's groups to reduce child undernutrition in rural tribal communities of Jharkhand and Orissa. In this final chapter I have synthesised the different types of evidence collected to determine how effective 'cycle 2' of the women's groups was in its original form, and the likely impact of a new improved cycle of group meetings on child nutrition.

I have revisited data from chapter five that shows the extreme levels of undernutrition in the study areas and have considered possible reasons for the lack of apparent women's group impact. I have drawn upon my findings from chapter six to pinpoint the nutrition behaviours that seem to have been positively influenced by the groups and their public health significance. I have also considered the behaviours and health indicators that were not influenced, and how 'cycle 2'could be changed to have a greater impact on these aspects.

My analysis of the determinants of undernutrition in chapter seven has guided my thinking about how 'cycle 2' could be improved because it provides insight into the most important drivers of stunting and wasting in the study areas. Some of these determinants are those that women's groups appear able to influence, such as water treatment and hygiene behaviours; more emphasis could be given to these in future meetings. Other determinants highlight some relatively simple interventions that could be recommended to groups with potentially large benefits, such as reducing exposure to indoor air pollution by cooking outdoors. There are also behaviours that may be more amenable to change through individualised approaches (such as home visits), or that require wider structural changes instigated by the government.

The findings from the focus groups in chapter eight provide an essential background against which to judge the potential of women's groups. They emphasise the shortcomings of the

Integrated Child Development Services (ICDS) and the extreme food and livelihood insecurity experienced by communities in Jharkhand and Orissa, which is underpinned by erratic weather conditions and escalating food prices. I will consider how government action could help to transform this hostile landscape through health and nutrition programme reform. I will also use evidence from my literature review in chapter two and country case studies from Brazil and Thailand that highlight success factors for community-based approaches to improve child nutrition within government health systems.

Before concluding with the limitations of the thesis and ideas for future research I will argue for the importance of extending the activities and influence of women's groups to test whether this can lead to meaningful and sustained improvements in nutrition. I will reflect on the history of civil society actions in India, including those by *adivasi* women, and how these may play a role in resisting negative global forces and development plans that undermine health and nutrition, and shaping social policy.

9.2 The nutritional status of children in the study areas

The nutrition survey revealed shocking levels of stunting and wasting in the study areas: 40% of children were experiencing global acute malnutrition, 60% of children were stunted and a quarter of children had MUAC measurements in the moderate-severe undernutrition category. There are several methods available to classify the severity of this nutrition situation. These include standards set by the World Health Organisation, the Integrated Food Security Phase Classification and thresholds developed during nutritional emergencies (e.g. the Food Security and Nutrition Analysis Unit) (Food and Agriculture Organisation 2008;FSNAU 2012;World Health Organisation 2013). Whichever method is applied, the result is the same: the communities we surveyed are experiencing a nutritional crisis.

National Nutrition Monitoring Bureau data from 2006 also show extreme levels of underweight amongst *adivasi* communities, which prompted one health activist, Dr Binayak Sen, to call the situation an undeclared famine (National Nutrition Monitoring Bureau 2006;Padel 2012;Sethi 2011). According to Amartya Sen's definition, and the Integrated Food Security Phase Classification, famine cannot be declared unless there is also very high mortality (Food and Agriculture Organisation 2008;Sen 1982). We did not collect data on the crude death rate and are unable to fully classify the situation. However, Howe and Devereux (2004) caution against using definitions of famine that delays intervention until people are already dying in large numbers. This reiterates the need for urgent action in the surveyed areas, even without mortality data.

Amartya Sen's theory also states that famines cannot exist within functioning democracies (Sen 1982). The registration of births and deaths in the study areas is extremely poor and reflects considerable dysfunction of government health monitoring and responsiveness to its citizens. The remoteness of many of the participating villages means that many deaths would occur outside of the health system and be invisible to outsiders. It is essential that the government improve vital registration systems to be able to monitor the nutrition and general health situation of its most vulnerable citizens: 'for every mother and child to count, count every mother and child' (World Health Organisation 2005).

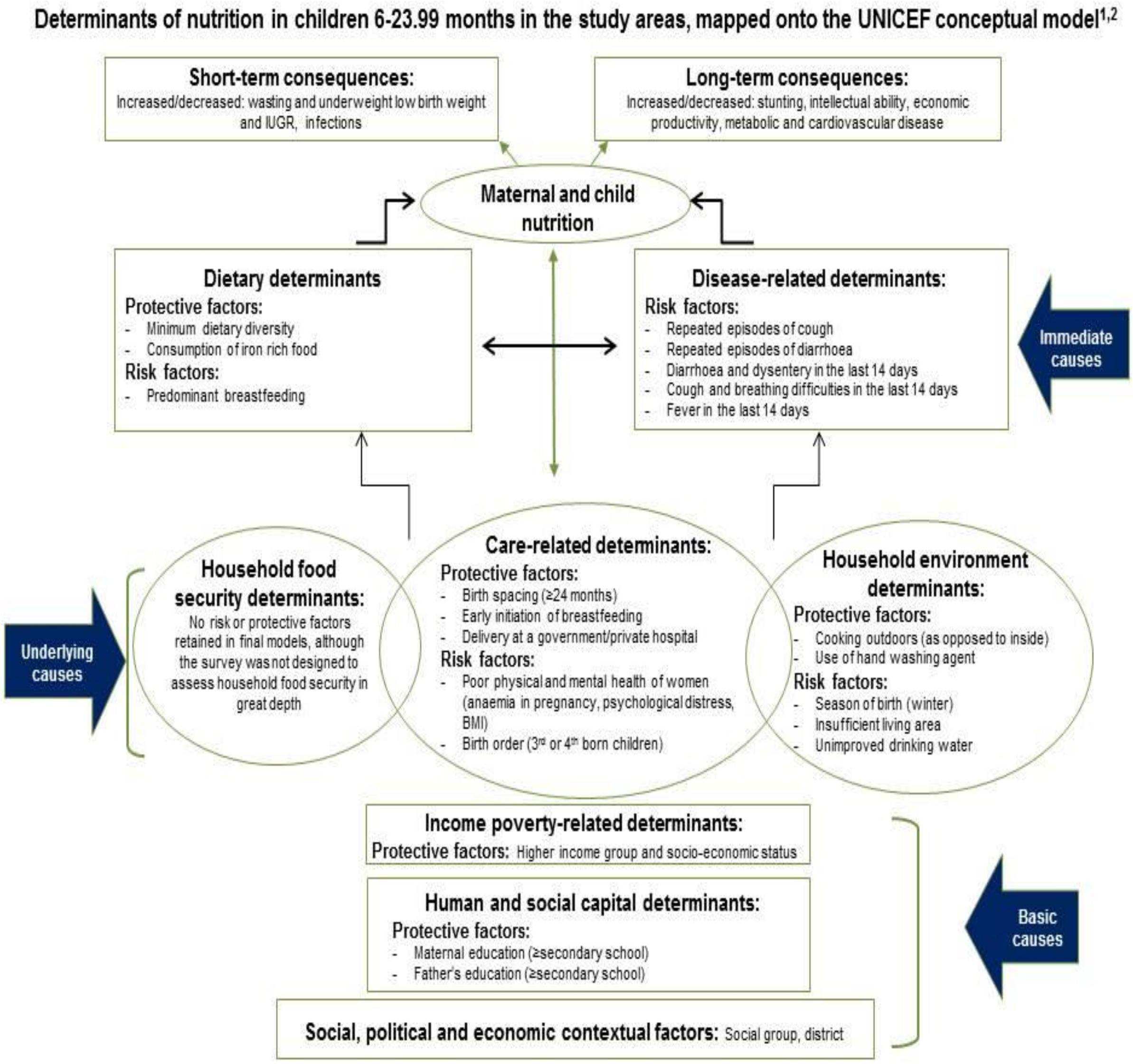
It is possible that errors in data collection and the challenges of remote management of the growth monitors led to an overestimation of undernutrition, particularly as younger children can be difficult to measure. However, the data conform to a normal distribution and provide acceptable standard deviations within the ranges found in DHS surveys. More than half of the women we measured were underweight and this lends support to the high levels of child undernutrition as a genuine finding. It has been suggested that evolutionary differences body size account for the disproportionate number of apparently undernourished children in South Asia compared to Western countries (de Haen et al. 2011), but in the context of such a high prevalence of recent child infections, rampant food insecurity, and inadequate hygiene and sanitation this is not a satisfactory explanation.

It is important to remember that our data are not representative of India or even of Jharkhand and Orissa as states. They are focused on non-randomly defined clusters of *adivasi* communities known to have some of the worst health outcomes in India. These and other areas should be re-surveyed as soon as possible, using random sampling methods, to confirm the integrity of our data and to check whether there is evidence of a worsening trend. The next National Family Health Survey (the NFHS-4) is overdue. This is a worrying delay given that the national government has reiterated their commitment to resolving the 'national shame' of malnutrition in India (Singh 2010). There is a strong argument for 'more frequent slimmer nutrition surveys', particularly in high burden states, districts and blocks (Haddad and Zeitlyn 2009).

9.3 What is driving undernutrition in the study areas?

My determinants analyses identified a range of risk factors for undernutrition (see chapter 7). In this final chapter I have focused on the strongest and most consistent determinants at different levels within the UNICEF nutrition framework. This tool was intended to facilitate the process of assessment, analysis and the development of context-specific nutrition action plans (the ‘triple A’ approach) (Pelletier 2002). The ‘action’ component applied to these data highlight some issues that could be included or developed in future cycles of women’s groups, in parallel with national and state government actions. Many of these determinants have additional implications for the redesign of health and nutrition programmes and the rethinking of intervention priorities to ensure greater equity and participation by underserved groups for improved nutrition. I have mapped the determinants of child nutrition in the study areas onto the UNICEF framework in Figure 9.1.

Figure 9.1 Determinants of child nutrition in the study areas



[1]Adapted from UNICEF, 1998

[2]Determinants of undernutrition identified in chapter 7, including those identified after accounting for missing data

Lack of maternal education

The strongest basic cause of child undernutrition was lack of maternal schooling (income and socioeconomic status were also important, but to a lesser extent). Education was only protective if women had attended secondary school - there was no influence of primary school education, which is consistent with a recent report by the International Food Policy and Research Institute (Bhagowalia et al. 2012). There are numerous ways in which maternal education can benefit child nutrition. One example from my analyses is the enhanced effect of hand washing if women had secondary education on weight-for-height Z-scores, which could reflect a greater understanding of when, how and why hand washing is important. It would therefore seem essential to support investment in female education beyond primary school and ensure the most marginalised groups are attending, as this will pay dividends for population health.

There are distinct needs of first generation female school attenders from rural poor communities that are not currently addressed by India’s education system (Balagopalan and Subrahmanian 2003;Nambissan 1996;Subrahmanian 2003;Vasavi 2003). Educational reform would need to tackle issues of affordability, accessibility, quality of teaching and the relevance of the curriculum. There could also be a role for women’s groups to sensitise communities to the added value of girls’ continuing education. MacCormack (1988) has identified a correlation between the perceived value of female agricultural labour, the extent to which women control the agricultural products they produce, their social status, and the extent of social investment in the education of girls. For this reason the women’s groups and social justice organisations may need to challenge established norms of differential investment in the education of boys and girls (ibid).

Social discrimination

Wasting was significantly worse for children from Scheduled Tribal groups and Scheduled Castes, consistent with other literature (Subramanian et al. 2006;Thorat and Sadana 2009). Caste-based discrimination remains problematic and is manifest in the way government health and nutrition programmes are designed and run. This includes a bias towards locating Anganwadi Centres in higher caste areas, where marginalised groups are less likely to attend, and an absence of guidelines to prevent discriminatory practices in service delivery (Mamgain and Diwakar 2012). There is evidence that women from Scheduled Caste groups applying to work as cooks within the Integrated Child Development Services have been rejected on the basis of caste, resulting in low human resources to deliver food-based services at Anganwadi Centres (Thorat and Lee 2005). Other reports identify refusal or aggression towards children from Scheduled Caste communities at Anganwadi Centres (George et al. 2009;Mamgain and Diwakar 2012). A recent review argues for representation of marginalised groups at all levels of the Integrated Child Development Services and better monitoring of programmes, including community audits (Mamgain and Diwakar 2012).

A review of the Targeted Public Distribution Scheme also highlights exclusion of marginalised groups and poor monitoring as severely undermining programme effectiveness. The 'fair price' shops through which the programme operates are located in higher caste areas and are run by the local 'elite' with no accountability in pricing, quality or quantity of food (Swain and Kumaran 2012). The Integrated Child Development Services and Public Distribution System are essential for the food security of underserved households. The new National Food Security Bill provides a valuable opportunity to address programme-based discrimination (see section 9.6).

Hand washing and hygiene

Hand washing with soap, ash or mud was strongly protective against child undernutrition. Hand washing could reduce undernutrition via 40-48% reductions in the incidence of diarrhoea (Cairncross et al. 2010;Fewtrell et al. 2005;World Health Organisation and UNICEF 2009), lowered risk of viral and bacterial pneumonia (Luby et al. 2005), and reduced risks of infection with intestinal worms, which are a problem in the study areas (Hall et al. 2008). Unsafe drinking water sources were also linked to wasting.

Hand washing and hygiene are one of 13 priority interventions in the Scaling up Nutrition Framework. An influential meta-analysis estimated that hygiene interventions (including hand washing, sanitation, water quality and hygiene) would reduce stunting by just 1-3% (Bhutta et al. 2008). Critics have argued that this underestimates the likely impact on stunting because the model only considered the effect of diarrhoea reduction and not reductions in environmental enteropathy (Humphrey 2009). Environmental enteropathy is caused by suboptimal water, sanitation and hygiene and is linked to chronic inflammation and increased permeability of the small intestine that enables transmission of bacteria into the blood. Environmental enteropathy may have a mutually reinforcing relationship with undernutrition: poor nutrient stores limit the repair of enteropathy induced intestinal damage, diarrhoea further reduces nutrient absorption, and other infections can reduce appetite but increase energy demands (Prendergast and Kelly 2012). Environmental enteropathy also disrupts zinc absorption and zinc insufficiency can result in structural changes to the intestine that increase diarrhoea, pneumonia and malaria risk (Black et al. 2008).

I was not able to include child faeces disposal or defecation practices in the determinants analysis due to inadequate variability in responses: safe faeces disposal and defecation practices were reported by <1% of respondents. These unsafe practices increase the risk of diarrhoea through contamination of water and food, and the general environment. It is also linked to environmental enteropathy and there is a strong argument for community-based water, sanitation and hygiene interventions in the study areas of which hand washing interventions are just one important component (Humphrey 2009;Pattanayak et al. 2009;Prendergast and Kelly 2012;World Health Organisation and UNICEF 2009).

Maternal physical and mental health

Maternal reproductive health and nutrition were significantly associated with child undernutrition, including maternal BMI, self-reported anaemia in pregnancy and inadequate birth spacing; birth order (4^{th} or later) was also a significant risk factor and reflects multiple pregnancies in women. We did not collect data on reproductive health choices but the most recent district-level data suggests there is a significant unmet need in the study areas (Ministry of Health and Family Welfare 2010). Anaemia in pregnancy may be related to a poor diet, inadequate birth spacing, malaria and exposure to indoor air pollution through cooking (which is primarily done by women) (Black et al. 2008;Bruce et al. 2000;Dewey and Cohen 2007;Duflo et al. 2008;Kumar et al. 2007). There is also evidence of anxiety and depression among women (12% of mothers were psychologically distressed), which was a significant determinant of child wasting. Although we cannot rule out that child wasting caused some of the maternal distress, there is growing evidence to suggest the relationship works both ways, particularly in younger children for whom mothers are the main caregivers (Stewart 2007;Surkan et al. 2011).

Strategies to raise the status and health of women and resolve the unmet need for family planning should be incorporated into health and nutrition policies affecting the study areas. Poverty reduction and improvements to social welfare programmes like the Public Distribution System are also important: as poverty and food insecurity decrease so will the additional work taken on by women. ‘Taking on extra work’ was a common coping strategy mentioned during the focus groups and the nutrition survey to manage household shocks and food insecurity. The Integrated Child Development Services have the potential to provide child-care to ease the burden on women and reduce the practice of young children (usually girls) caring for their younger siblings where infection transmission is increased and educational opportunities diminished (Balagopalan and Subrahmanian 2003;Griffiths et al. 2002;Koopman et al. 2001a). This is also likely to reduce women's psychological distress (Chandran et al. 2002).

Cooking location, season of birth and stunting

There was a strongly protective effect of cooking outdoors against stunting. This may reflect reduced exposure to indoor air pollution from burning biomass fuels, which can reduce intrauterine growth restriction and mitigate stunting of young children during early periods of linear growth (Mishra and Retherford 2007;Tielsch et al. 2009). Exposure to indoor air pollution from biomass fuels is hypothesised to cause intrauterine growth restriction and stunting directly due to the noxious elements within the smoke, and indirectly through increased infection and anaemia risk (Prendergast and Kelly 2012;Tielsch et al. 2009;World Health Organisation 2004b). Children born in the winter in this sample also had a greater stunting risk. This could be partly due to greater exposure to indoor air pollution through burning fuels to keep warm at a time that coincides with the latter stages of gestation and early months of life (Bruce et al. 2000). Rates of growth are also slower in winter (Panter-Brick 1997;Wales 1998), infection risk is higher (Berman 1991), food may be scarcer at the point of weaning when the child reaches six months (Muhuri 1996), and hypothermia risk is higher (Bhutta et al. 2005).

One very successful aspect of cycle 1 was advice to wrap babies soon after birth. A substantial proportion of the subsequent reduction in neonatal mortality was attributed to reductions in hypothermia (Tripathy et al. 2010). There is an argument for special consideration for winter-born children, for the reasons given above, including a previously demonstrated role for women's groups. Improved perinatal care is also essential and this should be achieved through the activities of Auxiliary Nurse Midwives, ASHAs and Anganwadi Workers but the current coverage and capacity for this is inadequate (Paul et al. 2011).

Problematic weaning practices and inadequate diets

More than two-thirds of women reported early initiation and exclusive breastfeeding, which equalled or exceeded district-level estimates (Ministry of Health and Family Welfare 2010). Whilst acknowledging that breastfeeding could be improved, and needs continual reinforcement and support, weaning practices seem to pose a greater risk to child health than breastfeeding practices in the study areas. Predominant breastfeeding (i.e. breast milk and a limited range of other liquids but not soft, semi-solid or sold foods) was a risk factor for underweight in children 6-23 months of age. This reflects a combination of late weaning, and for those who have been weaned, inadequate dietary diversity. Just 5.4% of children consumed ≥four food groups the previous day and iron intake was low, both of which were associated with undernutrition and lower estimates than in the NFHS-3 (Patel et al. 2012).

The focus group discussions revealed a cultural preference by some groups to wean children at 7-8 months, where weaning foods were low in nutrients (e.g. rice cakes). Other research has identified late introduction of foods by Indian mothers, although breastfeeding may continue beyond two years (Patel et al. 2012). Stunted children may be at a further disadvantage as their small size may be seen as a sign that they are not 'ready' for new foods (Patel et al. 2012). In terms of iron intake, apart from meat being expensive, cultural beliefs that children cannot digest meats or animal products such as eggs contribute to low iron consumption (Patel et al. 2010;Patel et al. 2012). Low income may also influence weaning: for women facing extreme food insecurity there may be a conscious choice to delay the introduction of foods. The high proportion of women identified as underweight suggests that food availability may be low, and this was confirmed in the focus groups where people reported reducing their intake, or eating an extremely restricted diet: "We only buy salt and chilli with the money we have and eat it with rice".

Diarrhoea

Child fever (for which a large percentage is likely to be malaria in the study areas) and recurrent and recent severe cough were important for child wasting, but diarrhoea emerged as a central driver of all nutritional outcomes; dysentery (i.e. blood in the stool in the last 14 days, reported by mothers) doubled the severity of wasting. A multi-country longitudinal study echoes my finding that repeated bouts of diarrhoea are linked to child stunting: Checkley (2008) found that the number of diarrhoea episodes in the first two years explained 25% of stunting. The duration of each diarrhoeal episode is also important. One study noted that prolonged diarrhoea of 7-13 days was linked to significantly worse stunting than acute episodes (<7 days); prolonged episodes also doubled the risk of developing persistent diarrhoea (≥14 days) in later childhood (Moore et al. 2010).

The high prevalence of blood in children's stools is worrying. This could be due to worms or Shigella bacteria and undernourished children are particularly vulnerable to acquiring these infections where risks of mortality are also higher due to a negatively reinforcing cycle of diarrhoea and weight loss (World Health Organisation and UNICEF 2009). Diarrhoea from measles is the leading cause of diarrhoeal deaths and a substantial number of children were not immunised in the study areas (World Health Organisation and UNICEF 2009). Diarrhoea may also have an indirect effect on growth, by increasing the risk of acute lower respiratory infection in already malnourished populations (Schmidt et al. 2009).

Overall, this makes a strong case for early intervention for child diarrhoea as each day of infection represents a lost opportunity for growth and increases infection and mortality risks. Treatment of diarrhoea with oral rehydration solution has been voted as the most significant health technology of the last Century (UNICEF 2013). For oral rehydration solution to be an effective diarrhoea management strategy it requires timely treatment-seeking and availability of low osmolality packets from Anganwadi Centres, and that caregivers have the knowledge and means to make oral rehydration solution safely at home. Evidence of dysentery may require deworming, or more urgent medical attention, and measles vaccination provision and uptake should continue to be improved.

9.4 How effective were the women's group cycles for the reduction of undernutrition?

My analyses suggest there has been no impact of women's group cycles one and two on child undernutrition. My determinants analyses indicate that until there has been a significant impact on the immediate determinants of child undernutrition, infections and dietary intake, an impact on anthropometric measurements is unlikely (summarised in Figure 9.1). There are still some reasons to be optimistic about the intervention in relation to some of the underlying causes of undernutrition.

Hand washing and water treatment

My analyses of secondary outcomes indicate that women's groups are a potentially important platform for behaviour change around water treatment and hand washing. Women in the intervention areas were more than five times as likely to wash their hands with soap after defecation and more than 11 times as likely after cleaning up a child who had defecated than women in control areas; the intervention group were also more than four times as likely to treat their household drinking water than the control group. Drinking water quality was an important determinant of wasting and I have already underlined the importance of hand washing for nutrition in the study areas. There is a match here between two strong protective influences for child nutrition and a strong influence of women's groups.

Whilst hand washing with soap for key occasions was much higher in the intervention group relative to the control, it was still a relatively uncommon practice in absolute terms. Our hand washing measures do not tell us about the consistency of hand washing, and although the questions were open-ended we cannot completely rule out socially desirable responses. Although we measured water treatment, household water storage is likely to play an important role. Similarly, water availability and the hand washing practices of other caregivers (such as older children) may influence the effectiveness of women's group hand washing and hygiene activities (Cairncross et al. 2010).

Birth spacing

A second positive finding from my analysis of secondary outcomes suggests that the groups positively influenced birth spacing. This is potentially very significant for the health of women and children. Wider birth intervals lessen the physical burden of child bearing and breastfeeding on women and can lower parity; it also lowers the risks of adverse birth outcomes (Wendt et al. 2012). Maternal physical health in subsequent pregnancies is likely to be better if birth intervals are wider, with lower levels of anaemia leading to a reduced risk of intrauterine growth restriction (Wendt et al. 2012). Greater birth spacing could signify greater control by women over family planning choices, and an analysis of cycle 1 suggests that women's agency did improve as a result of the groups (Montalvao et al. 2011). Wider birth spacing could also reflect better access to family planning through community health workers. During cycle 1, one women's group convinced the ASHA to store family planning supplies in the village because she was unwilling to carry everything for each visit, which was affecting access to contraception.

A reduction in overall parity could lead to better health for children, particularly given the nutritional risks associated with being born 4th or later in relation to other siblings in my determinants analyses. Smaller families usually mean higher quality child-care and less strain on household resources. Smaller families also reduce the need for sibling-to-sibling care, lowering infection transmission and freeing children from child care duties (particularly girls) enabling them to continue their education, which is another important determinant of child nutrition (Griffiths et al. 2002;Koopman et al. 2001b;Sengupta and Guha 2002). Planned reforms of the Integrated Child Development Services include child-care provision for eight hours a day at the Anganwadi Centre, although the current capacity to manage this is doubtful (Indian Planning Commission 2011).

Measles

The uptake of measles vaccinations was significantly greater in the intervention areas than the control, and this too could be of public health significance. India has been identified as needing ‘accelerated and sustained’ reduction in measles mortality (UNICEF India 2013). Measles is a highly contagious and life threatening respiratory illness, facilitated by household overcrowding (which is common in the study areas) and is more likely to infect malnourished children (which again is common in the study areas). This finding is encouraging and suggests that women’s groups could be a useful platform to encourage immunisation uptake generally.

Awareness of child underweight

The intervention also appeared to increase awareness of child underweight relative to the control areas. This is significant because awareness of a problem is usually a necessary precursor to behaviour change, and the women’s group cycle may have contributed to community sensitisation of undernutrition as a problem (Kumar et al. 2010b;World Bank 2009). However, despite the apparently increased awareness of child underweight in the intervention areas, absolute levels of awareness of undernutrition were low. This could reflect a shift in social norms whereby thin and small children are ‘normal’ and not a concern (He and Evans 2007). Awareness-raising with communities about the risks of underweight will be important if behaviour change strategies to decrease stunting and wasting are to be effective. Women’s groups could be a powerful forum to communicate the hidden dangers of stunting that also relate to the long-term reduced economic earning potential and poorer health of children in later life.

Broader barriers to women’s group effectiveness

There are broader barriers that may limit the potential for women’s groups to impact on nutrition in the study areas. The focus groups indicated widespread food insecurity, limited employment opportunities and very low incomes. Combined with escalating food prices and the impact of climate change on agriculture, and the availability of water and wild foods, it is doubtful that women’s groups can make meaningful inroads into undernutrition on their own. There are also poor quality services and patchy health coverage to contend with: in half of the focus groups participants reported that Anganwadi Workers did not come to their village or respond to their queries. Other supply-side failures undermine food insecurity and increase poverty, such as the inefficient Public Distribution System. Given this broader context it is no great surprise that undernutrition remains highly prevalent in the study areas, despite sustained women’s group efforts. However, the women’s groups ‘cycle 2’ was not perfect, and there are ways it could be strengthened to contribute to undernutrition reduction, in partnership with the government and civil society organisations.

9.5 How could 'cycle 2' be improved to impact on nutrition?

Format and content of 'cycle 2'

'Cycle 2' was not specifically designed to reduce child undernutrition, but it included a range of maternal and child nutrition issues, and thus it was deemed appropriate to assess for nutritional differences between exposure groups in the post-intervention period. The content of cycle 2 was derived from pooling suggestions for future meetings from all 244 women's groups who had just completed the maternal and child health cycle ('cycle 1'). The pooling of suggestions resulted in a wide range of health and nutrition topics to be incorporated into cycle 2, and led to fundamental changes to the way the women's groups were carried out.

Cycle 2 did not include the four phases of 'participatory learning and action': 1) prioritise problems (through discussion and voting) 2) plan strategies 3) carry out strategies 4) evaluate strategies. The first phase was omitted. Instead twelve out of 20 meetings were designated for discussion of pre-decided topics based on the pooled suggestions of all groups. Within each meeting women came up with strategies and assigned responsibilities to be carried out with immediate effect, which were evaluated at the next meeting. This contrasted with cycle 1, where each group prioritised a smaller number of problems, strategy planning occurred over several months, the wider community were consulted before strategy implementation, and strategies were evaluated in the final meetings of the cycle.

The omission of the first phase of the participatory learning and action cycle meant that although individual groups were asked to suggest which topics they would like to explore, the resulting cycle of groups represented the choices of *all* groups. This could have reduced feelings of ownership and relevance, and could have undermined intervention effectiveness. The voting process was also lost, which is an important symbol that each group member's opinion is valid and can influence proceedings. In a more practical sense, the original four phases of the women's group cycle gave participants more time to devise strategies, allowed them to get wider community support before implementing actions, and was an empowering democratic process that increased women's agency (Montalvao et al. 2011). Whilst most of the core features of the four-phase cycle were retained (including group influence over chosen topics, and group-led strategy formation, implementation, and self-evaluation) I cannot rule out that differences between the formats of cycles 1 and 2 influenced the effectiveness of the intervention.

Is undernutrition reduction a realistic aim for women's groups?

There is no guarantee that returning to the original four-phase structure would be effective for nutrition, or that reducing undernutrition is even a realistic aim for women's groups and justifies the resources required. There is evidence that community mobilisation with women's groups can work well for neonatal mortality reduction (Manandhar et al. 2004;Tripathy et al. 2010), but undernutrition is a very different problem. It involves a wider age range, constantly changing nutritional requirements and associated behaviours, greater exposure to disease, and may linger for generations. This is clearly demonstrated by Figure 9.1, which shows the breadth of determinants of undernutrition in the study areas mapped onto the UNICEF framework.

Nutrition is such a broad issue it becomes almost impossible to address the multiple issues and pathways within a single cycle of groups. The risk is then making artificial separations by running a series of women's group cycles when in reality everything is interlinked. The story-telling of cause and effect within meetings is important to demonstrate the complexity of pathways to undernutrition, but a small number of subsequent discrete women's group strategies are unlikely to show a demonstrable effect on nutrition, even if they are addressing important issues, and women's groups or donors may not positively evaluate them.

This thesis has shown that an intervention that was moderately participatory in the realms of planning and management, outside inputs, monitoring and evaluation and leadership, and that was empowering of women can have multiple beneficial effects on important nutrition determinants, although there was no apparent impact on child anthropometry itself. Perhaps an impact on anthropometry was not realistic given the breadth of risk factors and structural drivers of undernutrition identified.

Brett (2003) highlights that, of the different types of community participatory interventions that exist, not all will be suitable for addressing all types of problem. There are alternative routes to empowerment and benefits to state-led programmes, as well as costs associated with participation (ibid). Participation may be better considered as one component of development approaches to be combined with 'hierarchy, expertise and discipline in service delivery systems' (ibid).

In light of lessons learned from this thesis and what worked well in cycle 1, a rethink is required. We should adjust our expectations about what women's groups can achieve in terms of undernutrition reduction. Instead of expecting significant reductions in undernutrition it might be more pragmatic to focus on immediate undernutrition determinants, such as diarrhoea, as the primary outcome. This would allow a greater focus and a narrower range of problem cards and behaviours to address.

Alternatively the groups could be trialled to address distinct types of undernutrition, such as stunting or wasting. These have different determinants and would narrow the focus of the groups somewhat, although the issues would remain broad. Here, changes to behaviours or certain determinants might be more realistic than reductions in stunting or wasting. This might also require greater sensitisation of communities that these are problems with serious implications. Anecdotes from Ekjut suggest that undernutrition (and particularly stunting) is not seen as an issue whereas diarrhoea is more visible and is a clear source of discomfort for children.

These alternative approaches may require a longer time frame for evaluation, and could occur in a series of women's group cycles to allow for meaningful behaviour change, for longer-term strategies to have an effect, and to allow potential synergies between strategies and behaviours to develop. In the same way that interventions become more efficient over time, this could be true for women's group strategies, and the empowerment of participants (Taylor and Taylor 2002). In practice, it would be difficult to implement and manage multiple cycles of groups in the community. This approach may also be unappealing to donors or governments, and in some respects the Millennium Development Goal agenda may have derailed efforts for longer-term but more lasting change in favour of activities that will produce 'results' by 2015.

Ideas for new cycles of women's groups

1. Diarrhoea reduction via WASH improvement

One potential women's group cycle could aim to reduce diarrhoea through improved water, sanitation and hygiene. Diarrhoea was a key determinant of undernutrition. The use of oral rehydration solution is a simple but effective intervention that could be taken forward by women's groups. Oral rehydration solution is not a new intervention, but its coverage has been disappointing in India, with only a 4% increase between 2004 and 2008 to 34%

(Ministry of Health and Family Welfare 2010;Paul et al. 2011). Guidance about how to make oral rehydration solution and information that it should be provided at the Anganwadi Centre was already present in Cycle 2, but there was no evidence that use increased. Some successful methods in cycle 1 included behavioural drills and perhaps this could be applied to increase the use of oral rehydration solution. Reiterating the importance of measles vaccination, which was another apparently successful aspect of cycle 2 could also contribute to diarrhoea reduction.

Treatment of drinking water was much more common in the intervention areas than the control, and drinking water source was an important determinant of wasting. The groups could continue their work on water safety and extend it to include drinking water storage. The intervention also seemed to improve hand washing behaviour, and use of a cleansing agent to wash hands was shown to be highly protective against undernutrition. The groups could develop their focus on hand washing activities in a number of ways. Soap costs five rupees locally, and considering that people struggle to afford subsidised grain at six rupees a kilo, it seems doubtful that soap will be a priority purchase (Suchitra Rath, personal communication, November 2011). There is the potential to use ash as a cleansing agent, providing it can be kept sterile, and women's groups could become involved in promoting safe ash storage. This does not preclude the possibility of soap promotion, although if there are restrictions on water availability this could limit the effectiveness on diarrhoeal reduction (Cairncross et al. 2010). Very few studies have measured consistency of hand washing practices and it would be important to measure this element if such a cycle of groups was trialled. The lack of availability of clean water is a direct risk for undernutrition, and also an indirect risk because it inhibits hand washing and the use of latrines. In 2010 the UN General Assembly passed a resolution that "enshrined the right to safe and clean drinking water and sanitation as a human right" (United Nations 2011). But it may be some time, and require more input and campaigning by civil society before this right becomes legally enforceable in India (Dharmadhikary 2010).

Respondents almost universally reported open defecation and unsafe child faeces disposal. This is a major public health risk linked to diarrhoea and other infections. The economic implications are vast, estimated to be 6.4% of India's GDP (World Bank 2013). The government of India has tried to address this problem with limited success. They introduced the Total Sanitation Campaign which uses information, education and communication methods to increase community demand for toilets and provided subsidies for building latrines (Pattanayak et al. 2009).

A variation on this approach, 'community-led total sanitation' has proven more effective in terms of latrine coverage and use. This uses social mobilisation techniques to get community-wide commitment to making villages 'open defecation free'. Methods include defecation mapping and measuring core faecal counts to raise community awareness of the presence of faeces in their environment. But the approach goes beyond generating disgust and shame, and the health implications of open defecation, because it also emphasises the benefits of privacy for women and dignity of community members (Pattanayak et al. 2009). Women's groups already have a role in mobilising themselves and the wider community and if they linked up with Community-Led Total Sanitation Campaign facilitators there could be a powerful synergistic effect.

The women's groups could also expand their networks to include 'village health and sanitation committees'. These committees were initiated under the National Rural Health Mission and are led by the ASHA. They are community-owned organisations that monitor the health system and raise awareness about available services. Activities are supposed to include the development of village health plans, assistance with village surveys, and choice over the spending of a small, untied grant for improved village health and sanitation (NRHM 2008). Half of committee members are supposed to be women, and representation by self-help groups is encouraged (Ministry of Health and Family Welfare 2007).

Although this sounds promising, assessments of village health and sanitation committees have found they do not function well: ASHAs lack training and confidence in overseeing the committees, untied funds are not spent, monthly meetings are not held and there is generally low community awareness about them (Husain 2011;Nandan 2008). This represents a challenge and an opportunity for women's groups to expand their water, sanitation and hygiene activities and influence. They could aim to get formal representation on village health and sanitation committees: they are key stakeholders and are already mobilised; they can also impose regularity and structure because they already hold monthly meetings. Many of the groups are already involved in micro-credit activities and are responsible for money. Here they could apply their expertise and influence the spending of the untied fund. This will undoubtedly require village health and sanitation committee guideline reform, amongst many reforms that are currently being considered by the government.

2. An intergenerational approach to stunting reduction

There were extremely high levels of stunting in the study areas, and there is strong evidence to suggest that more than half of stunting may already be present at birth (Mamidi et al. 2011). This is attributed to low birth weight from intrauterine growth restriction and prematurity. Stunting may endure for several generations even with effective intervention (Black et al. 2008;De Onis 2008;Martorell and Zongrone 2012). This suggests that the women's groups could conduct a series of meeting cycles adopting an intergenerational approach. For example, each cycle could be designed to focus on a different chronological period on the pathway to stunting. The first cycle could focus on adolescent girls, the importance of secondary education, dietary considerations, and the issues around early pregnancy with opportunity to include family planning. In cycle 1 there were campaigns against early marriage, which matches a recent Lancet recommendation to delay first pregnancy until age 20 to reduce child undernutrition (Paul et al. 2011).

A second cycle could focus on women's health during pregnancy. This could include anaemia reduction, malaria prevention, improved dietary intake and diversity through kitchen gardens and wild foods, iron tablets and the benefits of birth spacing. This cycle could also include a focus on how to reduce exposure of women and unborn children to indoor air pollution. Cycle 2 indicated a positive impact on increasing food intake in pregnancy and birth spacing, which lends support to some of these ideas. A third cycle could focus on reducing stunting that occurs after a child is born. This might include improving the timing and increasing the quality and quantity of complementary foods to be more diverse and iron-rich, improving hand washing practices and reducing exposure to indoor air pollution, and special consideration for winter-born babies.

3. Child wasting reduction: linking with the CMAM approach

I have already discussed the high levels of wasting in the study areas. A cycle of groups focused on this problem could include improvements to water, sanitation and hygiene behaviours, timely health-care seeking for infections, the use of oral rehydration solution, continuing support for breastfeeding and improvements to the quality, quantity and timing of complementary foods as suggested previously. They could also focus on tracking the growth of their children, and mobilising Anganwadi Workers to ensure effective and timely growth monitoring. There were a very high proportion of children suffering with severe acute malnutrition in this sample, and this deserves special consideration because women's groups without support or links to external bodies will not be able to resolve this independently. Furthermore, an analysis of 58 DHS surveys from 42 developing countries identified that clustering of undernutrition in villages is very low, but is high within households. This supports the use of a more individualised case-finding approach, perhaps through home-visits, particularly if some women with undernourished children are not attending the groups (Fenn et al. 2004).

An effective and scalable community-based approach to managing moderate and severe acute malnutrition is the 'community management of acute malnutrition' (CMAM) (Collins et al. 2002). CMAM advocates for the treatment of severely acutely malnourished children who do not have additional complications in community settings. CMAM uses community mobilisation techniques and health services for case finding and the use of energy-dense nutrient-rich food (sometimes packaged as 'ready to use therapeutic food') for treatment. The Government of India has been slow to adopt this approach. There have been concerns over illegal imports of Plumpy Nut, and the capacity and safety of producing local variations of ready to use therapeutic food, as well as worries over the safety of treating severe acute malnutrition in community settings (Arie 2010;Emergency Nutrition Network 2012;The Times 2009). However, the climate for CMAM is changing in India (Emergency Nutrition Network 2012;Paul et al. 2011). Orissa is about to start a CMAM pilot, and Madhya Pradesh has also been involved in CMAM work. I believe there will be scope for women's groups to become involved, perhaps even in the preparation of locally sourced therapeutic food and case finding of children with severe acute malnutrition.

There will of course be cases of severe malnutrition that require inpatient treatment. One issue raised during the nutrition survey was the very low proportion of children going to malnutrition treatment centres, despite being referred. There are many barriers to this: treatment centres may be far away, costly to reach, involve long inpatient stays that take the caregiver away from her work and her other children. Women's groups could mobilise to provide child-care for those wanting to take a child referred for inpatient care, and create a community fund, similar to that created for emergency ambulatory care for pregnant women during cycle 1.

The zone of mutually acceptable compromise

Implementing organisations such as Ekjut have the opportunity to deliver technical knowledge that could be of use to groups (such as how to make oral rehydration solution). The difficulty is in deciding when this is imposing on communities and when this information would be welcomed, understood and usefully applied. Kumar and colleagues (2010b) have termed this the 'zone of mutually acceptable compromise'. These technical inputs could take form of standalone advice, demonstrations, direct provisions or subsidies.

Allowance of external inputs in this way is one reason why I positioned the intervention as reflecting ‘values for collaboration’ rather than ‘values for empowerment’ along the ‘finance and programme design’ dimension of participation (in chapter 3).

In consideration of my determinant analysis I would suggest continuing to facilitate the uptake of measles and other vaccinations. There is also an argument that NGOs could advocate for the introduction of the Rotavirus vaccine as part of integrated package of care. This is one technical intervention that could have huge impact on nutrition, well-being and mortality in India (Esposito et al. 2011). It is currently recommended by the Indian Academy of Paediatrics at six and ten weeks of age but is not yet included in the national immunisation schedule (Government of India 2010;Vashishtha 2012). I think there could be further emphasis and demonstration about how to make and use oral rehydration solution to reduce the length and severity of diarrhoeal episodes, continuing teaching of caregivers about how to recognise the signs of acute respiratory infection, and assistance plotting children’s and mother’s weight on growth and BMI charts.

In addition, I would recommend ways to reduce exposure to biomass fuels. This could include subsidising chimneys to divert smoke (Duflo et al. 2008), and if it was acceptable advise people to cook outdoors. There could also be awareness-raising that pregnant women and young children should be kept away from direct smoke, and linkage with indoor spraying programmes and the provision of bednets which would decrease the need for smoke to repel mosquitoes.

A fourth option: combining community-based behaviour change approaches

In chapter 3 I suggested that didactic educational approaches were limited in their effectiveness to reduce undernutrition because they failed to engage sufficiently with caregivers, or create a sense of ownership over interventions. This led to the rationale that a more participatory approach might address these shortcomings and be more effective. Unfortunately, the data from this particular intervention did not support this idea, despite demonstrating an influence on important secondary outcomes. However, it is important to remember that different interventions broadly characterised as participatory will vary in their level of participation for different dimensions. In chapter 3 I positioned this intervention within a typology of participation and judged that the groups reflected ‘values for empowerment’ for their involvement of women, but for the remaining dimension were moderately participatory, reflecting ‘values for collaboration’. Interventions that demonstrate different levels of participation for important participatory dimensions may produce different results.

Aside from the fact that the intervention (cycle 2) had evolved into something more prescriptive than the original, there is doubt that the intensity of the groups was adequate to instigate behaviour change for dietary improvement and infection control: the nutrition survey showed that women attended an average of just 4-6 meetings, and this included both cycles 1 and 2 (chapter 4). As undernutrition is so complex, and since it is still not clear which behaviour change approaches are likely to be the most effective, it seems sensible to consider piloting different combinations of behaviour change interventions in partnership with communities. There is tentative support for this from my literature review which identified consistent positive results for studies that used combined approaches. A framework for behaviour change management developed by Kumar and colleagues also suggests that targeting behaviours with a variety of behaviour change approaches and through multiple channels is likely to be the most effective (Kumar et al. 2010b).

My determinants chapter highlighted many of the drivers of undernutrition in the study areas. This evidence could be used in a behaviour change mapping exercise to identify the different types of behaviour change intervention that these determinants are likely to respond to. These do not need to be exclusively group-focused, but could include household and individual level interventions, as well as systems-strengthening. For example, addressing issues of drinking water quality could respond well to a mixture of community-based strategies (such as treating community water-sources with chlorine) and household-level strategies (such as boiling drinking water and ensuring safe storage). The strengths of community mobilisation with women's groups could be capitalised on for community-wide problems such as sanitation (as previously mentioned) and to raise-awareness of entitlements to increase service demand and improve programme monitoring; the process of prioritising, strategizing and implementing actions is well-suited to these issues.

Home-visits could be a more appropriate method for case-finding of malnourished children than monthly group meetings, although the women's groups could serve as reinforcement of positive behaviours. My literature review identified two randomised controlled trials that show promise for this, and could be usefully combined with community mobilisation or other approaches. Both studies used positive deviance in combination with health education: mentor mothers (local women, with well-nourished children despite adverse circumstances) made home-visits to households with at least one underweight or low birth weight child. Mentors shared their positive coping strategies and gave health information, were taught to recognise maternal depression and encourage caregiver-child interaction, and emphasised consistency of daily routines (le Roux et al. 2010;le Roux et al. 2011). In one study children had significantly higher weight-for-age Z-scores and greater weight gain than controls at 12 months (le Roux et al. 2011); in the other children were five times more likely to have rehabilitated to a ‘normal’ weight-for-age (i.e. WAZ >-2.00) than controls (le Roux et al. 2010).

Of course many of the suggestions I have made require system strengthening, including the increased capacity of frontline health workers. None of the recommendations I have made can be substitutes for government action. Again, referring back to Figure 9.1 although the women’s groups appear to have made notable improvements in the realms of hand washing and hygiene, aspects of reproductive health and the care of women, many determinants remain, and many of these require government action. The evidence generated from the focus groups also indicates that new cycles of women’s groups are unlikely to have any meaningful impact, and neither will combined behaviour change approaches unless the government acts to guarantee the food and livelihood security of its citizens and reform health programmes, especially given global food price increases and climate change.

9.6 The role of the government: system reforms

A number of commentators have called for urgent reform of India’s health and nutrition programmes, particular the Integrated Child Development Services and the Targeted Public Distribution Scheme (Gragnolati et al. 2006b;Haddad et al. 2012;Paul et al. 2011;Saxena 2012). One general criticism of these programmes is the lack of decentralised planning. With more flexibility to design, fund and implement programmes at district and block levels, interventions are likely to work better and may be monitored more effectively (Paul et al. 2011). This also applies to the monitoring of nutritional status outside of these programmes. The NFHS surveys, whilst incredibly useful, are also very time and resource-intensive. There is a clear need for smaller more frequent surveys that allow rapid district and block-level responses (Haddad and Zeitlyn 2009).

In general there is very little monitoring and evaluation of government programmes, and most is of poor quality (Paul et al. 2011;Saxena 2012). In this respect, effectiveness, coverage, quality of implementation, training needs, and service equity are unclear. There is also a culture of misreporting in the ICDS: Saxena (2012) quoted a District Collector (a district-level administrative and revenue officer) saying that accurate data reporting was a 'high risk low reward' activity. It is rare for community feedback to be incorporated into monitoring and evaluation, although women's groups and Panchayat leaders represent important stakeholders who could be included. Community monitoring will be crucial to assess equity and quality of services and to increase accountability at all levels of the administration (Paul et al. 2011). This would also help eradicate institutionalised discrimination within programme implementation guidelines as previously discussed (Mamgain and Diwakar 2012).

Funding of health and nutrition programmes is also inadequate: the State invests less than 1% of Gross Domestic Product in public health services (Paul et al. 2011). Available human resources are well below the recommended ratios per head of population for doctors, nurses and other health workers (World Health Organisation 2006). Vacancies are widespread, with unequal distribution of health workers biased against rural tribal hilly areas (Indian Planning Commission 2011;Ministry of Health and Family Welfare 2010). Funding allocation is also problematic and tends to result in 'politically visible schemes' that may increase popularity in forthcoming elections (such as conditional cash transfers) rather than investing in antenatal care and programmes to reduce diarrhoea and pneumonia (Paul et al. 2011). This leads to vertical rather than holistic health and nutrition interventions (Paul et al. 2011).

Supplementary Nutrition through the ICDS

The Integrated Child Development Services are mandated to provide regular 'supplementary nutrition' and midday meals to children under six, and supplementary nutrition to adolescent girls, and pregnant and lactating women via the Anganwadi Centre. For many underserved households, this service should provide cushioning against food insecurity. However, poor infrastructure at many Anganwadi Centres (e.g. lack of running water) makes it difficult to prepare food hygienically. Coverage of supplementary nutrition provision is also poor: in 2012, The Planning Commission found that only 31% of children, 38% of pregnant and lactating women and 10% of adolescent girls received supplementary nutrition (Ministry of Women and Child Development 2012). There are widespread inefficiencies in the system: 40% of allocated food does not make it to the end user (Ministry of Women and Child Development 2012). The quality of food at Anganwadi Centres has also been called into question. As a norm, supplementary nutrition should contain a minimum of 500 calories and be home cooked. However, through covert influence of food manufacturers, 'ready to eat' supplementary nutrition of 100 calories and low nutritional value has become increasingly common. The Supreme Court has now taken action to legally enforce standards to ensure the quality and means of production of supplementary nutrition (Saxena 2012).

The Integrated Child Development Services are too food focused

Critics argue that as India's flagship nutrition programme the Integrated Child Development Services are too food focused. They advocate for greater attention to increasing the coverage of home visits to newborn children and mothers to support breastfeeding. There also needs to be greater efforts to prevent and treat infection, improve water, sanitation and hygiene, and strengthen referral systems (Saxena 2012). Furthermore, there is a disproportionate focus on children aged 3-6 years, whilst children under-two receive fewer programme inputs (Haddad and Zeitlyn 2009).

Paul and colleagues (2011) have advocated for a National Child Nutrition Mission with children under-two and pregnant women at the centre of activities. They and others argue for the introduction of a second Anganwadi worker specially recruited for this purpose, which would allow the other Anganwadi Worker to continue her work with older children. The second Anganwadi would conduct home visits in the neonatal period and provide breastfeeding support, and additional advice about feeding low birth weight infants (Ministry of Women and Child Development et al. 2006;Paul et al. 2011;Working group on children under six 2007).

Inter-ministerial plans for reform of the Integrated Child Development Services

The Planning Commission of India has done its own reporting and responded well to criticisms of the Integrated Child Development Services, with comprehensive proposed reforms (Indian Planning Commission 2011). Their plans are aiming for 'effective, accountable and efficient human resources for health, enabling Universal Health Coverage' (Indian Planning Commission 2011). Methods include converting the Integrated Child Development Services from a static health programme to a decentralised 'mission-based' scheme. Decentralisation will enable more effective working with other programmes (such as the National Rural Health Mission) for a more holistic, context-specific and coordinated approach to improving nutrition and health (Indian Planning Commission 2011).

Reforms also include increased investment in infrastructure and funds to address the shortage and training of health workers. A second Anganwadi will be dedicated to children under-three and a second Auxiliary Nurse Midwife will be placed at each sub-centre. Childcare will also be available at the Anganwadi Centre with efforts to make it a 'community-owned' establishment that is welcoming for children. There is even suggestion of 'community-based care for undernourished children' although it is not clear whether this would be the same as CMAM. For these plans to be effective there will need to be rapid improvements to infrastructure and considerable strengthening of accountability, monitoring and evaluation systems. Here there is opportunity for women's groups to play an active role in monitoring as well as the delivery of the Integrated Child Development Services, but again, this will require considerable capacity building.

The National Food Security Bill

The new National Food Security Bill is mired in controversy. It has a bold purpose: 'to provide for food and nutritional security in a human life cycle approach, by ensuring access to adequate quantity of quality food at affordable prices for people to live with dignity' (Government of India 2011b). However, there are some concerns with the operationalization of the bill because its implementation depends on the efficient and equitable functioning of other health and nutrition programmes (Haddad et al. 2012;Mamgain and Diwakar 2012). The bill also fails to recognise the growing problem of climate change, particularly affecting small farmers, and may not do enough to protect *adivasi* communities (Padel 2012).

The Targeted Public Distribution System

The Targeted Public Distribution System is one of the main programmes the National Food Security Bill will work through, and new legislation will offer subsidised food grains to 70% of households in India (Haddad et al. 2012). In theory, the price of wheat and rice will decrease from 6 to 2 rupees per kilo. But this 'leaky vessel' of a programme has many shortcomings (Saxena 2012). Eligibility for the most heavily subsidised grain requires households to possess a Below Poverty Line card, for which there are issues of misappropriation by wealthier members of society, and the poorest people may not be covered because of difficulties with eligibility assessment.

A pilot of a non-targeted universalised version of the Public Distribution System in Chhattisgarh led to greater coverage. It also switched from private grain dealers to Panchayati Raj Institutions to distribute the gain, and included a robust 'grievance redress' system if people could not access their entitlements which increased accountability (Khera and Dreze 2011;Swain and Kumaran 2012). One of the major criticisms of the food security bill is that it continues with the targeted approach and has not made meaningful changes to eligibility assessment procedures, despite evidence that this may not be equitable or effective. Thus the scheme will continue to exclude some of the most food insecure households (Swain and Kumaran 2012).

A Planning Commission report has also noted that 58% of subsidised grain does not reach households with below poverty line cards (2005b). This is reinforced through a lack of transparency, monitoring and accountability within the Public Distribution System and social discrimination where the 'local elite' oversee food ration shops, often to the detriment of other groups (Saxena 2012;Swain and Kumaran 2012). Neither have there been attempts to extend provisions to include vegetables or lentils, even though these have all soared in price and are unaffordable to many (Swain and Kumaran 2012).

Agricultural investment

Another aspect of the National Food Security Bill that could be strengthened is agricultural investment in small farmers, particularly in Central and Eastern areas. This population represents 90% of farmers and 60% of farmed land in India (Ramanjaneyulu 2012). Bhagowalia et al (2012) found that agricultural conditions such as improved irrigation and ownership of livestock substantially improved household dietary diversity. But financial investment has been inadequate and will continue to be so under the current bill. There is general concern that the bill does not sufficiently consider the effects of climate change for small farmers. The nature of the investment includes a promise to 'extend the green revolution' to states such as Jharkhand and Orissa. This indiscriminate approach could be extremely damaging; there are more ecological and sustainable alternatives suited to those areas that are also nutritionally superior (Acharya and Das 2012).

Global and domestic influence over food prices

The National Food Security Bill could make greater attempts to control increasing food prices, minimise food price fluctuations, and guard against futures trading in food commodities. India is in a strong position to exert a global influence over food price fluctuations by becoming food self-sufficient, as well as stabilising domestic food prices to protect the poorest (Swaminathan and Vepa 2012). The bill could also address the widening gap between wholesale and retail food prices that mean producers do not get extra benefit and consumers pay inflated prices. In this respect, the government could move towards fair priced shops and cooperatives (Chandrasekhar 2012). Per capita calorie consumption is said to have decreased and hunger increased in India over the last decade for which a large proportion is attributed to increasing food prices (Chandrasekhar 2012). Futures trading is thought to have had the largest influence on food prices and was at the root of the Global Food Crisis of 2008 (Pace et al. 2008) where ''entire countries, ecosystems, and communities are vulnerable to instant collapse in this game of speculation' (Shiva 1998). At present, the government has suspended speculation over wheat, rice and two types of lentil but there is pressure to revoke this (Chandrasekhar 2012).

9.7 Wider potential for women's groups: the power of civil society organisations

Community mobilisation with women's groups can significantly reduce neonatal mortality with relatively few outside inputs. Evidence from this thesis suggests that, on its own and using the format adopted in 'cycle 2', this approach is unlikely to reduce undernutrition. I have recommended greater integration of women's groups with formal structures, such as Village Health and Sanitation Committees, to increase their influence over the distribution of community-level resources. I have also suggested expansion of their networks to include other organisations, such as the Community-led Total Sanitation Foundation to facilitate improvements in community sanitation. Missing from this are actions to address the structural drivers of undernutrition in tribal, Eastern Indian communities. Here I think that women's groups may have a broader role – in partnership with other civil society organisations – to hold the government to account for programme failures and activities that discriminate against women and exploit vulnerable communities. This type of citizen participation, the assertion of social rights to place demands on the government, has played a key role in the development of social policies around the world (Cornwall & Gaventa 2000).

Narratives from the focus groups describe the increasing and damaging effects of climate change on habitat, agriculture and livelihoods. It is likely that small subsistence farmers will continue to be plagued by unpredictable weather, increasing food prices and growing food insecurity (Brinkman et al. 2010;United Nations World Food Programme 2009). Corporate interests have the potential to worsen the situation, particularly where the purchasing of *adivasi* land rich in minerals and timber is concerned. Padel (2012) identifies that land appropriation for a greater 'public purpose' is a growing problem, and 'Free Prior Informed Consent' to purchase land is frequently faked. There is long history of displacement of indigenous people in India. Former experts of their environments and knowledgeable farmers are made homeless, landless, unskilled labourers and are immediately food insecure and dependent on external assistance (Padel 2012;Shiva 1998). For animist societies in India, whose deities, life and work are inextricably linked to the forest, displacement (and subsequent deforestation to build dams and mines) amounts to cultural genocide (Padel 2012). Deforestation not only contributes to climate change, but fails to recognise the value of women's work in the forest that maintains food production and water supplies in ecologically sustainable ways (Shah 2012;Shiva 1998).

There is a strong tradition of non-violent protest in India, including by *adivasi* women against deforestation (Shiva 1998). The women-led 'Chipko' movement spread between *adivasi* communities across India. Chipko was ecologically motivated: women recognised that tree felling led to flooding, loss of biomass, landslides, water shortage and desertification (Shiva 1998). The movement involved incredible endurance, continuing physical presence to guard the forest over many years, and loss of life. Women also marched to prevent the replacement of indigenous trees with those deemed more 'productive' economically, but were harmful ecologically. Chipko is an inspiring example of community resistance against corporate interests facilitated by those in power.

There are numerous examples of successful civil society actions applied to other problems in India. For many years the NGO 'Mazadoor Kisan Shakti Sangathan' has used social mobilisation in Rajasthan to confront corruption and increase accountability of government workers in marginalised communities. Official documents have been scrutinised at public hearings for collective, local detection of 'misdeeds' that would be missed in higher-level audits, and people have lobbied for the right-to-information (Mishra 2003). Saxena (2012) considers civil society organisations have a crucial role in exposing fraud and poor quality implementation of the Public Distribution System and other government programmes.

More recently, after ten years of campaigning and petitioning the Supreme Court, the People's Union for Civil Liberties (another civil society network) has made 'the right to food' legally enforceable and the state officially responsible for the food security of its citizens (Mander 2012;Right to Food Campaign 2008). This has been called the 'most significant litigation for socioeconomic rights' because it has transformed health and nutrition programmes into legal entitlements (Mander 2012). It has led to increased funding of government health and nutrition programmes. For example, the Supreme Court ruled that meals at Anganwadi Centres should be hot, hygienically prepared, home-cooked, and with a minimum calorie content, resulting in a 372% increase in funding for the Integrated Child Development Services. This has also moved service delivery away from poor quality and centrally procured 'ready to eat' food with its potential for corruption towards decentralised programme implementation involving community members.

The legal premise for 'the right to food' is based on two articles of the Indian constitution: article 21 ratifies the 'right to life' and article 47 reads that 'the state shall regard the raising of the level of nutrition and standard of living of its people and the improvement of public health as among its primary duties'. These two articles equally apply to the right to water. Access to clean water was formally recognised as a human right by the United Nations in 2010 but campaigning continues for this to be operationalised in a way that is meaningful for communities in India (Dharmadhikary 2010), and this could include a future role for women's groups.

Women's groups and other civil society organisations will need to continue to be vigilant against violations of the right to food, programme implementation failures and the hostile actions of corporations. Whilst there is 'little reason for presuming the terrible problem of hunger and starvation in the world cannot be changed by human action' (Dreze and Sen 1989), an issue of this scale cannot be solved by women's groups and civil society groups without effective partnership with the government.

9.8 Effective undernutrition reduction: learning from others

Government commitment to reducing undernutrition

Haddad (2011) argues that India needs a clear nutrition strategy, which includes stronger nutrition governance. He defines governance as the 'capacity, accountability and responsiveness of a society in dealing with challenges'. For India's undernutrition problem, this requires 'effective and coordinated investment in health, sanitation, agriculture, women's status, food and nutrition programmes' where Haddad cautions that 'any weak links in the chain can undermine the others' (Haddad 2011). The Scaling up Nutrition Framework specifies that these indirect nutrition actions should: address the basic causes of undernutrition (including poor governance), integrate nutrition into programmes of other sectors, and increase 'policy coherence' to ensure policies of other sectors do not inadvertently increase undernutrition (Scaling Up Nutrition 2010). We hear less about the importance of this multi-sectoral approach than the 13 direct nutrition interventions identified in the Scaling up Nutrition framework, perhaps because they may be more easily packaged and communicated. Indirect priorities may be harder to address within a single political term, be less visible to the voting public and may not be well received by sectors not used to considering nutrition in their policies (such as trade and fuel) (Haddad 2012;Paul et al. 2011).

It is interesting to compare the governments of India and Brazil in terms of their commitment to reducing undernutrition, particularly as there have been substantial improvements to child nutrition in Brazil. Firstly, Brazil has a clear nutrition strategy, whilst India does not. Secondly, whilst the Prime Minister of India has lamented frequently about the 'National Shame' of India's nutrition situation, even establishing a high powered Nutrition Council in 2010, the Council has convened only once, and no formal orders have been given (Saxena 2012). This is in contrast to President De Silva in Brazil who created a new ministry directly linked to his office, charged with coordinating the nutrition activities of all sectors. This involved regular inputs and updates to policies and programmes as part of a priority 'zero hunger strategy' (Haddad 2011).

It is important to judge governments by their actions rather than just focusing on outcomes, which may or may not be related to government programmes (te Lintelo 2012). Te Lintelo and colleagues (2012) have devised the Hunger Reduction Commitment Index, which considers policy and programme aspects (such as whether they have a national nutrition strategy, and the extent of civil registration of births), the extent of public expenditure (such as the percentage of total expenditure on health) and legal frameworks (such as women's access to agricultural land and a constitutional right to food). They judge India to have a medium level of commitment to reducing hunger, and whilst this includes some positive elements, such as the legally enforceable right to food, there is still a long way to go (te Lintelo 2012). Increased government commitment is a prerequisite for reducing undernutrition, but it is important that the problem is also tackled in the right way. It will involve the interaction of communities, 'experts' (NGOs and scientists) and service providers. Countries such as Thailand and Brazil lead the way in how governments can work more effectively with communities to reduce undernutrition.

Effective community-based approaches: Country case studies

Brazil has seen significant reductions in stunting over the last three decades, but particularly in the last ten years (Monteiro et al. 2010). This coincided with noticeable narrowing of the gap between rich and poor in terms of purchasing power, education, healthcare, water, sanitation, and reproductive health. This is largely attributed to policies aimed at increasing equity and tackling socioeconomic inequalities, as well as increasing standards of living for which stunting is a sensitive indicator (Monteiro et al. 2010). Considerable effort was made to improve community outreach in poorer areas using 'Family Health Teams' and service demand was dramatically increased through the use of cash transfers. Four key factors were changed that explain two-thirds of the stunting reduction: maternal schooling, household purchasing power (and reduced food insecurity), maternal and child health services (including greater access to family planning), and improved coverage of water supply and sanitation services (Monteiro et al. 2010). Much of the narrowing of the rich-poor gap is thought to be a result of policies that redistributed wealth and increased purchasing power of poorer households, particularly cash transfer programmes. This does not mean that cash transfers would be appropriate everywhere and for everything. It is important that they do not interfere with understanding or the ability to demand quality services, or cause unintended harm (Lagarde et al. 2009). There must also be country-capacity to deliver high quality services in response to increased demand on services (Paes-Sousa et al. 2011).

Thailand is another example of a country that has successfully reduced undernutrition. Their poverty alleviation plan appreciated that undernutrition is a problem with multiple causes requiring multi-sectoral solutions, and where undernutrition is usually a symptom of underlying poverty (Tontisirin and Winichagoon 1999). The government worked effectively at the community level using social mobilisation methods to increase community participation. One community health volunteer was trained as a 'change agent' to use problem-solving and community mobilisation techniques to engage 10-20 households. The community health volunteer facilitated an increase in demand and use of primary health care services, and health and nutrition-promoting behaviours that fitted the local context (Tontisirin and Winichagoon 1999;Wasantwisut et al. 2000).

What these two examples have in common is strong government commitment to reducing undernutrition in combination with improved quality and coverage of health services. There was also greater engagement with communities that allowed them to participate in service design and implementation. A recent review of community-based approaches for nutrition highlights that tackling socioeconomic inequalities through effective working with communities is an essential success factor. This requires community involvement in programme planning to empower people from the grassroots and ensure the most disenfranchised groups are included (Tontisirin and Bhattacharjee 2008). This would entail having 'micro-level planners' in the community (which could include women's groups) as well as block and district level staff working in a coordinated way towards 'clear, measureable goals and objectives' specified in 'working plans' (Tontisirin and Bhattacharjee

2008). In this regard, programmes are planned and implemented by and within communities, but are supported at higher levels of the government system. Taylor and Taylor (2002) emphasise that for community-based approaches to be effective genuine three way partnerships are needed: between communities, experts from outside and government officials.

Community participation, partnerships and power

Taylor and Taylor suggest a framework for three-way partnership to operate within, based on annual cycles of steps. These steps focus on capacity building, creating a common vision based on local data, and community action. Capacity building would require (re)establishing community-based coordinating committees to mobilise community members and engage with outside agencies (Taylor and Taylor 2002). Taylor and Taylor also think it is essential to learn from the successes of similar communities, and there is scope to increase learning and promote cooperation between women's groups in the study areas. Creating a common vision should be based on objectively collected community-level data to identify successes of previous actions and to prioritise problems. Taylor and Taylor advocate for 'collective' data collection involving all three partners to ensure universal acceptance of the findings and to create a 'coalition for later action'. Subsequent community discussions based on this evidence leads to prioritising of problems, identification of possible solutions and the development of a work plan that assigns roles and activities to all community members (Taylor and Taylor 2002).

The women's group participatory learning and action cycle mirrors many of these processes, such as discussing and prioritising problems, identifying solutions, and devising and evaluating local strategies. The women's groups are also linked to outside 'experts' and NGOs that facilitate some of these processes, have introduced new ideas and scientific knowledge, and have helped monitor changes in health behaviours and indicators. However, at present, the women's groups are working in more of a two-way partnership that does not include the government. Taylor and Taylor identify an essential government role to create an 'enabling environment' for positive change. This requires system strengthening to support sustainable working within and between communities. It could involve changes to policies, administrative structures (to promote inter-sectoral collaboration), and greater decentralisation so learning can be adapted to local contexts. An important shift in working with communities more effectively and sustainably is that both the government and the outside 'experts' must transfer control to communities as their capacity increases: ‘those in power have to learn to share power. This sets new expectations and standards, and does not create dependency’ (Taylor and Taylor 2002). Applying this idea to the women’s groups, power could begin to be transferred in more established groups from external actors to women and community members. Women’s group members could, for example, take more of a leading role in the planning and management of a new cycle of groups (Draper et al. 2010), and accountability mechanisms between the implementing agency and women’s group members could be more explicitly defined (Brett 2003).

Community participation is essential for sustainable and equitable use of natural resources but this requires that community-based organisations have the capacity to manage their resources effectively, and are able to overcome embedded hierarchies. In this sense, caution should be used in assuming that every activity in the name of ‘participation’ manages to be truly equitable: ‘elite capture and financial irregularities are common’ which often excludes women and underserved groups (Shah 2012). For example, a rain-fed farming project in India used participatory methods to engage communities but was ‘less successful at targeting the poor than richer families’, the long-term effect being the ‘thinning of social networks of the poorest and most vulnerable’ undermining their political capabilities (Kumar and Corbridge 2002).

Participatory discourse is often wrongly based upon a binary notion of power assuming that it is only located at the macro level (Hailey 2001). Foucault’s understanding of power counters this by asserting that power is everywhere, all individuals are vehicles of it, and it circulates and functions in the ‘form of a chain’ (Foucault 1980). Power is found in the creation of social and cultural norms at all levels, and is not fixed but is continually reconstructed, embedded within a network of power relations. By ignoring power differentials operating at local levels, ‘daily oppressions’ are concealed, inequalities are widened and reinforced, and the process serves to disempower (Kothari 2001), as well as becoming a convenient excuse not to invest in services because people have undergone mobilisation for behaviour change.

One major criticism of participatory interventions led by the World Bank is that their programmes have historically placed the onus on poor communities to manage their own poverty whilst the structural drivers of poverty are overlooked. Here there is a danger that participatory discourse is becoming coercive (Morgan 2001;Cornwall & Brock 2004). Whilst many interventions are described as ‘participatory’ it is worth reiterating from chapter 3 that the term has multiple meanings and may reflect opposing perspectives. At the extremes of the participation spectrum are interventions based on utilitarian and empowerment ideals and this manifests in the conflicting ways that interventions are planned and carried out (Morgan 2001).

The utilitarian position tends to adopt a target-oriented approach and advocates for the use of community resources to compensate for weak services (Rifkin 1996); historically World Bank interventions would be positioned at this end (Morgan 2001). My analysis of the women's groups suggests they were positioned towards the other end of the spectrum, demonstrating values for collaboration and empowerment (Rifkin 1996; Draper et al. 2010). This is based on the idea that democratizing local decision-making and redressing power differentials can result in more equitable distribution of resources, and lead to improved service delivery and uptake which are key determinants of health (ibid).

Brett (2003) asserts that interventions based on participatory learning and action should not be mislabelled as putting 'the poor in charge' and prioritising community knowledge over that of outside experts. Instead this type of approach should be recognised as forging progressive partnerships that enable people to demand change and exert meaningful influence over the organisation of health care and other social policies that they would not have otherwise had the power to do (ibid).

Intuitively community involvement in decision-making, prioritising, shaping and evaluating strategies carried out locally has the potential to increase ownership and pave the way for sustainable behaviour change in parallel with challenges to wider oppression (Howard-Grabman 2007). However, this will not be achieved through simplistic understandings of power and participation, or complacency that participatory activities will continue to be equitable. This requires on-going qualitative interrogation of processes and mechanisms of change, and quantification of outcomes, not just in the short-term and with a narrow focus, but incorporating wider social and political changes over the longer-term.

9.9 Limitations of the PhD work

One of the main limitations of my thesis is the cross-sectional design of the nutrition survey. This means I cannot attribute causality and can only infer the meaning of associations. Secondly, although I included a broad range of socio-demographic confounders and nutrition determinants, unmeasured confounding factors could have influenced my findings. There may have been differences in the quality of height-for-age and weight-for-age measures between exposure groups because of less reliable dates of birth in the control areas, which could have biased the models. There could also have been greater heterogeneity in the control group because we sampled children at the cluster-level, whereas only children of women's group members were sampled in the intervention group.

It is also possible that the previous trial of women's groups to reduce neonatal mortality in the intervention areas led to the incorrect conclusion that 'cycle 2' did not influence nutritional outcomes. A greater proportion of children born at low birth weight in the intervention areas may have survived beyond the neonatal period than in the control areas due to enhanced newborn care practices. The greater risks of undernutrition associated with low birth weight could have thus skewed the nutritional status of children in the intervention areas. I could have used the proxy birth weight variable 'perceived size of the child at birth' to explore this issue, but it appeared unreliable as those perceived smaller than average at birth were significantly taller for their age. It would be prudent to repeat the study and measure actual birth weight to account for pre-existing differences, especially as evidence suggests that half of stunting may have already occurred at birth (Mamidi et al. 2011).

In terms of stunting reduction, it could have been too soon to expect to see an effect of the intervention because it is an intergenerational problem that can take decades to eradicate. However, there are too many risk factors in the study areas to convince me that cycle 2 in its current form could be contributing to future stunting reduction in a meaningful way. Triangulation of different data sources and evidence of the wider influences that are driving undernutrition adds strength to my conclusions.

There are other limitations to some of the survey variables and these would benefit from development in future surveys. For example, we could improve our assessment of socioeconomic status by including livestock as an 'asset' as well as access to irrigation facilities, both of which seem to have an impact on different foods consumed and overall dietary diversity in other studies (Bhagowalia et al. 2012). It would also be important to measure the consistency, types of cleansing agent and longevity of hand washing amongst women's group participants. Linking to this we could include interventions and subsequent measurement of household drinking water storage practices. It would be interesting to assess any impact of water, sanitation and hygiene interventions on environmental enteropathy, should non-invasive reliable measures be developed. It could also be useful to differentiate between malaria and fever particularly given that Plasmodium falciparum (which is endemic in tribal forested areas) is showing signs of drug resistance (Kumar et al. 2007). Future work could attempt to further characterise fever by combining it with other symptoms and attribute the cause, perhaps using Integrated Management of Neonatal and Childhood Illness guidelines or those suggested by Dhingra and colleagues (Dhingra et al. 2010;Ministry of Health and Family Welfare 2003).

Other limitations to my thesis have been given previously within each chapter.

9.10 Future research

I reiterate here that it would be valuable to resolve issues around the meaning of our nutritional data, possibly through a repeat survey and the collection of follow-up data on mortality. It would be useful to combine this with the creation of a local coping strategies index which would allow us to fully characterise and monitor the nutritional crisis in the study areas (Maxwell et al. 2003). We could use the data collected on household shocks and coping to develop a simple context-specific tool for rapid assessment and monitoring of food security.

In terms of outcomes, the fact that so much stunting has already occurred at birth suggests a need for a greater focus on interventions to reduce low birth weight. It would be useful to estimate the differential burden of intrauterine growth restriction and prematurity, which may have different determinants. This would require close monitoring in pregnancy and accurate birth weight measurement. One of the major determinants of stunting in the study areas appears to be exposure to the burning of biomass fuels. It would be prudent to measure indoor air pollution and explore the feasibility and acceptability of different approaches to reducing the exposure of pregnant women and young children to biomass fuels.

Operational research could focus on the roles of community health workers in promoting different health and nutrition actions in rural, underserved areas. There is currently considerable confusion and role overlap between ASHAs, Anganwadi Workers, and Auxiliary Nurse Midwives (Bajpai and Dholakia 2011) and this has the potential to increase with the introduction of a second Anganwadi as part of health service reform. CMAM is also a new model in India. Operational research in terms of how CMAM could be effectively incorporated into the Integrated Child Development Services, who is best placed for case-finding amongst all the frontline workers, and which ready-to-use therapeutic food (or equivalent) is most acceptable and feasible to make locally, are some of the many issues that would need to be resolved.

Other research could explore local means to improve dietary diversity and iron intake without increasing household costs too much. This would require consultation with local dieticians and nutritionists who are aware of local foods and their content, and some of the contextual factors and barriers to consuming particular foods. We already have a glossary of local foods that was developed for the survey and can build on this through further qualitative work. The end result may involve local cooking classes to illustrate the different dishes that can be made with optimal nutritional content.

9.11 Conclusion

There is a huge burden of undernutrition in the study areas and a wide range of risk factors that contribute to this situation. Prior to this thesis, there was a gap in our understanding about the potential for community mobilisation with women's groups to reduce this problem. Whilst this work provides tentative evidence that the groups impacted on important nutrition pathways, their greatest potential lying in improvements to hygiene and sanitation behaviours and reproductive health, there is no evidence that the groups reduced stunting or wasting. Given the broader context this intervention alone will be insufficient to surmount the problem of undernutrition. The communities are facing a multitude of wider challenges including food insecurity, extreme poverty, and social discrimination. These environmental, social and economic barriers will seriously limit women's group actions, although they make community mobilisation to lobby for government entitlements even more essential. It is timely for the government to increase its commitment to reducing undernutrition, reform health systems, and narrow the gap between rich and poor. Civil society is needed to guide these changes towards more equitable solutions, and take legal measures if necessary to resist negative global forces associated with food price hikes (such as futures trading), and the illegal commandeering of land for 'economic' reasons that destroys the earth and amounts to cultural genocide (Padel 2012). Effective partnership is needed in these uncertain times and in the face of climate change – between communities, the government, and other civil society organisations. In the words of Taylor and Taylor: 'the choices before us are two: either we work out a process to address our problems or we let ourselves be buffeted and driven forwards into the future by forces we do not control. In either case uncertainty and risk lie ahead' (Taylor and Taylor 2002).

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Appendices

Appendices: chapter 2

Appendix 2.1 Grading health education studies

Study author	Outcome	Design grade	Strength of association	Limitation to study quality	Important inconsistency	Uncertainty about directness	Imprecise/ sparse data	Reporting bias	Study grade
Aboud et al, 2008	Weight/ weight gain	High (4)	+1	No	No	No	No	No	High
Aboud et al, 2009	Weight gain and WAZ[1]	High (4)	0	-1	No	No	No	No	Moderate
Ahmed et al, 1993	WAZ[1]	Moderate (3)	+2	-2	No	No	-1	-1	Very low
	HAZ[2]	Moderate (3)	0	-2	No	No	-1	-1	Very low
Bhandari et al, 2001	Weight gain	High (4)	+1	No	No	No	No	No	High
	Length gain/LAZ[2]	High (4)	0	No	No	No	No	No	High

	WHZ[3]	High (4)	0	No	No	No	No	No	High
Bhandari et al, 2004	Weight gain/WAZ[1]	High (4)	0	No	No	No	No	No	High
	Length gain/LAZ[2]	High (4)	+1	No	No	No	No	No	High
Bowen et al, 2012	WAZ[1]	High (4)	0	-2	No	No	No	-1	Very low
	HAZ[2]	High (4)	0	-2	No	No	No	-1	Very low
	BMI z-score[4]	High (4)	0	-2	No	No	No	-1	Very low
Elizabeth et al, 1997	Weight gain	Moderate (3)	+1	-1	No	No	-1	-1	Very low
	Height gain	Moderate (3)	+1	-1	No	No	-1	-1	Very low
George et al, 1993	Weight gain/WAZ[1]	High (4)	0	No	No	No	-1	No	Moderate
Hamad et al, 2011	WAZ[1]	High (4)	0	-2	-1	-1	No	-1	Very low
	HAZ[2]	High (4)	0	-2	-1	-1	No	-1	Very low
	BMI z-score[4]	High (4)	0	-2	-1	-1	No	-1	Very low
Salehi et al, 2004	Weight gain, WAZ[1]	Moderate (3)	+2	-2	No	No	No	-1	Low
	LAZ[2]	Moderate (3)	+2	-2	No	No	No	-1	Low

	WHZ[3]	Moderate (3)	+1	-2	No	-1	No	-1	Very low
	Arm circumference	Moderate (3)	+2	-2	No	-1	-1	-1	Very low
Santos et al, 2001	Weight gain, WAZ[1]	High (4)	0	-2	No	-1	No	No	Very low
	Length gain, LAZ[2]	High (4)	0	-2	No	-1	No	No	Very low
	WHZ[3]	High (4)	0	-2	No	-1	No	No	Very low
Vazir et al, 2012	Weight gain, WAZ[1]	High (4)	0	No	No	No	-1	-1	Low
	Length gain, LAZ[2]	High (4)	+2	No	-1	No	-1	No	High
	WHZ[3]	High (4)	0	No	No	No	-1	No	Moderate
Walker et al, 1991	WAZ[1]	High (4)	0	-2	No	No	No	No	Low
	HAZ[2]	High (4)	0	-2	No	No	No	No	Low
	Arm circumference	High (4)	0	-2	No	No	No	No	Low

[1]WAZ – Weight-for-age Z-score
[2]HAZ/LAZ – Height-for-age or length-for-age Z-score
[3]WHZ – Weight-for-height Z-score
[4]BMI – Body Mass Index

Appendix 2.2 Grading behaviour change and communication studies

Study author	Outcome	Design grade	Strength of association	Limitation to study quality	Important inconsistency	Uncertainty about directness	Imprecise/ sparse data	Reporting bias	Study grade
Aboud & Akhter, 2011	Weight gain, WAZ[1]	High (4)	0	No	No	No	-1	No	Moderate
	Length gain	High (4)	0	No	No	No	-1	No	Moderate
Arifeen et al, 2009	HAZ[2]	High (4)	+1	No	No	No	No	No	High
	WHZ[3]	High (4)	0	No	No	No	No	No	High
Bhandari et al, 2003	HAZ[2]	High (4)	0	-1	No	No	No	No	Moderate
	WAZ[1]	High (4)	0	-1	No	No	No	No	Moderate
Brown et al, 1992	WAZ[1]	Moderate (3)	+2	-1	No	No	No	-1	Moderate
	Arm circumference	Moderate (3)	+1	-1	No	No	No	-1	Low
Hamadani et al, 2006	HAZ[2]	High (4)	0	-1	No	No	-1	No	Low
	WHZ[3]	High (4)	0	-1	No	No	-1	No	Low
	WAZ[1]	High (4)	0	-1	No	No	-1	No	Low

Langford et al, 2011	HAZ[2]	Moderate (3)	0	-2	No	No	No	-1	Very low
	WHZ[3]	Moderate (3)	0	-2	No	No	No	-1	Very low
	WAZ[1]	Moderate (3)	0	-2	No	No	No	-1	Very low
Lutter et al, 2008	Weight gain	Moderate (3)	+1	-1	No	No	No	-1	Low
	Linear growth	Moderate (3)	0	-1	No	No	No	-1	Very low
	WLZ[3]	Moderate (3)	0	-1	No	-1	No	-1	Very low
Roy et al, 2005	WAM[1], WAZ[1]	High (4)	+2	No	No	-1	-1	-1	Moderate
Roy et al, 2007	Length change, LAZ[2]	High (4)	+1	No	No	-1	No	No	High
	Weight change, WAZ[1]	High (4)	+2	No	No	-1	No	No	High
	WLZ[3]	High (4)	0	No	No	-1	No	No	Moderate
	MUAC[4]	High (4)	0	No	No	-1	No	No	Moderate

Ruel et al, 2008	WAZ[1]	High (4)	+1	No	No	No	No	No	High
	WHZ[3]	High (4)	+1	No	No	No	No	No	High
	HAZ[2]	High (4)	0	No	No	No	No	No	High
Shi et al, 2009	Weight gain	High (4)	+1		-1	-1	-1	-1	Very low
	Length gain	High (4)	+2		-1	-1	-1	-1	Low

[1]WAZ – Weight-for-age Z-score; WHM – Weight-for-age percentage of the median

[2]HAZ/LAZ – Height-for-age or length-for-age Z-score

[3]WHZ/WLZ – Weight-for-height or weight-for-length Z-score

[4]MUAC – Mid-upper arm circumference

Appendix 2.3 Grading of other behaviour change studies

Study author	Outcome	Design grade	Strength of association	Limitation to study quality	Important inconsistency	Uncertainty about directness	Imprecise/ sparse data	Reporting bias	Study grade
Mixed behaviour change approaches									
Alderman et al, 2008	WAZ[1]	Moderate (3)	+1	No	No	No	No	No	High
Le Roux et al, 2010	WAZ[1]	High (4)	+2	-2	No	No	No	-1	Moderate
Le Roux et al, 2011	Weight gain, WAZ[1]	High (4)	+1	-2	No	No	No	-1	Low
Schroeder et al, 2002	WAZ[1]	High (4)	0	-1	No	No	-1	No	Low
	HAZ[2]	High (4)	0	-1	No	No	-1	No	Low
	WHZ[3]	High (4)	0	-1	No	No	-1	No	Low
Complex interventions									
Maluccio & Flores 2005	WAZ[1]	High (4)	+1	No	No	No	-1	No	High
	HAZ[2]	High (4)	0	No	No	No	-1	No	Moderate
	WHZ[3]	High (4)	0	No	No	-1	-1	No	Low

Pant et al, 1996	WHZ[3]	High (4)	0	-1	No	No	-1	No	Moderate
Rivera et al, 2004	Height gain	High (4)	+2	No	No	No	-1	No	High
Cognitive behavioural therapy									
Rahman et al, 2008	WAZ[1]	High (4)	0	No	No	No	No	No	High
	HAZ[2]	High (4)	+1	No	No	No	No	No	High

[1]WAZ – Weight-for-age Z-score
[2]HAZ– Height-for-age Z-score
[3]WHZ – Weight-for-height Z-score

Appendices: chapter 4

Appendix 4.1: Cluster matching characteristics

District	INTERVENTION CLUSTERS				CONTROL CLUSTERS			
	Cluster Name	Population[a]	% ST[b]	No of AWWs[c]	Cluster Name	Population	% ST	No of AWWs
WS[d]	ASANTALIA	7406	71	13	GULIKEDA (Dharamsai)	6928	84	11
WS	KUIDA	7033	91	8	AMRAI (Dalaikela)	6092	92	9
WS	KUSNOPUR	5736	82	12	SARJOMDIH (Bhalupani)	6373	75	17
WS	PERTOL	7079	77	14	BIHATTU (Sanjhinkpani)	6278	75	11
WS	SAGEISAHI	6826	79	12	JHINGI MIRCHA (Raghoi)	6181	67	11
WS	TENDRAULI	7080	79	17	RONGO (Nandpur)	4774	90	11
WS	**ALL CLUSTERS**	**41160**	**80**	**76**	**ALL CLUSTERS**	**36626**	**81**	**70**
Sk[e]	BARA BAMBOO	7490	46	15	Simla	6860	62	13
SK	CHURAKPATHAR	6750	56	10	Gendesai	7121	65	15
SK	GULIO	7011	61	10	Sijulata	6419	48	12
SK	KUNABEDA	7326	50	10	Rangamatiya	4617	68	9
SK	NETO TIRIL	7529	75	13	Matakambera	6132	55	12
SK	RIDING	**6794**	70	14	Ghoralang	6078	51	12
SK	**ALL CLUSTERS**	**42900**	**59**	**72**	**ALL CLUSTERS**	**37227**	**58**	**73**
KJR[f]	CHAMPEI	5330	87	11	Kanjipani	5052	84	10
KJR	KUSHUKALA	7013	69	13	Kalanda	6712	82	14
KJR	KUSHUMITA	6722	75	10	Fuljhar	7501	83	9
KJR	MAHAEIJODA	6360	75	12	Nuagaon	6462	64	9
KJR	MUNDALA	7402	86	13	Saharpur	7214	84	12
KJR	TALAKOINSARI	3806	77	8	Baragada	3985	89	11
KJR	**ALL CLUSTERS**	**36633**	**84**	**67**	**ALL CLUSTERS**	**36926**	**81**	**65**

a - Population size from the Indian census 2001, adjusted for expected population increase by 2009
b - Scheduled Tribe
c - Anganwadi Workers; from recent government reports, and including mini-AWWs
d - West Singhbhum
e - Saraikela
f - Keonjhar

Appendices: chapter 5

Appendix 5.1 The association of intervention exposure and key socio-demographic variables with child weight-for-height z-score in unadjusted and adjusted GEE models

Predictor[1,2]	β (95%CI) Unadjusted model	β (95%CI) Adjusted model	β (95%CI) Pooled estimate from adjusted multiple imputation models	β (95%CI) one randomly selected sibling removed from each pair in adjusted model
Exposure group (0=control, 1=intervention)	-0.105 (-0.255-0.046)	-0.049 (-0.174-0.076)	-0.057 (-0.177-0.062)	-0.048 (-0.173-0.077)
Socioeconomic quintile 1 (0= lowest, 1=second lowest)	0.194 (0.063-0.325)	0.192 (0.061-0.324)	0.094 (-0.091-0.279)	0.190 (0.061-0.319)
Socioeconomic quintile 2 (0= lowest, 1=middle)	0.180 (0.070-0.290)	0.163 (0.066-0.261)	0.074 (-0.077-0.225)	0.164 (0.067-0.262)
Socioeconomic quintile 3 (0= lowest, 1=second highest)	0.313 (0.188-0.437)	0.272 (0.147-0.398)	0.164 (-0.015-0.343)	0.276 (0.149-0.404)
Socioeconomic quintile 4 (0= lowest, 1=highest)	0.576 (0.422-0.730)	0.495 (0.289-0.701)	0.366 (0.129-0.603)	0.502 (0.295-0.710)
Social group 1 (0=ST, 1=SC)[3]	0.281 (-0.014-0.576)	0.294 (-0.010-0.598)	0.187 (-0.122-0.486)	0.323 (0.029-0.616)
Social group 2 (0=ST, 1=OBC)[3]	0.277 (0.161-0.392)	0.147 (0.017-0.276)	0.168 (0.044-0.293)	0.149 (0.017-0.282)
Social group 3 (0=ST, 1=other)[3]	0.230 (-0.208-0.669)	-0.045 (-0.494-0.405)	0.074 (-0.347-0.494)	-0.042 (-0.489-0.406)
Maternal age (years)	-0.023 (-0.030- -0.015)	-0.014 (-0.023- -0.006)	-0.016 (-0.024- -0.008)	-0.014 (-0.023- -0.005)

Relationship to household head 1 (0=wife, 1=daughter in law)	0.081 (-0.012-0.175)	n/a[4]	n/a[4]	n/a[4]
Relationship to household head 2 (0=wife, 1=other)	0.003 (-0.236-0.243)			
Religion 1 (0=Sarna, 1=Hindu)	0.070 (-0.038-0.179)	n/a[4]	n/a[4]	n/a[4]
Religion 2 (0=Sarna, 1=Christian)	-0.096 (-0.293-0.101)			
Religion 3 (0=Sarna, 1=Muslim)	0.772 (0.605-0.940)			
Religion 4 (0=Sarna, 1=Other)	-0.097 (-0.452-0.258)			
Maternal education 1 (0=no schooling, 1=primary school)	0.116 (-0.041-0.272)	n/a[4]	n/a[4]	n/a[4]
Maternal education 2 (0=no schooling, 1=Secondary school)	0.222 (0.129-0.314)			
Maternal education 3 (0=no schooling, 1=≥Higher secondary)	0.487 (0.199-0.775)			
Income group 1 (0=lowest, 1=middle)	0.022 (-0.067-0.111)	n/a[4]	n/a[4]	n/a[4]
Income group 2 (0=lowest, 1=highest)	0.142 (-0.010-0.293)			

[1]Season of measurement was not significantly associated with WHZ in univariate models (p>0.10) and was not included in the backward stepwise process

[2]Standardised βs for socio-demographic predictors in unadjusted models represent the combined association of each predictor and exposure group with the outcome

[3]ST=Scheduled Tribe, SC=Scheduled Caste, OBC=Other Backwards Class

[4]n/a – removed in backward stepwise process

Appendix 5.2 The association of intervention exposure and key socio-demographic variables with Global Acute Malnutrition in unadjusted and adjusted GEE models

Predictor[1,2]	OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	1.118 (0.915-1.366)	1.020 (0.843-1.233)	1.045 (0.873-1.252)	1.020 (0.843-1.233)
Socioeconomic quintile 1 (0= lowest, 1=second lowest)	0.714 (0.579-0.880)	0.653 (0.531-0.803)	0.808 (0.583-1.120)	0.653 (0.531-0.803)
Socioeconomic quintile 2 (0= lowest, 1=middle)	0.783 (0.649-0.944)	0.706 (0.588-0.847)	0.872 (0.666-1.142)	0.706 (0.588-0.847)
Socioeconomic quintile 3 (0= lowest, 1=second highest)	0.633 (0.516-0.776)	0.599 (0.489-0.735)	0.740 (0.535-1.023)	0.599 (0.489-0.735)
Socioeconomic quintile 4 (0= lowest, 1=highest)	0.447 (0.362-0.551)	0.445 (0.357-0.554)	0.563 (0.397-0.799)	0.445 (0.357-0.554)
Religion 1 (0=Sarna, 1=Hindu)	0.849 (0.716-1.005)	0.783 (0.669-0.917)	0.835 (0.715-0.976)	0.783 (0.669-0.917)
Religion 2 (0=Sarna, 1=Christian)	1.010 (0.673-1.516)	0.984 (0.651-1.489)	0.990 (0.646-1.516)	0.984 (0.651-1.489)
Religion 3 (0=Sarna, 1=Muslim)	0.357 (0.234-0.545)	0.642 (0.358-1.149)	0.474 (0.291-0.772)	0.642 (0.358-1.149)
Religion 4 (0=Sarna, 1=Other)	1.585 (0.741-3.393)	1.469 (0.589-3.665)	1.478 (0.662-3.304)	1.469 (0.589-3.665)
Maternal age (years)	0.975 (0.960-0.990)	1.015 (0.999-1.031)	1.017 (1.003-1.033)	1.015 (0.999-1.031)
Relationship to household head 1 (0=wife, 1=daughter in law)	0.837 (0.730-0.959)	n/a[3]	n/a[3]	n/a[3]
Relationship to household head 2 (0=wife, 1=other)	0.982 (0.587-1.644)			
Social group 1 (0=ST, 1=SC)[4]	0.660 (0.378-1.152)	n/a[3]	n/a[3]	n/a[3]
Social group 2 (0=ST, 1=OBC)[4]	0.629 (0.506-0.782)			

Social group 3 (0=ST, 1=other)[4]	0.801 (0.351-1.831)			
Maternal education 1 (0=no schooling, 1=primary school)	0.832 (0.579-1.195)	n/a[3]	n/a[3]	n/a[3]
Maternal education 2 (0=no schooling, 1=Secondary school)	0.704 (0.613-0.808)			
Maternal education 3 (0=no schooling, 1=≥Higher secondary)	0.445 (0.240-0.827)			
Income group 1 (0=lowest, 1=middle)	0.949 (0.830-1.084)	n/a[3]	n/a[3]	n/a[3]
Income group 2 (0=lowest, 1=highest)	0.725 (0.536-0.981)			

[1]Season of measurement was not significantly associated with GAM in univariate models (p>0.10) and was not included in the backward stepwise process
[2]Odds ratios for socio-demographic predictors in unadjusted models represent the combined association of each predictor and exposure group with the outcome
[3]n/a – removed in backward stepwise process
[4]ST=Scheduled Tribe, SC=Scheduled Caste, OBC=Other Backwards Class

Appendix 5.3 The association of intervention exposure and key socio-demographic variables with Severe Acute Malnutrition in unadjusted and adjusted GEE models

Predictor[1,2]	OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	1.037 (0.798-1.348)	0.926 (0.724-1.184)	0.968 (0.770-1.215)	0.926 (0.724-1.184)
Socioeconomic quintile 1 (0= lowest, 1=second lowest)	0.773 (0.586-1.021)	0.750 (0.553-1.018)	0.914 (0.619-1.349)	0.750 (0.553-1.018)
Socioeconomic quintile 2 (0= lowest, 1=middle)	0.781 (0.648-0.942)	0.777 (0.628-0.960)	0.943 (0.698-1.273)	0.777 (0.628-0.960)
Socioeconomic quintile 3 (0= lowest, 1=second highest)	0.608 (0.473-0.782)	0.664 (0.509-0.868)	0.792 (0.534-1.175)	0.664 (0.509-0.868)
Socioeconomic quintile 4 (0= lowest, 1=highest)	0.327 (0.244-0.438)	0.372 (0.269-0.514)	0.505 (0.304-0.838)	0.372 (0.269-0.514)
Social group 1 (0=ST, 1=SC)[2]	0.457 (0.173-1.209)	0.254 (0.083-0.784)	0.510 (0.194-1.336)	0.254 (0.083-0.784)
Social group 2 (0=ST, 1=OBC)[2]	0.532 (0.404-0.700)	0.688 (0.530-0.892)	0.640 (0.491-0.834)	0.688 (0.530-0.892)
Social group 3 (0=ST, 1=other)[2]	0.998 (0.457-2.177)	1.814 (0.837-3.935)	1.357 (0.608-3.028)	1.814 (0.837-3.935)
Maternal age (years)	1.022 (1.001-1.043)	1.005 (0.985-1.026)	1.008 (0.987-1.029)	1.005 (0.985-1.026)
Relationship to household head 1 (0=wife, 1=daughter in law)	0.736 (0.620-0.873)	0.788 (0.637-0.975)	0.818 (0.676-0.989)	0.788 (0.637-0.975)
Relationship to household head 2 (0=wife, 1=other)	0.690 (0.297-1.604)	0.556 (0.187-1.651)	0.732 (0.319-1.680)	0.556 (0.187-1.651)
Maternal education 1 (0=no schooling, 1=primary school)	0.823 (0.558-1.215)	n/a[4]	n/a[4]	n/a[4]
Maternal education 2 (0=no schooling, 1=Secondary school)	0.648 (0.500-0.839)			
Maternal education 3 (0=no schooling, 1=≥Higher secondary)	0.440 (0.189-1.023)			

[1]Season of measurement and income group were not significantly associated with SAM in univariate models (p>0.10) and were not included in the backward stepwise process

[2]Odds ratios for socio-demographic predictors in unadjusted models represent the combined association of each predictor and exposure group with the outcome

[3]ST=Scheduled Tribe, SC=Scheduled Caste, OBC=Other Backwards Class

[4] n/a – removed in backward stepwise process

Appendix 5.4 The association of intervention exposure and key socio-demographic variables with child height for age z-score in unadjusted and adjusted GEE models

Predictor[1,2]	β (95%CI) Unadjusted model	β (95%CI) Adjusted model	β (95%CI) Pooled estimate from adjusted multiple imputation models	β (95%CI) one randomly selected sibling removed from each pair in adjusted model
Exposure group (0=control, 1=intervention)	-0.178 (-0.392-0.036)	-0.216 (-0.406- -0.026)	-0.161 (-0.340-0.018)	-0.206 (-0.393- -0.018)
Socioeconomic quintile 1 (0= lowest, 1=second lowest)	0.198 (0.026-0.370)	0.168 (0.011-0.325)	0.177 (-0.043-0.397)	0.186 (0.033-0.339)
Socioeconomic quintile 2 (0= lowest, 1=middle)	0.177 (-0.009-0.362)	0.124 (-0.039-0.287)	0.161 (-0.067-0.389)	0.133 (-0.029-0.295)
Socioeconomic quintile 3 (0= lowest, 1=second highest)	0.525 (0.249-0.801)	0.312 (0.034-0.590)	0.375 (0.105-0.645)	0.322 (0.045-0.599)
Socioeconomic quintile 4 (0= lowest, 1=highest)	0.700(0.458-0.943)	0.380 (0.147-0.613)	0.457 (0.218-0.696)	0.391 (0.154-0.629)
Religion 1 (0=Sarna, 1=Hindu)	0.099 (-0.070-0.268)	0.063 (-0.088-0.214)	0.041 (-0.112-0.194)	0.056 (-0.100-0.213)
Religion 2 (0=Sarna, 1=Christian)	0.362 (0.089-0.635)	0.316 (0.110-0.522)	0.323 (0.097-0.549)	0.328 (0.119-0.536)
Religion 3 (0=Sarna, 1=Muslim)	-0.608 (-0.916- -0.300)	-1.007 (-1.632- -0.382)	-0.892 (-1.408- -0.377)	-1.014 (-1.638- -0.390)
Religion 4 (0=Sarna, 1=Other)	-0.310 (-1.031-0.412)	-0.337 (-1.128-0.454)	-0.299 (-0.988-0.390)	-0.342 (-1.133-0.449)
Maternal education 1 (0=no schooling, 1=primary school)	0.085 (-0.109-0.278)	-0.009 (-0.241-0.222)	-0.071 (-0.265-0.123)	0.002 (-0.230-0.235)
Maternal education 2 (0=no schooling, 1=Secondary school)	0.460 (0.339-0.581)	0.238 (0.109-0.367)	0.157 (0.046-0.269)	0.236 (0.111-0.360)
Maternal education 3 (0=no schooling, 1=≥Higher secondary)	0.988 (0.639-1.337)	0.514 (0.205-0.822)	0.503 (0.176-0.830)	0.499 (0.190-0.809)
Income group 1 (0=lowest, 1=middle)	0.143 (0.009-0.278)	0.079 (-0.083-0.241)	0.105 (-0.032-0.242)	0.070 (-0.093-0.234)
Income group 2 (0=lowest, 1=highest)	0.705 (0.408-1.001)	0.288 (0.046-0.530)	0.362 (0.117-0.606)	0.328 (0.092-0.565)

Social group 1 (0=ST, 1=SC)[3]	0.298 (0.057-0.539)	0.035 (-0.250-0.321)	0.138 (-0.122-0.397)	0.046 (0.328-0.101)
Social group 2 (0=ST, 1=OBC)[3]	0.402 (0.262-0.541)	0.222 (0.072-0.372)	0.199 (0.058-0.340)	0.224 (0.070-0.377)
Social group 3 (0=ST, 1=other)[3]	0.179 (-0.335-0.692)	0.040 (-0.440-0.520)	0.103 (-0.341-0.546)	0.039 (-0.445-0.522)
Maternal age (years)	-0.030 (-0.042- -0.018)	-0.018 (-0.028- -0.007)	-0.018 (-0.028- -0.008)	-0.018 (-0.028- -0.007)
Relationship to household head 1 (0=wife, 1=daughter in law)	0.184 (0.044-0.323)	n/a[4]	n/a[4]	n/a[4]
Relationship to household head 2 (0=wife, 1=other)	0.058 (-0.272-0.387)			

[1]Season of measurement was not significantly associated with HAZ in univariate models (p>0.10) and was not included in the backward stepwise process

[2]Standardised βs for socio-demographic predictors in unadjusted models represent the combined association of each predictor and exposure group with the outcome

[3]ST=Scheduled Tribe, SC=Scheduled Caste, OBC=Other Backwards Class

[4] n/a – removed in backward stepwise process

Appendix 5.5 The association of intervention exposure and key socio-demographic variables with severe child stunting in unadjusted and adjusted GEE models

Predictor[1,2]	OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	0.875 (0.656-1.166)	0.886 (0.684-1.147)	0.869 (0.688-1.100)	0.869 (0.669-1.130)
Socioeconomic quintile 1 (0= lowest, 1=second lowest)	0.728 (0.581-0.913)	0.763 (0.615-0.946)	0.777 (0.595-1.016)	0.756 (0.609-0.940)
Socioeconomic quintile 2 (0= lowest, 1=middle)	0.809 (0.643-1.017)	0.912 (0.747-1.112)	0.878 (0.678-1.138)	0.899 (0.735-1.099)
Socioeconomic quintile 3 (0= lowest, 1=second highest)	0.498 (0.354-0.701)	0.712 (0.488-1.037)	0.653 (0.459-0.929)	0.694 (0.478-1.008)
Socioeconomic quintile 4 (0= lowest, 1=highest)	0.364 (0.281-0.470)	0.584 (0.429-0.795)	0.532 (0.397-0.712)	0.576 (0.417-0.798)
Religion 1 (0=Sarna, 1=Hindu)	0.985 (0.781-1.242)	1.063 (0.869-1.299)	1.075 (0.887-1.303)	1.064 (0.866-1.308)
Religion 2 (0=Sarna, 1=Christian)	0.548 (0.368-0.814)	0.583 (0.426-0.798)	0.576 (0.403-0.823)	0.579 (0.421-0.795)
Religion 3 (0=Sarna, 1=Muslim)	1.375 (0.862-2.193)	1.884 (0.910-3.901)	1.257 (0.731-2.160)	1.877 (0.913-3.858)
Religion 4 (0=Sarna, 1=Other)	2.099 (0.773-5.699)	2.444 (0.718-8.322)	1.917 (0.746-4.923)	2.444 (0.716-8.341)
Maternal education 1 (0=no schooling, 1=primary school)	0.810 (0.589-1.114)	0.912 (0.634-1.312)	0.999 (0.720-1.385)	0.914 (0.650-1.286)
Maternal education 2 (0=no schooling, 1=Secondary school)	0.494 (0.415-0.589)	0.705 (0.563-0..883)	0.754 (0.618-0.921)	0.703 (0.562-0.879)
Maternal education 3 (0=no schooling, 1=≥Higher secondary)	0.302 (0.160-0.571)	0.583 (0.285-1.196)	0.616 (0.302-1.259)	0.596 (0.291-1.220)
Income group 1 (0=lowest, 1=middle)	0.815 (0.670-0.993)	0.905 (0.728-1.124)	0.850 (0.705-1.024)	0.909 (0.732-1.129)
Income group 2 (0=lowest, 1=highest)	0.286 (0.186-0.438)	0.521 (0.318-0.853)	0.443 (0.290-0.675)	0.473 (0.274-0.817)
Social group 1 (0=ST, 1=SC)[3]	0.623 (0.377-1.027)	0.848 (0.487-1.475)	0.722 (0.433-1.203)	0.818 (0.475-1.410)

Social group 2 (0=ST, 1=OBC)[3]	0.593 (0.487-0.723)	0.710 (0.577-0.875)	0.731 (0.599-0.890)	0.707 (0.571-0.876)
Social group 3 (0=ST, 1=other)[3]	1.149(0.819-1.611)	1.419 (0.879-2.292)	1.592 (1.046-2.423)	1.427 (0.879-2.316)
Maternal age (years)	1.042 (1.026-1.057)	1.027 (1.012-1.042)	1.026 (1.011-1.041)	1.026 (1.011-1.041)
Relationship to household head 1 (0=wife, 1=daughter in law)	0.720 (0.613-0.844)	n/a[4]	n/a[4]	n/a[4]
Relationship to household head 2 (0=wife, 1=other)	0.747 (0.457-1.220)			

[1]Season of measurement was not significantly associated with HAZ in univariate models (p>0.10) and was not included in the backward stepwise process

[2]Odds ratios for socio-demographic predictors in unadjusted models represent the combined association of each predictor and exposure group with the outcome

[3]ST=Scheduled Tribe, SC=Scheduled Caste, OBC=Other Backwards Class

[4] n/a – removed in backward stepwise process

Appendix 5.6 The association of intervention exposure and key socio-demographic variables with weight-for-age Z-score in unadjusted and adjusted GEE models

Predictor[1,2]	β (95%CI) Unadjusted model	β (95%CI) Adjusted model	β (95%CI) Pooled estimate from adjusted multiple imputation models	β (95%CI) one randomly selected sibling removed from each pair in adjusted model
Exposure group (0=control, 1=intervention)	-0.184 (-0.357- -0.011)	-0.158 (-0.300- -0.016)	-0.145 (-0.278- -0.013)	-0.151 (-0.291- -0.010)
Socioeconomic quintile 1 (0= lowest, 1=second lowest)	0.260 (0.133-0.386)	0.235 (0.100-0.369)	0.168 (-0.005-0.342)	0.247 (0.115-0.379)
Socioeconomic quintile 2 (0= lowest, 1=middle)	0.215 (0.070-0.361)	0.168 (0.035-0.300)	0.117 (-0.043-0.277)	0.179 (0.046-0.312)
Socioeconomic quintile 3 (0= lowest, 1=second highest)	0.482 (0.305-0.659)	0.329 (0.141-0.516)	0.260 (0.055-0.466)	0.337 (0.155-0.519)
Socioeconomic quintile 4 (0= lowest, 1=highest)	0.766 (0.593-0.939)	0.504 (0.299-0.708)	0.426 (0.202-0.650)	0.517 (0.316-0.717)
Maternal education 1 (0=no schooling, 1=primary school)	0.154 (0.003-0.305)	0.036 (-0.145-0.218)	0.019 (-0.137-0.175)	0.051 (-0.127-0.228)
Maternal education 2 (0=no schooling, 1=Secondary school)	0.412 (0.311-0.513)	0.138 (0.026-0.249)	0.142 (0.029-0.255)	0.139 (0.033-0.246)
Maternal education 3 (0=no schooling, 1=≥Higher secondary)	0.899 (0.580-1.218)	0.401 (0.087-0.716)	0.462 (0.149-0.776)	0.397 (0.079-0.715)
Income group 1 (0=lowest, 1=middle)	0.089 (-0.012-0.190)	0.044 (-0.066-0.153)	0.064 (-0.033-0.160)	0.042 (-0.070-0.154)
Income group 2 (0=lowest, 1=highest)	0.586 (0.388-0.783)	0.265 (0.043-0.486)	0.264 (0.091-0.438)	0.273 (0.042-0.504)
Social group 1 (0=ST, 1=SC)[3]	0.368 (0.164-0.572)	0.246 (0.000-0.492)	0.230 (0.023-0.436)	0.269 (0.037-0.502)
Social group 2 (0=ST, 1=OBC)[3]	0.417 (0.302-0.532)	0.234 (0.150-0.318)	0.235 (0.155-0.315)	0.238 (0.149-0.327)
Social group 3 (0=ST, 1=other)[3]	0.346 (-0.029-0.721)	0.006 (-0.322-0.334)	0.121 (-0.224-0.466)	0.006 (-0.319-0.332)
Maternal age (years)	-0.029 (-0.041- -0.018)	-0.017 (-0.028- -0.006)	-0.018 (-0.028- -0.008)	-0.017 (-0.028- -0.006)
Religion 1 (0=Sarna, 1=Hindu)	0.088 (-0.055-0.232)	n/a[4]	n/a[4]	n/a[4]
Religion 2 (0=Sarna, 1=Christian)	0.161 (0.002-0.320)			
Religion 3 (0=Sarna, 1=Muslim)	0.294 (0.157-0.430)			

Religion 4 (0=Sarna, 1=Other)	-0.389 (-0.820-0.042)			
Relationship to household head 1 (0=wife, 1=daughter in law)	0.142 (0.044-0.239)	n/a[4]	n/a[4]	n/a[4]
Relationship to household head 2 (0=wife, 1=other)	0.007 (-0.258-0.271)			

[1]Season of measurement was not significantly associated with WAZ in univariate models (p>0.10) and was not included in the backward stepwise process

[2]Standardised βs for socio-demographic predictors in unadjusted models represent the combined association of each predictor and exposure group with the outcome

[3]ST=Scheduled Tribe, SC=Scheduled Caste, OBC=Other Backwards Class

[4] n/a – removed in backward stepwise process

Appendix 5.7 The association of intervention exposure and key socio-demographic variables with severe child underweight in unadjusted and adjusted GEE models

Predictor[1,2]	OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	1.146 (0.880-1.492)	1.113 (0.884-1.402)	1.081 (0.868-1.349)	1.100 (0.872-1.389)
Socioeconomic quintile 1 (0= lowest, 1=second lowest)	0.698 (0.579-0.841)	0.711 (0.588-0.861)	0.787 (0.598-1.036)	0.705 (0.583-0.852)
Socioeconomic quintile 2 (0= lowest, 1=middle)	0.730 (0.592-0.902)	0.749 (0.630-0.891)	0.842 (0.651-1.089)	0.742 (0.622-0.885)
Socioeconomic quintile 3 (0= lowest, 1=second highest)	0.499 (0.396-0.630)	0.631 (0.482-0.827)	0.705 (0.501-0.992)	0.615 (0.469-0.807)
Socioeconomic quintile 4 (0= lowest, 1=highest)	0.265 (0.208-0.339)	0.390 (0.283-0.538)	0.452 (0.299-0.685)	0.386 (0.283-0.527)
Maternal education 1 (0=no schooling, 1=primary school)	0.750 (0.538-1.047)	0.936 (0.629-1.391)	0.930 (0.657-1.314)	0.907 (0.606-1.356)
Maternal education 2 (0=no schooling, 1=Secondary school)	0.494 (0.409-0.598)	0.757 (0.597-0.960)	0.748 (0.581-0.962)	0.759 (0.601-0.959)
Maternal education 3 (0=no schooling, 1=≥Higher secondary)	0.188 (0.092-0.385)	0.387 (0.181-0.828)	0.351 (0.163-0.756)	0.390 (0.181-0.839)
Social group 1 (0=ST, 1=SC)[3]	0.568 (0.311-1.036)	0.586 (0.303-1.135)	0.700 (0.381-1.289)	0.515 (0.272-0.977)
Social group 2 (0=ST, 1=OBC)[3]	0.476 (0.393-0.576)	0.676 (0.533-0.857)	0.629 (0.503-0.787)	0.670 (0.522-0.860)
Social group 3 (0=ST, 1=other)[3]	0.759 (0.376-1.530)	1.564 (0.862-2.841)	1.318 (0.728-2.387)	1.565 (0.868-2.821)
Maternal age (years)	1.039 (1.022-1.057)	1.022 (1.004-1.040)	1.022 (1.006-1.038)	1.022 (1.004-1.041)
Religion 1 (0=Sarna, 1=Hindu)	0.859 (0.692-1.065)	0.912 (0.728-1.142)	0.981 (0.795-1.210)	0.908 (0.723-1.139)
Religion 2 (0=Sarna, 1=Christian)	0.727 (0.524-1.008)	0.755 (0.577-0.988)	0.756 (0.567-1.007)	0.795 (0.595-1.063)
Religion 3 (0=Sarna, 1=Muslim)	0.216 (0.146-0.321)	0.282 (0.147-0.541)	0.262 (0.142-0.486)	0.281 (0.146-0.539)
Religion 4 (0=Sarna, 1=Other)	2.150 (0.968-4.775)	2.693 (1.045-6.942)	2.145 (1.036-4.437)	2.678 (1.040-6.895)
Income group 1 (0=lowest, 1=middle)	0.881 (0.715-1.084)	n/a[4]	n/a[4]	n/a[4]
Income group 2 (0=lowest, 1=highest)	0.404 (0.258-0.632)			

Relationship to household head 1 (0=wife, 1=daughter in law)	0.788 (0.674-0.921)	n/a[4]	n/a[4]	n/a[4]
Relationship to household head 2 (0=wife, 1=other)	0.986 (0.610-1.592)			

[1]Season of measurement was not significantly associated with severe underweight in univariate models (p>0.10) and was not included in the backward stepwise process

[2]Odds ratios for socio-demographic predictors in unadjusted models represent the combined association of each predictor and exposure group with the outcome

[3]ST=Scheduled Tribe, SC=Scheduled Caste, OBC=Other Backwards Class

[4] n/a – removed in backward stepwise process

Appendix 5.8 The association of intervention exposure and key socio-demographic variables with child mid-to-upper-arm circumference in unadjusted and adjusted GEE models

Predictor[1,2]	β (95%CI) Unadjusted model	β (95%CI) Adjusted model	β (95%CI) Pooled estimate from adjusted multiple imputation models	β (95%CI) one randomly selected sibling removed from each pair in adjusted model
Exposure group (0=control, 1=intervention)	-0.082 (-0.280-0.117)	-0.011 (-0.205-0.184)	-0.055 (-0.234-0.124)	-0.012 (-0.209-0.185)
Socioeconomic quintile 1 (0= lowest, 1=second lowest)	0.143 (0.000-0.286)	0.136 (-0.026-0.297)	0.037 (-0.148-0.221)	0.139 (-0.023-0.301)
Socioeconomic quintile 2 (0= lowest, 1=middle)	0.164 (0.025-0.303)	0.142 (-0.001-0.284)	0.044 (-0.115-0.202)	0.146 (005.836-0.291)
Socioeconomic quintile 3 (0= lowest, 1=second highest)	0.352 (0.198-0.506)	0.280 (0.122-0.439)	0.155 (-0.035-0.346)	0.289 (0.133-0.445)
Socioeconomic quintile 4 (0= lowest, 1=highest)	0.508 (0.337-0.679)	0.296 (0.153-0.439)	0.189 (-0.011-0.389)	0.291 (0.147-0.434)
Social group 1 (0=ST, 1=SC)[3]	0.324 (0.080-0.568)	0.319 (0.049-0.589)	0.267 (0.019-0.514)	0.345 (0.079-0.610)
Social group 2 (0=ST, 1=OBC)[3]	0.438 (0.325-0.552)	0.339 (0.255-0.423)	0.352 (0.265-0.440)	0.353 (0.268-0.438)
Social group 3 (0=ST, 1=other)[3]	0.360 (-0.026-0.746)	0.025 (-0.304-0.353)	0.250 (-0.105-0.605)	0.030 (-0.301-0.361)
Maternal age (years)	-0.018 (-0.027- -0.010)	-0.008 (-0.017-0.000)	-0.008 (-0.016-0.000)	-0.008 (-0.016-0.001)
Income group 1 (0=lowest, 1=middle)	0.099 (-0.032-0.229)	0.073 (-0.086-0.233)	0.092 (-0.039-0.223)	0.076 (-0.085-0.236)
Income group 2 (0=lowest, 1=highest)	0.530 (0.334-0.727)	0.360 (0.144-0.576)	0.335 (0.157-0.513)	0.408 (0.178-0.639)
Relationship to household head 1 (0=wife, 1=daughter in law)	0.287 (0.208-0.367)	0.201 (0.125-0.278)	0.203 (0.135-0.271)	0.199 (0.121-0.277)
Relationship to household head 2 (0=wife, 1=other)	-0.015 (-0.240-0.209)	0.067 (-0.172-0.306)	-0.053 (-0.272-0.167)	0.086 (-0.165-0.337)
Maternal education 1 (0=no schooling, 1=primary school)	0.159 (-0.005-0.322)	n/a[4]	n/a[4]	n/a[4]
Maternal education 2 (0=no schooling, 1=Secondary school)	0.303 (0.216-0.390)			
Maternal education 3 (0=no schooling, 1=≥Higher secondary)	0.752 (0.542-0.962)			
Religion 1 (0=Sarna, 1=Hindu)	0.179 (0.042-0.317)	n/a[4]	n/a[4]	n/a[4]

Religion 2 (0=Sarna, 1=Christian)	0.102 (-0.082-0.286)
Religion 3 (0=Sarna, 1=Muslim)	0.490 (0.378-0.602)
Religion 4 (0=Sarna, 1=Other)	-0.123 (-0.428-0.183)

[1]Season of measurement was not significantly associated with MUAC measurement in univariate models (p>0.10) and was not included in the backward stepwise process

[2] Standardised βs for socio-demographic predictors in unadjusted models represent the combined association of each predictor and exposure group with the outcome

[3]ST=Scheduled Tribe, SC=Scheduled Caste, OBC=Other Backwards Class

[4] n/a – removed in backward stepwise process

Appendix 5.9 The association of intervention exposure and key socio-demographic variables with moderate-to-severe malnutrition (MUAC <125mm +/- oedema)in unadjusted and adjusted GEE models

Predictor[1,2]	OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	1.069 (0.749-1.525)	1.074 (0.766-1.507)	1.000 (0.723-1.384)	1.061 (0.754-1.492)
Socioeconomic quintile 1 (0= lowest, 1=second lowest)	0.779 (0.619-0.981)	1.293 (0.983-1.702)	1.099 (0.780-1.548)	1.321 (1.000-1.745)
Socioeconomic quintile 2 (0= lowest, 1=middle)	0.756 (0.596-0.959)	1.315 (1.027-1.684)	1.115 (0.815-1.525)	1.333 (1.041-1.707)
Socioeconomic quintile 3 (0= lowest, 1=second highest)	0.501 (0.370-0.680)	1.814 (1.323-2.486)	1.489 (1.009-2.199)	1.840 (1.345-2.517)
Socioeconomic quintile 4 (0= lowest, 1=highest)	0.391(0.302-0.507)	1.979 (1.479-2.647)	1.610 (1.045-2.479)	1.965 (1.468-2.629)
Social group 1 (0=ST, 1=SC)[3]	0.572 (0.324-1.011)	1.773 (0.958-3.281)	1.590 (0.899-2.815)	1.743 (0.932-3.260)
Social group 2 (0=ST, 1=OBC)[3]	0.460 (0.369-0.572)	1.864 (1.507-2.305)	1.879 (1.490-2.373)	1.872 (1.523-2.300)
Social group 3 (0=ST, 1=other)[3]	0.761 (0.417-1.386)	0.832 (0.527-1.314)	1.062 (0.605-1.866)	0.838 (0.529-1.326)
Maternal age (years)	1.027 (1.009-1.044)	0.991 (0.974-1.008)	0.989 (0.972-1.006)	0.991 (0.974-1.009)
Relationship to household head 1 (0=wife, 1=daughter in law)	0.645 (0.538-0.773)	1.339 (1.125-1.593)	1.390 (1.168-1.654)	1.328 (1.112-1.587)
Relationship to household head 2 (0=wife, 1=other)	0.782 (0.429-1.423)	1.278 (0.692-2.361)	1.201 (0.660-2.184)	1.260 (0.690-2.302)
Income group 1 (0=lowest, 1=middle)	0.879 (0.674-1.148)	n/a[4]	n/a[4]	n/a[4]
Income group 2 (0=lowest, 1=highest)	0.346 (0.190-0.632)			
Maternal education 1 (0=no schooling, 1=primary school)	0.923 (0.640-1.330)	n/a[4]	n/a[4]	n/a[4]
Maternal education 2 (0=no schooling, 1=Secondary school)	0.562 (0.458-0.689)			

Maternal education 3 (0=no schooling, 1=≥Higher secondary)	0.216 (0.087-0.531)

[1]Season of measurement and religion were not significantly associated with MUAC moderate-severe malnutrition in univariate models (p>0.10) and were not included in the backward stepwise process

[2]Odds ratios for socio-demographic predictors in unadjusted models represent the combined association of each predictor and exposure group with the outcome

[3]ST=Scheduled Tribe, SC=Scheduled Caste, OBC=Other Backwards Class

[4] n/a – removed in backward stepwise process

Appendix 5.10 The association of intervention exposure and key socio-demographic variables with Severe malnutrition (MUAC <115mm +/- oedema)in unadjusted and adjusted GEE models

Predictor[1,2]	OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	1.106 (0.648-1.594)	0.858 (0.542-1.359)	0.904 (0.592-1.381)	0.852 (0.528-1.375)
Socioeconomic quintile 1 (0= lowest, 1=second lowest)	0.831 (0.510-1.354)	0.902 (0.543-1.500)	0.912 (0.526-1.582)	0.886 (0.531-1.477)
Socioeconomic quintile 2 (0= lowest, 1=middle)	0.765 (0.499-1.173)	0.704 (0.441-1.124)	0.850 (0.531-1.362)	0.693 (0.432-1.112)
Socioeconomic quintile 3 (0= lowest, 1=second highest)	0.533 (0.305-0.932)	0.605 (0.351-1.043)	0.658 (0.374-1.157)	0.570 (0.322-1.008)
Socioeconomic quintile 4 (0= lowest, 1=highest)	0.288 (0.162-0.511)	0.341 (0.203-0.574)	0.411 (0.216-0.780)	0.341 (0.202-0.507)
Maternal age (years)	1.044 (1.017-1.071)	1.023 (0.996-1.051)	1.024 (0.997-1.052)	1.021 (0.993-1.049)
Relationship to household head 1 (0=wife, 1=daughter in law)	0.440 (0.293-0.660)	0.486 (0.316-0.749)	0.510 (0.336-0.774)	0.498 (0.321-0.771)
Relationship to household head 2 (0=wife, 1=other)	0.600 (0.133-2.707)	0.268 (0.035-2.033)	0.657 (0.146-2.954)	0.275 (0.036-2.087)
Social group 1 (0=ST, 1=SC)[3]	0.143 (0.020-1.009)	n/a[4]	n/a[4]	n/a[4]
Social group 2 (0=ST, 1=OBC)[3]	0.586 (0.381-0.899)			
Social group 3 (0=ST, 1=other)[3]	0.659 (0.188-2.310)			
Income group 1 (0=lowest, 1=middle)	0.634 (0.453-0.885)	n/a[4]	n/a[4]	n/a[4]
Income group 2 (0=lowest, 1=highest)	0.205 (0.047-0.897)			

Maternal education 1 (0=no schooling, 1=primary school)[5]	0.704	n/a[4]	n/a[4]	n/a[4]
Maternal education 2 (0=no schooling, 1=≥Secondary school)[5]	0.410			

[1]Season of measurement and religion were not significantly associated with MUAC moderate-severe malnutrition in univariate models (p>0.10) and were not included in the backward stepwise process

[2]Odds ratios for socio-demographic predictors in unadjusted models represent the combined association of each predictor and exposure group with the outcome

[3]ST=Scheduled Tribe, SC=Scheduled Caste, OBC=Other Backwards Class

[4] n/a – removed in backward stepwise process

[5]The higher two maternal education categories were combined due to small numbers of cases which caused model instability

Appendices: chapter 6

Appendix 6.1 The association between intervention exposure and food intake in pregnancy being the same or more than before pregnancy

Model predictors[1]	Unadjusted OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	4.141 (2.154-7.962)	4.391 (2.386-8.080)	4.364 (2.383-7.991)	4.441 (2.419-8.154)
SES Dummy variable 1 (0= lowest, 1=second lowest)[2]	1.356 (0.781-2.353)	1.357 (0.782-2.357)	1.187 (0.758-1.857)	1.386 (0.796-2.413)
SES Dummy variable 2 (0= lowest, 1=middle)[2]	1.863 (1.005-3.445)	1.847 (0.999-3.416)	1.595 (1.008-2.524)	1.846 (0.997-3.418)
SES Dummy variable 3 (0= lowest, 1=second highest)[2]	1.818 (0.894-3.699)	1.774 (0.878-3.586)	1.528 (0.889-2.624)	1.794 (0.889-3.619)
SES Dummy variable 4 (0= lowest, 1=highest)[2]	2.445 (0.987-6.057)	2.223 (0.923-5.398)	1.904 (0.939-3.859)	2.304 (0.947-5.607)
Social group Dummy variable 1 (0=ST, 1=SC)[3]	1.789 (0.862-3.711)	1.684 (0.764-3.712)	1.610 (0.783-3.310)	1.731 (0.797-3.761)
Social group Dummy variable 2 (0=ST, 1=OBC)[3]	1.342 (0.973-1.852)	1.224 (0.945-1.585)	1.199 (0.909-1.577)	1.206 (0.939-1.550)
Social group Dummy variable 3 (0=ST, 1=other)[3]	2.328 (0.665-8.143)	1.921 (0.606-6.088)	1.962 (0.612-6.296)	1.893 (0.596-6.009)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome
[2]Socioeconomic status
[3]ST=Scheduled Tribe, SC=Scheduled Caste, OBC=Other Backwards Class

Appendix 6.2 The association between intervention exposure and birth spacing (>24 months)

Model predictors[1]	Unadjusted OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	2.049 (1.175-3.571)	2.459 (1.577-3.835)	2.459 (1.577-3.835)	2.379 (1.526-3.708)
Religion 1 (0=Sarna, 1=Hindu)	0.982 (0.629-1.535)	1.947 (1.166-3.253)	1.947 (1.166-3.253)	1.992 (1.179-3.365)
Religion 2 (0=Sarna, 1=Other)	0.995 (0.287-3.457)	0.792 (0.334-1.877)	0.792 (0.334-1.877)	0.805 (0.338-1.921)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome

Appendix 6.3 The association between intervention exposure and iron tablets in pregnancy

Model predictors[1]	Unadjusted OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	1.138 (0.727-1.781)	1.266 (0.803-1.998)	1.311 (0.851-2.021)	1.240 (0.786-1.958)
SES Dummy variable 1 (0= lowest, 1=second lowest)[2]	0.962 (0.727-1.272)	0.956 (0.745-1.227)	0.821 (0.571-1.180)	0.951 (0.736-1.229)
SES Dummy variable 2 (0= lowest, 1=middle)[2]	1.189 (0.824-1.717)	1.265 (0.895-1.788)	1.000 (0.672-1.486)	1.273 (0.894-1.812)
SES Dummy variable 3 (0= lowest, 1=second highest)[2]	1.876 (1.263-2.787)	1.877 (1.262-2.790)	1.404 (0.889-2.216)	1.944 (1.315-2.872)
SES Dummy variable 4 (0= lowest, 1=highest)[2]	2.762 (1.654-4.613)	2.664 (1.543-4.597)	1.888 (1.049-3.401)	2.630 (1.516-4.563)
Household status 1 (0=wife, 1=daughter in law)	2.018 (1.476-2.759)	1.626 (1.207-2.192)	1.719 (1.270-2.325)	1.584 (1.174-2.137)
Household status 2 (0=wife, 1=other)	1.560 (0.812-3.00)	1.395 (0.678-2.873)	1.435 (0.733-2.807)	1.569 (0.678-3.633)
Maternal age	0.955 (0.937-0.973)	0.971 (0.952-0.990)	0.971 (0.953-0.989)	0.969 (0.950-0.989)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome
[2]Socioeconomic status

Appendix 6.4 The association between intervention exposure and attendance for antenatal care

Model predictors[1]	Unadjusted OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	1.359 (0.647-2.855)	1.741 (0.836-3.629)	1.644 (0.807-3.349)	1.746 (0.837-3.639)
SES Dummy variable 1 (0= lowest, 1=second lowest)[2]	1.112 (0.867-1.426)	1.407 (1.162-1.702)	1.147 (0.780-1.687)	1.405 (1.157-1.708)
SES Dummy variable 2 (0= lowest, 1=middle)[2]	1.036 (0.717-1.496)	1.390 (1.022-1.891)	1.091 (0.748-1.592)	1.390 (1.014-1.905)
SES Dummy variable 3 (0= lowest, 1=second highest)[2]	1.979 (1.180-3.319)	2.369 (1.468-3.823)	1.552 (0.884-2.726)	2.403 (1.488-3.880)
SES Dummy variable 4 (0= lowest, 1=highest)[2]	4.860 (2.441-9.679)	4.612 (2.264-9.396)	2.722 (1.242-5.966)	4.856 (2.371-9.946)
Maternal education 1 (0=no schooling, 1=primary school)	1.605 (1.055-2.442)	1.221 (0.775-1.924)	1.303 (0.857-1.979)	1.336 (0.833-2.142)
Maternal education 2 (0=no schooling, 1=Secondary school)	3.075 (2.291-4.129)	1.513 (1.178-1.943)	2.003 (1.474-2.721)	1.487 (1.148-1.926)
Maternal education 3 (0=no schooling, 1=Higher secondary+)	6.736 (2.734-16.598)	1.946 (0.775-4.887)	2.913 (1.163-7.295)	1.858 (0.740-4.664)
Household status 1 (0=wife, 1=daughter in law)	1.981 (1.357-2.892)	1.331 (0.935-1.895)	1.431 (0.983-2.084)	1.300 (0.910-1.857)
Household status 2 (0=wife, 1=other)	1.592 (0.885-2.864)	1.491 (0.821-2.705)	1.374 (0.739-2.555)	1.607 (0.860-3.002)
Religion Dummy variable 1 (0=Sarna, 1=Hindu)	2.176 (1.260-3.756)	2.500 (1.433-4.360)	2.173 (1.287-3.667)	2.523 (1.444-4.409)
Religion Dummy variable 2 (0=Sarna, 1=Other)	1.335 (0.820-2.171)	1.149 (0.821-2.705)	1.154 (0.686-1.941)	1.198 (0.734-1.953)
Maternal age	0.961 (0.939-0.984)	0.991 (0.968-1.014)	0.988 (0.967-1.010)	0.989 (0.965-1.013)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome
[2]Socioeconomic status

Appendix 6.5 The association between intervention exposure and kitchen gardens for own consumption

Model predictors[1]	Unadjusted OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	0.859 (0.405-1.823)	0.936 (0.481-1.820)	0.901 (0.453-1.792)	0.928 (0.475-1.813)
SES Dummy variable 1 (0= lowest, 1=second lowest)[2]	1.775 (1.095-2.876)	1.754 (1.071-2.874)	1.274 (0.791-2.050)	1.774 (1.078-2.919)
SES Dummy variable 2 (0= lowest, 1=middle)[2]	2.152 (1.356-3.417)	2.024 (1.242-3.297)	1.429 (0.927-2.203)	2.025 (1.254-3.270)
SES Dummy variable 3 (0= lowest, 1=second highest)[2]	2.902 (1.682-5.006)	2.101 (1.156-3.818)	1.385 (0.808-2.373)	2.132 (1.167-3.897)
SES Dummy variable 4 (0= lowest, 1=highest)[2]	3.503 (1.611-7.616)	2.232 (1.023-4.869)	1.442 (0.743-2.799)	2.228 (1.014-4.896)
Maternal education 1 (0=no schooling, 1=primary school)	2.186 (1.400-3.412)	1.758 (1.084-2.852)	2.004 (1.240-3.237)	1.673 (1.043-2.684)
Maternal education 2 (0=no schooling, 1=Secondary school)	2.306 (1.748-3.043)	1.686 (1.320-2.152)	1.998 (1.548-2.579)	1.663 (1.302-2.124)
Maternal education 3 (0=no schooling, 1=Higher secondary+)	3.606 (1.722-7.549)	2.490 (1.381-4.489)	2.958 (1.572-5.567)	2.483 (1.369-4.506)
Household status 1 (0=wife, 1=daughter in law)	1.794 (1.222-2.633)	1.611 (1.148-2.260)	1.594 (1.129-2.251)	1.625 (1.162-2.272)
Household status 2 (0=wife, 1=other)	0.803 (0.394-1.638)	0.651 (0.303-1.399)	0.777 (0.393-1.537)	0.668 (0.311-1.433)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome
[2]Socioeconomic status

Appendix 6.6 The association between intervention exposure and being 18 years or older when first married

Model predictors[1]	Unadjusted OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	1.805 (0.688-4.732)	1.529 (0.572-4.087)	1.890 (0.720-4.960)	1.448 (0.536-3.910)
Maternal age	1.094 (1.052-1.137)	1.094 (1.052-1.137)	1.078 (1.042-1.116)	1.089 (1.047-1.133)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome

Appendix 6.7 Core Infant and Young Child Feeding Indicators by exposure group

WHO Core Indicator[1,2,3]		Intervention % (n)	Control % (n)
1. Early initiation of breastfeeding			
	2.00-35.99 months (n=4031)	71.7 (1295)	64.2 (1430)
	2.00-23.99 months (n=2672)	71.0 (853)	63.5 (934)
	2.00-11.99 months (n=1151)	72.9 (382)	65.1 (408)
	12.00-23.99 months (n=1524)	69.4 (471)	62.5 (528)
2. Exclusive breastfeeding under 6 months			
	2.00-5.99 months (n=322)	71.2 (89)	67.0 (132)
	2.00-3.99 months (n=83)	68.2 (15)	78.7 (48)
	4.00-5.99 months (n=239)	71.8 (74)	61.8 (84)
3. Continued breastfeeding at 1 year			
	≥365 and <487 days (n=539)	95.5 (252)	93.8 (258)
4. Introduction of solid, semi-solid and soft foods			
	6.00-8.99 months (n=390)	42.0 (76)	45.0 (94)
5. Minimum dietary diversity (≥4 food groups)			
	6.00-35.99 months (n=3706)	9.3 (156)	7.7 (156)
	6.00-23.99 months (n=2350)	7.2 (78)	5.4 (69)
	6.00-11.99 months (n=829)	3.5 (14)	2.3 (10)
	12.00-17.99 months (n=812)	7.8 (30)	6.1 (26)
6. Minimum meal frequency			
	Breastfed 6.00-23.99 months (n=2074)	61.4 (603)	67.0 (732)
	Non-breastfed 6.00-23.99 months (n=276)	48.4 (46)	55.2 (100)
7. Minimum acceptable diet			
Breastfed	6.00-23.99 months(n=2074)	62.0 (609)	67.2 (734)
	6.00-11.99 months (n=766)	40.4 (153)	44.2 (171)
	12.00-17.99 months (n=722)	69.6 (245)	77.0 (285)
	18.00-23.99 months (n=589)	83.7 (211)	83.1 (280)
Non-breastfed[4]	6.00-23.99 months (n=270)	0.0 (0)	3.3 (6)
8. Consumption of iron-rich or iron-fortified foods[5]			
	6.00-35.99 months (n=3706)	10.4 (174)	12.4 (251)
	6.00-23.99 months (n=2350)	8.4 (91)	9.2 (117)
	6.00-11.99 months (n=829)	3.8 (15)	4.4 (19)
	12.00-17.99 months (n=812)	8.6 (33)	12.1 (52)
	18.00-23.99 months (n=712)	14.5 (43)	11.1 (46)

[1] Includes living children at the time of survey
[2] Missing IYCF data have been re-coded to zero
[3] 3 cases with missing age are included in Indicator 1, 2-35 months
[4] Inadequate sample size for further age disaggregation
[5] Iron fortified foods were not included in the survey: consultation with facilitators suggested low use

Appendix 6.8 Optional Infant and Young Child Feeding Indicators by exposure group

WHO Optional Indicator[1,2,3]	Intervention %(n)	Control % (n)
9. Children ever breastfed		
2.00-35.99 months (n=4031)	98.6 (1780)	98.8 (2199)
2.00-23.99 months (n=2672)	98.4 (1183)	99.0 (1456)
2.00-11.99 months (n=1151)	99.2 (520)	99.0 (621)
12.00-23.99 months (n=1524)	97.8 (664)	99.1 (837)
10. Continued breastfeeding at 2 years		
20.00-23.99 months (n=480)	82.7 (162)	84.9 (241)
11. Age appropriate breastfeeding		
2.00-23.99 months (n=2672)	70.1 (843)	68.2 (1002)
12. Predominant breastfeeding under 6 months		
2.00-5.99 months (n=322)	87.2 (109)	75.6 (149)
13. Median duration of breastfeeding		
2.00-35.99 months (n=4028)	[4]	30.89 (2226)
14. Bottle-feeding[5]		
2.00-35.99 months (n=4031)	16.7 (301)	11.3 (251)
2.00-23.99 months (n=2672)	16.9 (203)	11.5 (169)
2.00-5.99 months (n=322)	12.8 (16)	10.7 (21)
6.00-11.99 months (n=829)	17.3 (69)	14.4 (62)
12.00-23.99 months (n=1524)	17.4 (118)	10.2 (86)
15. Milk feeding frequency for non-breastfed children[6]		
Non breastfed 6.00-23.99 months (n=276)	6.3 (6)	7.2 (13)

[1] Includes living children at the time of survey
[2] Missing IYCF data have been re-coded to zero
[3] Three children with missing age are included in 2.00-35.99 estimates for indicators 9 and 14 only
[4] Median duration of breastfeeding goes beyond the oldest age group (35.99 months) in this subsample
[5] This question is whether the child had ever been fed from a bottle and may over-estimate prevalence of bottle feeding
[6] Inadequate sample size for further age disaggregation

Appendix 6.9 Additional breastfeeding characteristics by exposure group

Aspect of breastfeeding		Intervention %(n)	Control % (n)
Pre-lacteal feeds – what was fed to the baby when first born?	Breast milk	91.9 (1659)	88.1 (1962)
	Other	7.7 (140)	10.7 (238)
	Unknown/missing	0.4 (6)	1.2 (26)
Pre-lacteal feeds specified[1] (multiple categories possible)	Cow's milk (powder/fresh)	26.4 (37)	16.0 (38)
	Goat's milk	20.7 (29)	24.8 (59)
	Honey/honey water	21.1 (31)	55.0 (131)
	Rice/rice water	6.4 (9)	0.4 (1)
	Sugar/sugar water	18.6 (26)	2.9 (7)
	Herbs/traditional medicine	2.9 (4)	0.8 (2)
Initial breastfeeding[2] difficulties	No difficulty	33.1 (589)	92.9 (2042)
	Baby had difficulty	2.8 (50)	2.2 (49)
	Mother had difficulty	2.1 (37)	4.9 (108)
	Unknown/missing	62.0 (1104)	-
Duration of breastfeeding Problem[3]	Stopped breastfeeding	-	4.9 (12)
	<24 hours	-	3.7 (9)
	1-2 days	-	23.3 (57)
	3-7 days	-	17.6 (43)
	1-2 weeks	-	3.7 (9)
	2 weeks or more	-	9.8 (24)
	Unknown/missing	100.0 (87)	2.5 (4)
Colostrum discarded prior to beginning breastfeeding[2]	Yes	1.9 (33)	20.9 (459)
	No	36.2 (644)	79.0 (1737)
	Unknown/missing	62.0 (1103)	0.1 (3)
Other modes of giving breastmilk (by another woman, cup/spoon/bottle/other way)	Yes	9.4 (170)	10.9 (243)
	No	89.4 (1613)	87.9 (1957)
	Unknown/missing	1.3 (22)	1.2 (26)

[1]Denominator is number of respondents reporting giving something other than breast milk at birth
[2]Denominator is number of respondents reporting that their child has been breastfed (ever breastfed)
[3]Denominator is number of respondents reporting that the baby or mother had difficulty breastfeeding

Appendix 6.10 The association between intervention exposure and early initiation of breastfeeding

Model predictors[1]	Unadjusted OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	1.413 (0.580-3.442)	1.410 (0.585-3.394)	1.405 (0.898-2.200)	1.430 (0.591-3.548)
Maternal education 1 (0=no schooling, 1=primary school)	0.662(0.456-0.960)	0.624 (0.429-0.908)	0.623 (0.515-0.755)	0.627 (0.424-0.928)
Maternal education 2 (0=no schooling, 1=Secondary school)	0.963 (0.671-1.382)	0.912 (0.639-1.301)	0.912 (0.761-1.094)	0.901 (0.630-1.290)
Maternal education 3 (0=no schooling, 1=Higher secondary+)	1.535 (0.761-3.097)	1.378 (0.668-2.844)	1.377 (0.952-1.993)	1.367 (0.665-2.809)
Household status 1 (0=wife, 1=daughter in law)	0.718 (0.499-1.031)	0.700 (0.486-1.009)	0.699 (0.580-0.842)	0.708 (0.493-1.018)
Household status 2 (0=wife, 1=other)	1.782 (0.907-3.503)	1.758 (0.902-3.429)	1.755 (1.248-2.467)	1.736 (0.895-3.369)
Social group Dummy variable 1 (0=ST, 1=SC)[3]	1.316 (0.788-2.198)	1.390 (0.835-2.314)	1.390 (0.835-2.314)	1.478 (0.908-2.407)
Social group Dummy variable 2 (0=ST, 1=OBC)[3]	1.507 (1.079-2.105)	1.596 (1.163-2.190)	1.593 (1.356-1.872)	1.615 (1.178-2.215)
Social group Dummy variable 3 (0=ST, 1=other)[3]	1.296 (0.446-3.772)	1.354 (0.480-3.817)	1.352 (0.481-3.801)	1.366 (0.485-3.851)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome
[2]Socioeconomic status
[3]ST=Scheduled Tribe, SC=Scheduled Caste, OBC=Other Backwards Class

Appendix 6.11 The association between intervention exposure and pre-lacteal feeding

Model predictors[1]	Unadjusted OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	0.696 (0.302-1.603)	0.665 (0.292-1.512)	0.667 (0.293-1.520)	0.670 (0.292-1.537)
SES Dummy variable 1 (0= lowest, 1=second lowest)[2]	1.236 (0.791-1.932)	1.230 (0.804-1.881)	1.211 (0.844-1.736)	1.234 (0.802-1.899)
SES Dummy variable 2 (0= lowest, 1=middle)[2]	1.358 (0.841-2.193)	1.295 (0.817-2.051)	1.274 (0.903-1.799)	1.290 (0.797-2.087)
SES Dummy variable 3 (0= lowest, 1=second highest)[2]	1.595 (0.924-2.755)	1.409 (0.824-2.409)	1.385 (0.909-2.111)	1.438 (0.838-2.466)
SES Dummy variable 4 (0= lowest, 1=highest)[2]	1.547 (0.698-3.043)	0.976 (0.493-1.933)	0.975 (0.554-1.714)	1.007 (0.509-1.993)
Social group Dummy variable 1 (0=ST, 1=SC)[3]	3.100 (1.632-5.890)	3.432 (1.781-6.614)	3.121 (1.674-5.819)	3.488 (1.816-6.698)
Social group Dummy variable 2 (0=ST, 1=OBC)[3]	2.575 (1.558-4.257)	2.733 (1.666-4.485)	2.696 (1.664-4.368)	2.694 (1.634-4.441)
Social group Dummy variable 3 (0=ST, 1=other)[3]	2.293 (0.854-6.158)	2.541 (0.988-6.533)	2.493 (0.977-6.363)	2.504 (0.978-6.413)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome
[2]Socioeconomic status

Appendix 6.12 The association between intervention exposure and exclusive breastfeeding in children under six months

Model predictors[1]	Unadjusted OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	1.217 (0.620-2.390)	1.246 (0.669-2.318)	1.246 (0.669-2.318)	1.214 (0.640-2.303)
Income group Dummy variable 1 (0=lowest, 1=middle)	0.802 (0.401-1.603)	0.802 (0.401-1.603)	0.802 (0.401-1.603)	0.861 (0.442-1.677)
Income group Dummy variable 2 (0=lowest, 1=highest)	0.492 (0.251-0.963)	0.492 (0.251-0.963)	0.492 (0.251-0.963)	0.498 (0.253-0.980)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome

Appendix 6.13 The association between intervention exposure and bottle-feeding

Model predictors[1]	Unadjusted OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	1.575 (0.854-2.903)	1.463 (0.841-2.545)	1.499 (0.859-2.617)	1.458 (0.841-2.528)
SES Dummy variable 1 (0= lowest, 1=second lowest)[2]	1.763 (1.216-2.558)	1.905 (1.288-2.816)	1.348 (0.844-2.153)	1.895 (1.280-2.805)
SES Dummy variable 2 (0= lowest, 1=middle)[2]	1.724 (1.252-2.374)	1.775 (1.298-2.816)	1.273 (0.854-1.897)	1.785 (1.309-2.434)
SES Dummy variable 3 (0= lowest, 1=second highest)[2]	2.291(1.453-3.613)	2.322 (1.493-3.610)	1.640 (0.985-2.732)	2.376 (1.527-3.699)
SES Dummy variable 4 (0= lowest, 1=highest)[2]	2.429 (1.457-4.051)	2.273 (1.372-3.765)	1.617 (0.937-2.789)	2.300 (1.399-3.783)
Household status 1 (0=wife, 1=daughter in law)	1.367 (0.990-1.888)	1.343 (1.007-1.791)	1.312 (0.970-1.776)	1.357 (1.018-1.809)
Household status 2 (0=wife, 1=other)	1.629 (0.849-3.124)	1.657 (0.815-3.371)	1.613 (0.863-3.017)	1.664 (0.808-3.425)
Maternal age	0.964 (0.941-0.988)	0.974 (0.953-0.996)	0.975 (0.954-0.996)	0.974 (0.953-0.996)
Season measured (0=winter, 1=summer)	0.310 (0.196-0.491)	0.226 (0.144-0.355)	0.293 (0.187-0.460)	0.215 (0.136-0.340)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome
[2]Socioeconomic status

Appendix 6.14 The association between intervention exposure and the introduction of solid, semi-solid and soft foods (6.00-8.99 months)

Model predictors[1]	Unadjusted OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	0.886 (0.504-1.557)	1.161 90.638-2.112)	0.848 (0.462-1.556)	1.166 (0.638-2.132)
SES Dummy variable 1 (0= lowest, 1=second lowest)[2]	2.198 (0.750-6.446)	2.198 (0.750-6.446)	1.286 (0.505-3.279)	2.303 (0.791-6.706)
SES Dummy variable 2 (0= lowest, 1=middle)[2]	2.405 (1.140-5.074)	2.405 (1.140-5.074)	1.362 (0.668-2.776)	2.404 (1.140-5.069)
SES Dummy variable 3 (0= lowest, 1=second highest)[2]	2.408 (1.154-5.026)	2.408 (1.154-5.026)	1.454 (0.687-3.076)	2.342 (1.140-4.811)
SES Dummy variable 4 (0= lowest, 1=highest)[2]	2.183(0.933-5.110)	2.183 (0.933-5.110)	1.318 (0.584-2.974)	2.181 (0.934-5.092)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome
[2]Socioeconomic status

Appendix 6.15 The association between intervention exposure and minimum feeding frequency (6.00-23.99 months)

Model predictors[1]	Unadjusted OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	0.782 (0.490-1.250)	0.770 (0.483-1.229)	0.744 (0.468-1.183)	0.763 (0.478-1.219)
SES Dummy variable 1 (0= lowest, 1=second lowest)[2]	1.340 (0.956-1.877)	1.486 (1.048-2.108)	1.067 (0.671-1.697)	0.518 (1.070-2.152)
SES Dummy variable 2 (0= lowest, 1=middle)[2]	1.690 (1.160-2.463)	1.822 (1.254-2.649)	1.270 (0.795-2.032)	1.828 (1.250-2.673)
SES Dummy variable 3 (0= lowest, 1=second highest)[2]	1.402 (0.950-2.069)	1.465 (0.993-2.160)	1.075 (0.656-1.764)	1.469 (0.993-2.172)
SES Dummy variable 4 (0= lowest, 1=highest)[2]	1.117 (0.656-1.903)	1.346 (0.821-2.206)	0.890 (0.514-1.539)	1.351 (0.822-2.221)
Maternal age	1.031 (1.005-1.059)	1.032 (1.008-1.058)	1.028 (1.004-1.052)	1.032 (1.007-1.058)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome
[2]Socioeconomic status

Appendix 6.16 Childhood immunisations, vitamin A supplementation and treatment for intestinal worms in children 12.00 -23.99 months by exposure group (n=1524)[1,2]

Vaccination	Completion	Intervention % (n)	Control % (n)
Full immunisation[3]	Yes	71.9 (488)	62.7 (530)
	No	27.7 (188)	36.0 (304)
	Missing/Don't know	0.4 (3)	1.3 (11)
BCG	Yes	97.3 (661)	93.1 (787)
	No	2.7 (18)	6.9 (58)
DPT 1	Yes	97.5 (662)	94.3 (797)
	No	2.5 (17)	5.7 (48)
DPT 2	Yes	94.3 (640)	88.2 (745)
	No	5.7 (39)	11.7 (99)
	Missing/Don't know	-	0.1 (1)
DPT 3	Yes	85.9 (583)	82.5 (697)
	No	14.1 (96)	17.0 (144)
	Missing/Don't know	-	0.5 (4)
DPT – All doses	Yes	85.9 (583)	82.2 (695)
	No	14.1 (96)	17.3 (146)
	Missing/Don't know	-	0.5 (4)
Polio 1	Yes	97.6 (663)	95.9 (810)
	No	2.4 (16)	4.1 (35)
Polio 2	Yes	96.6 (656)	93.3 (788)
	No	3.4 (23)	6.7 (57)
Polio 3	Yes	92.8 (630)	88.8 (750)
	No	7.1 (48)	11.2 (95)
	Missing/Don't know	0.1 (1)	-
Polio – All doses	Yes	92.3 (627)	88.5 (748)
	No	7.5 (51)	11.5 (97)
	Missing/Don't know	0.2 (1)	-
Measles	Yes	77.0 (523)	64.9 (548)
	No	22.7 (154)	34.2 (289)
	Missing/Don't know	0.3 (2)	0.9 (8)
Vitamin A dose (last 6 months)	Yes	72.9 (495)	58.8 (497)
	No	27.0 (183)	40.0 (338)
	Missing/Don't know	0.1 (1)	1.2 (10)
Treatment for intestinal worms (last 6 months)[4]	Yes	24.6 (167)	21.9 (184)
	No	75.0 (509)	76.4 (646)
	Missing/Don't know	0.4 (3)	1.7 (15)

[1]Age range chosen to allow comparison with National Family Health Survey data
[2]Vaccination cards were available for 66% (n=1006) of children aged 12.00 to 23.99 months; maternal report was used for children without vaccination cards
[3]Full immunisation defined as children 12.00-23.99 months who have received BCG, measles and three doses each of DPT and Polio vaccinations
[4]Not available from National Family Health Survey state factsheets

Appendix 6.17 Current child diarrhoea, home management and associated healthcare seeking by exposure group

Aspect of diarrhoeal illness		Intervention % (n)	Control % (n)
Diarrhoeal prevalence and severity			
Diarrhoea in the last 14 days[1]	Yes	20.1 (364)	22.9 (509)
	No	79.8 (1440)	77.0 (1714)
	Missing	0.1 (1)	0.1 (3)
Blood present in the stool[2]	Yes	18.1 (66)	15.9 (81)
	No	81.9 (298)	84.1 (428)
Current diarrhoea[2]	Yes	23.1 (84)	13.2 (67)
	No	76.9 (280)	86.8 (442)
Home-management of diarrhoea			
Quantity of liquids/ breastmilk given[2]	None	6.0 (22)	2.8 (14)
	Less than usual	27.5 (100)	38.3 (195)
	Same as usual	54.4 (198)	41.8 (213)
	More than usual	12.1 (44)	17.1 (87)
Quantity of food given[2]	Stopped food	6.3 (23)	3.9 (20)
	Less than usual	35.7 (130)	51.3 (261)
	Same as usual	39.8 (145)	28.5 (145)
	More than usual	1.9 (7)	3.5 (18)
	Continued EBF[3]	16.2 (59)	12.8 (65)
Healthcare seeking for child diarrhoea			
Was advice sought?[2]	Yes	54.4 (198)	47.7 (243)
	No	45.6 (166)	52.3 (266)
Advice source used (first point of contact)	Anganwadi worker	13.1 (26)	28.0 (68)
	ASHA[5]	7.6 (15)	4.5 (11)
	Auxiliary Nurse Midwife	9.1 (18)	4.1 (10)
	Women'sgroup member	4.5 (9)	6.6 (16)
	Other[6]	65.7 (130)	56.8 (138)
Treatment seeking for child diarrhoea			
Treatment seeking (multi-option)[2]	Sub-centre	11.3 (41)	12.8 (65)
	Missing sub-centre	0.3 (1)	-
	Primary healthcare centre	11.3 (41)	24.8 (126)
	Other Govt. hospital	9.9 (36)	4.7 (24)
	Private facility	34.6 (126)	28.1 (143)
	None of the above	34.6 (126)	32.2 (164)
	Missing	0.3 (1)	-
Treatment decided at home/ prescribed (multi-option)[2]	Oral Rehydration Solution	43.4 (158)	37.9 (193)
	Missing	0.8 (3)	-
	Gruel (rice/local grain)	38.7 (141)	42.8 (218)
	Missing	0.5 (2)	-
	Breastfeeding	64.8 (236)	70.7 (360)
	Missing	1.1 (4)	-
	Other[7]	22.3 (81)	13.8 (70)
	Missing	1.1 (4)	-
	None of the above	1.6 (6)	1.6 (8)
	Missing	0.8 (3)	-

[1]Diarrhoea defined as loose stools > 3 times per day

[2]Denominator taken as the total 'yes' responses to diarrhoea within the last 14 days
[3]Exclusive breastfeeding
[4]Denominator taken as the total 'yes' responses to healthcare seeking for diarrhoea within the last 14 days
[5]Accredited Social Health Activist
[6]Traditional medicine/faith healer/village doctor/homeopathy (n=59); Pharmacy (n=5); Private doctor/centre (n=33); CHC/PHC/Clinic/doctor/'medical' (n=131); Sub-centre (n=2); Family member (n=26); Government hospital/hospital (n=10); Non-health NGO (n=1); not specified (n=1)
[7]Treated/untreated water (n=20); 'syrups'/'tablets'/'medicine'/'vitamins' (n=83); traditional medicine/village doctor (n=18); soft food/rice/milk/bottle (n=8); n=3 gave multiple responses; n=26 did not specify 'other'

Appendix 6.18 Current child fever, home management and associated healthcare seeking by exposure group

Aspect of fever		Intervention % (n)	Control % (n)
Fever prevalence			
Fever in the last 14 days	Yes	21.2 (383)	28.0 (622)
	No	78.7 (1421)	71.9 (1601)
	Missing	0.1 (1)	0.1 (3)
Current fever[1]	Yes	31.1 (119)	19.1 (119)
	No	68.9 (264)	80.9 (503)
Home-management of fever			
Quantity of liquids/ breastmilk given[1]	None	1.8 (7)	1.9 (12)
	Less than usual	37.1 (142)	45.3 (282)
	Same as usual	53.0 (203)	41.2 (256)
	More than usual	8.1 (31)	11.6 (72)
Quantity of food given[1]	Stopped food	15.4 (59)	10.5 (65)
	Less than usual	39.7 (152)	56.1 (349)
	Same as usual	43.6 (167)	29.4 (183)
	More than usual	1.3 (5)	4.0 (25)
Healthcare seeking for child fever			
Was advice sought?[1]	Yes	57.4 (220)	57.9 (360)
	No	42.3 (162)	42.1 (262)
	Missing	0.3 (1)	-
Advice source used (first point of contact)[2]	Anganwadi worker	9.5 (21)	21.4 (77)
	ASHA[3]	7.2 (16)	10.0 (36)
	Auxiliary Nurse Midwife	11.8 (26)	4.2 (15)
	Women's group member	10.0 (22)	10.8 (39)
	Other[4]	61.1 (135)	53.6 (193)
	Missing	0.5 (1)	-
Treatment seeking (multi-option)[1]	Sub-centre	10.7 (41)	12.2 (76)
	Missing	-	0.2 (1)
	Primary healthcare centre	7.0 (27)	25.7 (160)
	Other Govt. hospital	13.6 (52)	5.0 (31)
	Missing	-	0.2 (1)
	Private facility	38.4 (147)	29.7 (185)
	Missing	-	0.2 (1)
	None of the above	31.6 (121)	32.8 (204)
	Missing	-	0.2 (1)

[1]Denominator taken as the total 'yes' responses to fever within the last 14 days
[2]Denominator taken as the total 'yes' responses to healthcare seeking for fever within the last 14 days
[3]Accredited Social Health Activist
[4]Faith healer/Village doctor/Homeopathy (n=59); Pharmacy (n=3); Private doctor/centre (n=37); CHC/PHC/Clinic/doctor/'medical'/Block (n=156); Sub-centre (n=1); Family member (n=21); Government hospital/hospital (n=17); Non-health NGO (n=1); not specified (n=3)

Appendix 6.19 Current child cough, home management and associated healthcare seeking by exposure group

Aspect of cough		Intervention % (n)	Control % (n)
Cough prevalence and severity			
Cough in the last 14 days	Yes	25.7 (463)	28.5 (634)
	No	74.3 (1342)	71.4 (1589)
	Missing	-	0.1 (1)
Cough + atypical breathing[1,2]	Yes	64.5 (298)	69.1 (439)
	No	35.5 (164)	30.9 (196)
Cough + chest problem/ blocked or runny nose	Yes	81.0 (374)	68.8 (437)
	No	19.0 (88)	31.2 (198)
Current cough[1]	Yes	53.1 (246)	45.9 (291)
	No	46.9 (217)	54.1 (343)
Home-management of cough			
Quantity of liquids/ breastmilk given[1]	None	4.3 (20)	4.7 (30)
	Less than usual	30.5 (141)	47.5 (301)
	Same as usual	61.3 (284)	41.6 (264)
	More than usual	3.9 (18)	6.2 (39)
Quantity of food given[1]	Stopped food	11.2 (52)	12.1 (77)
	Less than usual	34.8 (161)	52.3 (332)
	Same as usual	53.1 (246)	32.8 (208)
	More than usual	0.9 (4)	2.7 (17)
Healthcare seeking for child cough			
Was advice sought?[1]	Yes	35.4 (164)	33.4 (212)
	No	64.6 (299)	66.6 (422)
Advice source used (first point of contact)[3]	Anganwadi worker	9.8 (16)	13.2 (28)
	ASHA[4]	6.1 (10)	5.2 (11)
	Auxiliary Nurse Midwife	7.9 (13)	7.1 (15)
	Women's group member	11.0 (18)	9.0 (19)
	Other[5]	65.2 (107)	65.6 (139)
Treatment seeking *(multi-option)*[1]	Sub-centre	6.0 (28)	5.5 (35)
	Missing	-	0.2 (1)
	Primary healthcare centre	5.4 (25)	27.1 (172)
	Missing	-	0.2 (1)
	Other Govt. Hospital	8.2 (38)	3.6 (23)
	Missing	-	0.2 (1)
	Private facility	36.1 (167)	24.8 (157)
	Missing	-	02 (1)
	None of the above	44.7 (207)	40.1 (254)
	Missing	-	0.2 (1)

[1]Denominator taken as the total 'yes' responses to cough within the last 14 days
[2]Atypical breathing defined as 'breathing faster than usual/short rapid breaths or difficulty breathing'
[3]Denominator taken as the total 'yes' responses to healthcare seeking for cough within the last 14 days
[4]Accredited Social Health Activist
[5]Traditional medicine/faith healer/village doctor/homeopathy (n=42); Pharmacy (n=4); Private doctor/centre (n=25); CHC/PHC/Clinic/doctor/Block/'medical' total (n=138); Sub-centre (n=2); Family member (n=23); Government hospital/hospital (n=10); Non-health NGO (n=2)

Appendix 6.20 The association between intervention exposure and feeding the child the same or more than usual during diarrhoea, fever and cough

Model predictors[1]	Unadjusted OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	1.928 (0.942-3.946)	1.965 (0.970-3.979)	1.946 (0.982-3.855)	1.988 (0.979-4.037)
SES Dummy variable 1 (0= lowest, 1=second lowest)[2]	1.065 (0.725-1.565)	0.993 (0.660-1.493)	0.898 (0.609-1.324)	1.001 (0.658-1.524)
SES Dummy variable 2 (0= lowest, 1=middle)[2]	1.392 (0.953-2.034)	1.220 (0.838-1.776)	1.070 (0.749-1.527)	1.216 (0.833-1.776)
SES Dummy variable 3 (0= lowest, 1=second highest)[2]	1.575 (0.940-2.639)	1.342 (0.804-2.241)	1.161 (0.721-1.868)	1.341 (0.797-2.257)
SES Dummy variable 4 (0= lowest, 1=highest)[2]	1.414 (0.700-2.858)	1.323 (0.648-2.702)	1.148 (0.605-2.178)	1.299 (0.637-2.646)
Religion Dummy variable 1 (0=Sarna, 1=Hindu)	0.726 (0.403-1.308)	0.723 (0.387-1.351)	0.738 (0.406-1.342)	0.733 (0.392-1.371)
Religion Dummy variable 2 (0=Sarna, 1=Other)	2.168 (1.173-4.009)	1.952 (1.027-3.708)	2.102 (1.135-3.893)	2.219 (1.066-4.618)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome
[2]Socioeconomic status

Appendix 6.21The association between intervention exposure and giving the child the same or greater than usual the amount of liquids during diarrhoea, fever and cough

Model predictors[1]	Unadjusted OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	1.382 (0.582-3.281)	1.364 (0.653-2.849)	1.406 (0.644-3.071)	1.384 (0.661-2.894)
SES Dummy variable 1 (0= lowest, 1=second lowest)[2]	1.203 (0.873-1.658)	0.983 (0.689-1.403)	0.960 (0.681-1.352)	0.992 (0.704-1.399)
SES Dummy variable 2 (0= lowest, 1=middle)[2]	1.808 (1.230-2.656)	1.296 (0.822-2.045)	1.266 (0.828-1.934)	1.306 (0.828-2.060)
SES Dummy variable 3 (0= lowest, 1=second highest)[2]	2.125 (1.144-3.948)	1.276 (0.641-2.540)	1.225 (0.711-2.111)	1.264 (0.632-2.527)
SES Dummy variable 4 (0= lowest, 1=highest)[2]	1.559 (0.525-4.632)	1.060 (0.403-2.790)	1.050 (0.480-2.294)	1.065 (0.407-2.787)
Religion Dummy variable 1 (0=Sarna, 1=Hindu)	0.386 (0.194-0.768)	0.419 (0.202-0.870)	0.414 (0.206-0.831)	0.430 (0.207-0.890)
Religion Dummy variable 2 (0=Sarna, 1=Other)	0.676 (0.338-1.351)	0.631 (0.296-1.345)	0.623 (0.301-1.290)	0.642 (0.304-1.355)
Maternal education 1 (0=no schooling, 1=primary school)	1.532 (0.790-2.972)	1.496 (0.699-3.205)	1.548 (0.745-3.217)	1.495 (0.698-3.205)
Maternal education 2 (0=no schooling, 1=Secondary school)	1.512 (0.802-2.848)	1.490 (0.813-2.731)	1.508 (0.867-2.625)	1.500 (0.810-2.778)
Maternal education 3 (0=no schooling, 1=Higher secondary+)	6.059 (0.743-49.437)	7.523 (0.866-65.384)	7.593 (0.919-62.751)	7.772 (0.900-67.118)
Income group Dummy variable 1 (0=lowest, 1=middle)	1.713 (0.994-2.952)	1.436 (0.754-2.734)	1.481 (0.767-2.859)	1.429 (0.749-2.727)
Income group Dummy variable 2 (0=lowest, 1=highest)	0.564 (0.193-1.654)	0.490 (0.208-1.154)	0.496 (0.217-1.136)	0.452 (0.188-1.085)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome
[2]Socioeconomic status

Appendix 6.22 The association between intervention exposure and using Oral Rehydration Solution for child diarrhoea in the last 14 days

Model predictors[1]	Unadjusted OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	1.274 (0.529-3.072)	1.310 (0.648-2.648)	1.227 (0.598-2.518)	1.309 (0.647-2.649)
SES Dummy variable 1 (0= lowest, 1=second lowest)[2]	0.654 (0.413-1.036)	0.844 (0.527-1.351)	0.805 (0.516-1.256)	0.836 (0.518-1.350)
SES Dummy variable 2 (0= lowest, 1=middle)[2]	0.578 (0.321-1.042)	0.882 (0.497-1.565)	0.817 (0.478-1.397)	0.882 (0.496-1.567)
SES Dummy variable 3 (0= lowest, 1=second highest)[2]	0.700 (0.364-1.346)	1.227 (0.725-2.077)	1.114 (0.677-1.834)	1.189 (0.698-2.028)
SES Dummy variable 4 (0= lowest, 1=highest)[2]	0.806 (0.345-1.885)	0.991 (0.360-2.726)	0.899 (0.374-2.160)	
Religion Dummy variable 1 (0=Sarna, 1=Hindu)	5.163 (2.910-9.161)	5.214 (2.921-9.306)	5.106 (2.874-9.070)	5.229 (2.957-9.244)
Religion Dummy variable 2 (0=Sarna, 1=Other)	0.978 (0.378-2.526)	0.906 (0.350-2.347)	0.940 (0.370-2.388)	0.917 (0.356-2.363)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome
[2]Socioeconomic status

Appendix 6.23 The association between intervention exposure and treatment seeking from formal healthcare providers for child cough with atypical breathing in the last 14 days

Model predictors[1]	Unadjusted OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	1.046 (0.336-3.259)	1.505 (0.545-4.161)	1.285 (0.451-3.663)	1.487 (0.539-4.108)
SES Dummy variable 1 (0= lowest, 1=second lowest)[2]	0.755 (0.397-1.433)	0.727 (0.382-1.382)	0.648 (0.325-1.294)	0.724 (0.375-1.400)
SES Dummy variable 2 (0= lowest, 1=middle)[2]	1.053 (0.641-1.731)	0.976 (0.603-1.580)	0.847 (0.492-1.458)	0.958 (0.593-1.549)
SES Dummy variable 3 (0= lowest, 1=second highest)[2]	1.333 (0.526-3.377)	1.261 (0.503-3.162)	1.067 (0.467-2.436)	1.223 (0.483-3.092)
SES Dummy variable 4 (0= lowest, 1=highest)[2]	5.658 (2.210-14.489)	1.609 (1.650-12.874)	3.251 (1.146-9.226)	4.685 (1.633-13.439)
Social group Dummy variable 1 (0=ST, 1=SC)[3]	9.019 (1.770-45.956)	15.385 (1.772-133.576)	8.436 (1.595-44.600)	15.446 (1.784-133.761)
Social group Dummy variable 2 (0=ST, 1=OBC)[3]	2.458 (1.331-4.540)	1.622 (0.846-3.108)	1.850 (0.997-3.432)	1.729 (0.909-3.288)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome
[2]Socioeconomic status
[3]ST=Scheduled Tribe, SC=Scheduled Caste, OBC=Other Backwards Class

Appendix 6.24 The association between intervention exposure and uptake of child measles vaccination (9.00-35.00 months)

Model predictors[1]	Unadjusted OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	1.673 (0.898-3.115)	2.019 (1.089-3.743)	1.987 (1.076-3.6660	1.999 (1.076-3.714)
SES Dummy variable 1 (0= lowest, 1=second lowest)[2]	1.501 (1.073-2.099)	1.531 (1.104-2.129)	1.375 (0.956-1.977)	1.510 (1.089-2.093)
SES Dummy variable 2 (0= lowest, 1=middle)[2]	1.834 (1.261-2.666)	1.807 (1.273-2.565)	1.642 (1.155-2.334)	1.809 (1.276-2.564)
SES Dummy variable 3 (0= lowest, 1=second highest)[2]	2.594 (1.568-4.293)	2.373 (1.462-3.851)	2.137 (1.293-3.533)	2.381 (1.454-3.899)
SES Dummy variable 4 (0= lowest, 1=highest)[2]	3.710 (2.069-6.653)	3.055 (1.650-5.655)	2.553 (1.378-4.733)	2.984 (1.612-5.524)
Social group Dummy variable 1 (0=ST, 1=SC)[3]	2.335 (1.307-4.170)	1.866 (1.046-3.330)	2.028 (1.186-3.466)	1.835 (1.029-3.270)
Social group Dummy variable 2 (0=ST, 1=OBC)[3]	2.416 (1.727-3.380)	1.818 (1.310-2.523)	1.927 (1.407-2.639)	1.802 (1.293-2.511)
Social group Dummy variable 3 (0=ST, 1=other)[3]	1.497 (0.718-3.122)	1.271 (0.554-2.915)	1.097 (0.545-2.207)	1.274 (0.557-2.915)
Household status 1 (0=wife, 1=daughter in law)	1.706 (1.222-2.383)	1.618 (1.144-2.288)	1.513 (1.093-2.092)	1.609 (1.137-2.277)
Household status 2 (0=wife, 1=other)	1.638 (0.930-2.885)	1.573 (0.912-2.712)	1.496 (0.857-2.610)	1.572 (0.910-2.716)
Maternal age	0.972 (0.951-0.992)	0.995 (0.972-1.018)	0.992 (0.970-1.014)	0.994 (0.971-1.018)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome
[2]Socioeconomic status
[3]ST=Scheduled Tribe, SC=Scheduled Caste, OBC=Other Backwards Class

Appendix 6.25 The association between intervention exposure and uptake of routine child deworming medication (12.00-35.99 months)

Model predictors[1]	Unadjusted OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	1.181 (0.506-2.758)	1.043 (0.440-2.469)	1.089 (0.460-2.581)	1.057 (0.443-2.524)
SES Dummy variable 1 (0= lowest, 1=second lowest)[2]	0.796 (0.553-1.146)	0.916 (0.661-1.268)	0.932 (0.673-1.291)	0.894 (0.646-1.237)
SES Dummy variable 2 (0= lowest, 1=middle)[2]	0.676 (0.450-1.013)	0.795 (0.495-1.278)	0.807 (0.518-1.259)	0.794 (0.490-1.286)
SES Dummy variable 3 (0= lowest, 1=second highest)[2]	0.600 (0.351-1.027)	0.675 (0.390-1.168)	0.692 (0.409-1.170)	0.675 (0.384-1.189)
SES Dummy variable 4 (0= lowest, 1=highest)[2]	0.424 (0.196-0.917)	0.434 (0.198-0.949)	0.450 (0.212-0.955)	0.428 (0.193-0.950)
Household status 1 (0=wife, 1=daughter in law)	1.448 (1.057-1.984)	1.451 (1.046-.012)	1.446 (1.044-2.003)	1.482 (1.066-2.061)
Household status 2 (0=wife, 1=other)	1.686 (0.948-2.997)	1.795 (0.952-3.384)	1.745 (0.967-3.150)	1.803 (0.951-3.419)
Religion Dummy variable 1 (0=Sarna, 1=Hindu)	1.807 (0.814-4.009)	1.640 (0.719-3.739)	1.670 (0.735-3.795)	1.658 (0.723-3.801)
Religion Dummy variable 2 (0=Sarna, 1=Other)	1.945 (0.995-3.804)	2.011 (1.045-3.866)	2.013 (1.038-3.904)	2.031 (1.049-3.932)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome
[2]Socioeconomic status

Appendix 6.26 Hygiene and sanitation indicators by exposure group

Indicator		Intervention % (n)	Control % (n)
Sufficient living area	Yes (≤ 3)	37.3 (673)	40.9 (910)
(persons per bedroom)[1,2]	No (>3)	62.6 (1131)	59.0 (1315)
	Missing/unknown	0.1 (1)	0.1 (1)
Indoor air pollution			
Cooking fuel (multi-option)	Wood/leaves	97.8 (1766)	97.0 (2160)
	Charcoal[3]	1.4 (26)	3.8 (85)
	Dung	9.5 (172)	11.2 (250)
	Coal[3]	2.2 (40)	13.0 (290)
	Oil/Kerosene/Gas	0.3 (5)	0.3 (6)
Cooking facility (multi-option)	Stove[3]	0.4 (8)	0.8 (18)
	Chullah	3.3 (60)	14.3 (318)
	Open fire	99.0 (1787)	97.7 (2174)
Cooking area	In the house	72.3 (1305)	62.8 (1399)
	In a separate room	22.4 (405)	30.6 (682)
	Outdoors	5.3 (95)	6.5 (145)
Access to safe drinking water			
Source of drinking water[4]	Unimproved	35.4 (638)	35.3 (787)
	Other improved	63.8 (1152)	64.5 (1435)
	Piped into dwelling	0.7 (13)	0.1 (2)
	Missing/unknown	01 (2)	0.1 (2)
Availability of drinking water by season[5, 6]	Summer	97.0 (1058)	96.6 (1331)
	Winter	99.7 (1088)	99.6 (1373)
	Rainy	99.6 (1087)	98.4 (1356)
Time taken to collect water	Accessible (≤30)	93.7 (1692)	90.3 (2011)
and return (minutes)[7]	Not accessible (>30)	6.3 (113)	9.7 (215)
Treatment of drinking water[8]	No treatment	62.9 (1135)	80.7 (1796)
	Physical treatment	31.5 (568)	18.6 (414)
	Chemical treatment	4.8 (87)	0.5 (11)
	Missing/unknown	0.8 (15)	0.2 (5)
Source of water (not for	Unimproved	24.8 (448)	38.4 (856)
Drinking but other	Other improved	75.0 (1353)	61.5 (1369)
household purposes)[4]	Piped into dwelling	0.1 (2)	0.1 (1)
	Missing/unknown	0.1 (2)	-
Toilet facilities and faeces disposal			
Toilet facilities for	Open defecation	99.3 (1792)	99.2 (2208)
household members	Unimproved[9]	0.6 (12)	0.8 (18)
	Missing/unknown	0.1 (1)	-
Disposal of children's faeces	Children use the latrine	0.6 (10)	0.5 (11)
(unprompted, multi-response)	Throw outside	97.9 (1767)	97.3 (2166)
	Throw into latrine	1.2 (22)	0.8 (17)
	Rinse away	42.0 (758)	29.2 (651)
	Bury/cover with mud/ash	12.3 (222)	3.0 (66)
	Wash away/mix with cow dung	5.1 (92)	-
	Missing/unknown	0.2 (4)	-
Hand washing			
Hand washing agents	None/plain water	68.2 (1231)	87.2 (1941)

generally used (unprompted, multi-response)	Soap/Detergent	35.6 (642)	9.4 (209)
	Ash	14.4 (260)	2.5 (55)
	Mud	12.6 (227)	12.1 (269)
	Missing/unknown	2.1 (38)	-
Occasions when detergent/ soap/cleansing agent are used for hand washing (unprompted, multi-response)	After use of toilet	40.4 (729)	14.3 (319)
	Before eating	28.1 (507)	54.7 (1218)
	After cleaning up child faeces	30.9 (558)	6.4 (143)
	After eating	6.0 (109)	0.9 (21)
	Before preparing food	7.2 (130)	0.4 (9)
	Before feeding a child	0.8 (15)	1.3 (30)
Other text recoded (additional responses)	Whilst bathing	27.6 (499)	31.9 (709)
	When washing clothes	5.5 (100)	-
	Washing utensils	0.3 (5)	-
	Does not use soap	17.3 (312)	0.2 (4)
	Missing/unknown	2.0 (36)	0.1 (1)

[1]Estimated size of room is not available
[2]Definition UN (2011)
[3] Missing data 0.1% (n=2)
[4]Improved: Household connection, Public standpipe, Borehole, Protected dug well, Protected spring
Rainwater collection; Unimproved: Unprotected well, Unprotected spring, Rivers or ponds, Vendor-provided water, Bottled water*, Tanker truck water (WHO 2004)
[5]Denominator – those answering main drinking water source as 'tube well/bore hole' (61.3% n=2469)
[6] Missing Summer 0.1% (n=1); Winter and Rainy missing 0.1 (2)
[7]International Water and Sanitation Centre (2004)
[8]Physical treatments: Boil, strain, filter, stand and settle; Chemical treatments: Bleach/Chlorine/Calcium Carbonate/alum (WHO 2011)
[9]Unimproved: pit, hanging and bucket latrines

Appendix 6.27 The association between intervention exposure and washing hands with soap after defecation

Model predictors[1]	Unadjusted OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	4.188 (1.717-10.214)	5.354 (1.801-15.915)	5.234 (1.940-14.119)	5.340 (1.778-16.042)
SES Dummy variable 1 (0= lowest, 1=second lowest)[2]	2.316 (1.451-3.696)	1.476 (0.871-2.500)	1.170 (0.767-1.783)	1.467 (0.868-2.481)
SES Dummy variable 2 (0= lowest, 1=middle)[2]	3.240 (1.751-5.994)	2.032 (0.972-4.248)	1.448 (0.893-2.347)	2.015 (0.959-4.233)
SES Dummy variable 3 (0= lowest, 1=second highest)[2]	2.869 (1.337-6.154)	1.544 0.545-4.378)	1.070 (0.538-2.132)	1.552 (0.534-4.512)
SES Dummy variable 4 (0= lowest, 1=highest)[2]	6.944 (2.205-21.866)	3.018 (0.758-12.011)	2.095 (0.821-5.348)	2.924 (0.722-11.837)
Maternal education 1 (0=no schooling, 1=primary school)	1.329 (0.914-1.933)	1.115 (0.755-1.645)	1.093 (0.758-1.575)	1.119 (0.749-1.672)
Maternal education 2 (0=no schooling, 1=Secondary school)	1.790 (1.193-2.684)	1.119 (0.719-1.740)	1.205 (0.824-1.762)	1.134 (0.725-1.775)
Maternal education 3 (0=no schooling, 1=Higher secondary+)	5.781 (2.170-15.404)	2.814 (1.221-6.485)	3.224 (1.447-7.183)	2.821 (1.214-6.557)
Social group Dummy variable 1 (0=ST, 1=SC)[3]	1.341 (0.640-2.810)	2.325 (1.041-5.196)	2.468 (1.205-5.055)	2.375 (1.068-5.280)
Social group Dummy variable 2 (0=ST, 1=OBC)[3]	1.884 (1.211-2.932)	3.205 (1.896-5.417)	3.380 (2.058-5.550)	3.231 (1.933-5.399)
Social group Dummy variable 2 (0=ST, 1=Other)[3]	4.149 (1.550-11.101)	6.260 (1.611-24.327)	5.994 (1.855-19.374)	6.329 (1.657-24.177)
Season measured (0=winter, 1=summer)	0.569 0.361-0.896	0.595 (0.334-1.059)	0.615 (0.375-1.007)	0.594 (0.327-1.080)
Income group Dummy variable 1 (0=lowest, 1=middle)	1.302 (0.631-2.685)	1.125 (0.608-2.082)	1.210 (0.632-2.316)	1.124 (0.605-2.086)
Income group Dummy variable 2 (0=lowest, 1=highest)	4.300 (2.492-7.418)	3.357 (1.985-5.676)	3.362 (2.113-5.349)	3.558 (2.113-5.994)
Household status 1 (0=wife, 1=daughter in law)	0.590 (0.357-0.974)	0.558 (0.326-0.954)	0.501 (0.286-0.879)	0.567 (0.332-0.969)
Household status 2 (0=wife, 1=other)	1.219 (0.562-2.642)	1.357 (0.676-2.723)	1.277 (0.605-2.695)	1.260 (0.655-2.388)
Religion Dummy variable 1 (0=Sarna, 1=Hindu)	0.499 (0.262-0.949)	0.266 (0.114-0.621)	0.272 (0.132-0.560)	0.262 (0.112-0.611)
Religion Dummy variable 2 (0=Sarna, 1=Other)	0.644 (0.367-1.129)	0.484 (0.261-0.900)	0.499 (0.283-0.877)	0.476 (0.255-0.887)
Maternal age	0.959 (0.933-0.986)	0.966 (0.942-0.990)	0.962 (0.940-0.985)	0.967 (0.943-0.991)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome
[2]Socioeconomic status
[3]ST=Scheduled Tribe, SC=Scheduled Caste, OBC=Other Backwards Class

Appendix 6.28 The association between intervention exposure and washing hands with soap after cleaning up a child who has defecated

Model predictors[1]	Unadjusted OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	6.709 (2.875-15.656)	11.696 (5.268-25.969)	9.752 (4.411-21.559)	11.591 (5.183-25.921)
SES Dummy variable 1 (0= lowest, 1=second lowest)[2]	2.822 (1.879-4.237)	2.410 (1.653-3.512)	1.288 (0.777-2.135)	2.387 (1.621-3.515)
SES Dummy variable 2 (0= lowest, 1=middle)[2]	4.436 (2.648-7.430)	3.329 (1.904-5.821)	1.759 (1.020-3.034)	3.336 (1.902-5.851)
SES Dummy variable 3 (0= lowest, 1=second highest)[2]	4.430 (2.621-7.486)	2.769 (1.388-5.524)	1.266 (0.613-2.611)	2.737 (1.334-5.615)
SES Dummy variable 4 (0= lowest, 1=highest)[2]	12.251 (7.632-19.664)	7.160 (4.068-12.601)	2.897 (1.362-6.163)	6.847 (3.873-12.106)
Income group Dummy variable 1 (0=lowest, 1=middle)	0.993 (0.404-2.446)	0.856 (0.383-1.915)	0.850 (0.361-2.000)	0.864 (0.387-1.933)
Income group Dummy variable 2 (0=lowest, 1=highest)	3.536 (2.159-5.791)	2.987 (1.653-5.396)	2.415 (1.439-4.050)	3.127 (1.794-5.449)
Maternal education 1 (0=no schooling, 1=primary school)	1.117 (0.690-1.808)	0.798 (0.497-1.280)	0.925 (0.567-1.510)	0.803 (0.495-1.304)
Maternal education 2 (0=no schooling, 1=Secondary school)	2.373(1.534-3.671)	1.244 (0.782-1.978)	1.667 (1.056-2.631)	1.272 (0.801-2.021)
Maternal education 3 (0=no schooling, 1=Higher secondary+)	5.484 (2.543-11.828)	2.625 (1.196-5.764)	3.174 (1.460-6.903)	2.634 (1.199-5.786)
Social group Dummy variable 1 (0=ST, 1=SC)[3]	1.691 (0.793-3.607)	2.037 (1.113-3.729)	2.838 (1.442-5.586)	2.060 (1.137-3.731)
Social group Dummy variable 2 (0=ST, 1=OBC)[3]	1.862 (1.227-2.824)	2.733 (1.668-4.475)	3.149 (1.834-5.407)	2.829 (1.750-4.571)
Social group Dummy variable 2 (0=ST, 1=Other)[3]	1.857 (0.615-5.610)	1.663 (0.433-6.385)	1.986 (0.477-8.268)	1.699 (0.447-6.453)
Household status 1 (0=wife, 1=daughter in law)	0.536 (0.295-0.973)	0.456 (0.273-0.761)	0.461 (0.271-0.785)	0.459 (0.274-0.770)
Household status 2 (0=wife, 1=other)	0.739 (0.405-1.349)	0.833 (0.446-1.556)	0.777 (0.413-1.463)	0.839 (0.452-1.558)
Religion Dummy variable 1 (0=Sarna, 1=Hindu)	0.554 (0.323-0.949)	0.315 (0.176-0.565)	0.299 (0.170-0.526)	0.312 (0.175-0.555)
Religion Dummy variable 2 (0=Sarna, 1=Other)	1.030 (0.577-1.838)	0.916 (0.523-1.604)	0.889 (0.513-1.540)	0.904 (0.510-1.600)
Maternal age	0.965 (0.935-0.996)	0.975 (0.950-1.002)	0.975 (0.949-1.002)	0.976 (0.949-1.003)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome
[2]Socioeconomic status
[3]ST=Scheduled Tribe, SC=Scheduled Caste, OBC=Other Backwards Class

Appendix 6.29 The association between intervention exposure and washing hands with soap before eating

Model predictors[1]	Unadjusted OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	0.332 (0.119-0.930)	0.243 (0.096-0.613)	0.240 (0.095-0.607)	0.246 (0.097-0.621)
SES Dummy variable 1 (0= lowest, 1=second lowest)[2]	3.374 (2.348-4.848)	2.342 (1.775-3.090)	1.501 (0.806-2.799)	2.314 (1.756-3.049)
SES Dummy variable 2 (0= lowest, 1=middle)[2]	4.855 (2.805-8.404)	2.823 (1.835-4.343)	1.789 (1.021-3.135)	2.798 (1.809-4.327)
SES Dummy variable 3 (0= lowest, 1=second highest)[2]	7.440 (3.655-15.144)	4.265 (2.515-7.232)	2.585 (1.284-5.206)	4.222 (2.487-7.167)
SES Dummy variable 4 (0= lowest, 1=highest)[2]	8.154 (3.301-20.142)	4.867 (2.362-10.027)	2.914 (1.300-6.531)	4.858 (2.353-10.030)
Religion Dummy variable 1 (0=Sarna, 1=Hindu)	0.184 (0.088-0.384)	0.084 (0.034-0.207)	0.083 (0.035-0.195)	0.083 (0.034-0.207)
Religion Dummy variable 2 (0=Sarna, 1=Christian)	0.345 (0.105-1.129)	0.317 (0.095-1.061)	0.343 (0.107-1.094)	0.326 (0.099-1.079)
Religion Dummy variable 1 (0=Sarna, 1=Muslim)	3.607 (0.355-36.659)	1.169 (0.150-9.118)	1.239 (0.165-9.291)	1.162 (0.149-9.034)
Religion Dummy variable 2 (0=Sarna, 1=Other)	0.497 (0.180-1.370)	0.437 (0.087-2.198)	0.373 (0.093-1.500)	0.437 (0.086-2.213)
Social group Dummy variable 1 (0=ST, 1=SC)[3]	0.956 (0.450-2.034)	5.523 (2.661-11.462)	5.900 (2.962-11.753)	3.118 (1.314-7.395)
Social group Dummy variable 2 (0=ST, 1=OBC)[3]	1.498 (1.007-2.230)	3.171 (1.359-7.403)	3.746 (1.689-8.311)	5.691 (2.701-11.992)
Social group Dummy variable 2 (0=ST, 1=Other)[3]	1.377 (0.481-3.937)	2.424 (1.051-5.593)	2.726 (1.194-6.222)	2.459 (1.062-5.693)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome
[2]Socioeconomic status
[3]ST=Scheduled Tribe, SC=Scheduled Caste, OBC=Other Backwards Class

Appendix 6.30 The association between intervention exposure and treatment of drinking water

Model predictors[1]	Unadjusted OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	2.439 (0.904-6.578)	4.363 (1.631-11.671)	3.211 (1.198-8.608)	4.316 (1.599-11.651)
SES Dummy variable 1 (0= lowest, 1=second lowest)[2]	1.991 (1.374-2.885)	2.000 (1.349-2.965)	1.382 (0.820-2.329)	1.976 (1.328-2.941)
SES Dummy variable 2 (0= lowest, 1=middle)[2]	2.284 (1.378-3.786)	2.258 (1.263-4.037)	1.511 (0.894-2.555)	2.231 (1.240-4.016)
SES Dummy variable 3 (0= lowest, 1=second highest)[2]	3.571 (1.935-6.592)	2.708 (1.241-5.909)	1.793 (0.871-3.691)	2.695 (1.224-5.934)
SES Dummy variable 4 (0= lowest, 1=highest)[2]	6.100 (3.201-11.622)	4.013 (1.877-8.579)	2.524 (1.179-5.404)	3.990 (1.846-8.628)
Maternal education 1 (0=no schooling, 1=primary school)	1.899 (1.182-3.053)	1.712 (1.138-2.574)	1.626 (0.987-2.679)	1.820 (1.207-2.744)
Maternal education 2 (0=no schooling, 1=Secondary school)	2.340 (1.738-3.149)	1.533 (1.096-2.143)	1.624 (1.169-2.256)	1.550 (1.108-2.168)
Maternal education 3 (0=no schooling, 1=Higher secondary+)	3.618 (1.892-6.918)	2.362 (1.136-4.907)	2.194 (1.063-4.529)	2.364 (1.137-4.912)
Season measured (0=winter, 1=summer)	0.538 (0.295-0.981)	0.436 (0.223-0.852)	0.548 (0.290-1.037)	0.427 (0.217-0.814)
Income group Dummy variable 1 (0=lowest, 1=middle)	0.601 (0.339-1.067)	0.529 (0.297-0.945)	0.555 (0.311-0.992)	0.524 (0.291-0.941)
Income group Dummy variable 2 (0=lowest, 1=highest)	3.527 (1.322-9.408)	1.338 (0.620-2.886)	2.139 (0.810-5.649)	1.310 (0.597-2.876)
Maternal age	0.962 (0.927-0.999)	0.983 (0.950-1.018)	0.981 (0.952-1.010)	0.983 (0.950-1.017)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome
[2]Socioeconomic status

Appendix 6.31 Health and nutrition services: utilisation and provision by exposure group

Aspect of health/nutrition services		Intervention % (n)	Control % (n)
Quality and access to health services beyond primary care			
Access to a community fund in event of serious illness	Yes	32.9 (594)	15.0 (334)
	No	66.9 (1207)	85.0 (1982)
	Missing	0.2 (4)	-
Distance to travel to reach private health facility /government hospital	<5kms	28.5 (514)	22.5 (500)
	5-10kms	31.9 (576)	30.4 (677)
	>10kms	22.5 (407)	19.0 (423)
	Missing/not attended	17.1 (308)	28.1 (626)
Perceived quality of care[1]	Very good	6.4 (96)	3.9 (62)
	Good	66.8 (999)	67.6 (1082)
	Fair	24.7 (371)	24.4 (390)
	Not so good	2.0 (30)	4.2 (67)
	Missing	0.1 (1)	-
Community-based health/nutrition services for pregnant women and mothers with children <3 years			
Antenatal care/visits[2] (for child in the survey)	Yes	75.8 (1368)	69.8 (1554)
	No	24.0 (434)	30.1 (670)
	Missing/unknown	0.2 (3)	0.1 (2)
Postnatal care/visits[3] (for child in the survey)	Yes	33.7 (608)	31.1 (693)
	No	66.1 (1193)	68.8 (1531)
	Missing/unknown	0.2 (4)	0.1 (2)
Frequency of food rations given to children aged ≥6 months in the last 3 months[4,5]	Almost daily	4.2 (70)	3.4 (68)
	≥ once per week	4.2 (71)	5.3 (108)
	≥ once per month	73.2 (1227)	72.6 (1473)
	≤ once in two months	2.7 (45)	0.8 (17)
	No food rations	13.3 (224)	16.5 (335)
	Missing/unknown	2.4 (40)	1.4 (28)
Frequency of food rations given to mothers with children <6 months in the last 3 months[5,6]	Almost daily	0.8 (1)	0.5 (1)
	≥ once per week	30.4 (38)	36.0 (71)
	≥ once per month	51.2 (63)	34.5 (68)
	≥ once in three months	0.8 (1)	4.6 (9)
	No food rations	11.2 (14)	21.4 (42)
	Missing/unknown	5.6 (7)	3.0 (6)
Frequency of growth monitoring by the Anganwadi Worker (AWW) in the last 3 months	≥ once per month	63.1 (1139)	65.9 (1467)
	≥ once in three months	21.5 (388)	14.6 (324)
	Not measured at all	13.6 (245)	18.9 (420)
	Missing/unknown	1.8 (33)	0.7 (15)
Nutritional counselling given post-weighing by AWW, ICDS[7] worker or ANM[8,9]	Yes	64.4 (983)	40.0 (716)
	No	35.2 (537)	59.7 (1070)
	Missing/unknown	0.5 (7)	0.3 (5)
Other sources of nutritional counselling ever received (not AWW, ICDS worker or ANM[10])	ASHA	1.3 (23)	1.4 (31)
	Ekjutfacilitator/member/monitor	45.2 (815)	n/a
	Doctor	0.1 (2)	0.2 (5)
	Family or community member	-	0.2 (5)
Maternal perception and care-seeking for undernutrition of children <3 years			
Maternal perception of	Underweight	23.4 (422)	9.2 (204)

Underweight	About the right weight	75.1 (1356)	88.9 (1979)
	Overweight	1.4 (25)	1.7 (37)
	Missing	0.1 (2)	0.3 (6)
Maternal healthcare seeking	Yes	28.8 (520)	24.6 (547)
Specifically for child	No	70.9 (1280)	75.1 (1673)
'Thinness'/'smallness'	Missing	0.3 (5)	0.3 (6)

[1]Denominator is those who have attended a private facility or government hospital
[2]ANC visits – number expected in rural areas and by whom
[3]PNC visits – number expected in rural areas and by whom
[4] Food ration entitlements for ≥ 6 months
[5] Three children with missing age were excluded from age-group specific analyses
[6] Food ration entitlements for mothers with children < 6 months are
[7] Integrated Child Development Services
[8]Auxiliary Nurse Midwife (ANM)
[9]Denominator is respondents saying their child had been weighed at least once in the last three months
[10] No other source 78.0%; n=3144 (Intervention 53.5% n=966; Control 97.8% n=2178); Missing 0.2%; n=7 (Intervention 0.1% n=1; Control 0.1% n=1)

Appendix 6.32 The association between intervention exposure and uptake of Anganwadi growth monitoring services

Model predictors[1]	Unadjusted OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	0.913 (0.434-1.919)	0.923 (0.443-1.923)	0.922 (0.634-1.341)	0.919 (0.441-1.917)
Season measured (0=winter, 1=summer)	1.521 (1.083-2.136)	1.446 (1.041-2.010)	1.459 (1.231-1.729)	1.401 (1.004-1.956)
Religion Dummy variable 1 (0=Sarna, 1=Hindu)	1.228 (0.732-2.061)	1.463 (0.767-2.790)	1.460 (1.050-2.028)	1.443 (0.756-2.753)
Religion Dummy variable 2 (0=Sarna, 1=Christian)	2.523 (1.530-4.158)	2.482 (1.513-4.071)	2.480 (1.927-3.1910	2.523 (1.531-4.159)
Religion Dummy variable 1 (0=Sarna, 1=Muslim)	5.196 (2.810-9.610)	19.691 (8.050-48.165)	19.623 (8.018-48.028)	19.327 (7.896-47.308)
Religion Dummy variable 2 (0=Sarna, 1=Other)	0.836 (0.369-1.896)	1.116 (0.426-2.920)	1.115 (0.683-1.822)	1.109 (0.426-2.888)
Social group Dummy variable 1 (0=ST, 1=SC)[3]	0.890 (0.387-2.044)	0.714 (0.300-1.700)	0.717 (0.302-1.703)	0.750 (0.310-1.818)
Social group Dummy variable 2 (0=ST, 1=OBC)[3]	0.774 (0.534-1.124)	0.642 (0.366-1.125)	0.642 (0.482-0.855)	0.635 (0.363-1.113)
Social group Dummy variable 2 (0=ST, 1=Other)[3]	0.440 (0.205-0.946)	0.252 (0.131-0.486)	0.253 (0.131-0.488)	0.255 (0.132-0.492)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome
[2]ST=Scheduled Tribe, SC=Scheduled Caste, OBC=Other Backwards Class

Appendix 6.33 The association between intervention exposure and maternal awareness of child underweight

Model predictors[1]	Unadjusted OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	2.738 (1.174-6.386)	3.027 (1.593-5.755)	3.026 (1.587-5.768)	2.971 (1.558-5.664)
SES Dummy variable 1 (0= lowest, 1=second lowest)[2]	0.517 (0.320-0.835)	0.800 (0.548-1.168)	0.928 (0.613-1.406)	0.800 (0.541-1.184)
SES Dummy variable 2 (0= lowest, 1=middle)[2]	0.382 (0.224-0.535)	0.620 (0.406-0.946)	0.723 (0.482-1.085)	0.615 (0.403-0.941)
SES Dummy variable 3 (0= lowest, 1=second highest)[2]	0.334 (0.209-0.535)	0.482 (0.322-0.719)	0.584 (0.364-0.938)	0.487 (0.328-0.725)
SES Dummy variable 4 (0= lowest, 1=highest)[2]	0.150 (0.074-0.301)	0.183 (0.096-0.350)	0.254 (0.124-0.517)	0.179 (0.096-0.336)
Household status 1 (0=wife, 1=daughter in law)	1.802 (1.055-3.079)	1.458 (0.996-2.135)	1.479 (0.990-2.208)	1.454 (0.998-2.118)
Household status 2 (0=wife, 1=other)	1.623 (0.792-3.328)	1.204 (0.595-2.437)	1.428 (0.770-2.647)	1.247 (0.616-2.525)
Religion Dummy variable 1 (0=Sarna, 1=Hindu)	5.723 (3.080-10.633)	4.810 (2.731-8.473)	5.211 (2.899-9.367)	4.868 (2.735-8.666)
Religion Dummy variable 2 (0=Sarna, 1=Other)	3.165 (1.271-7.879)	3.400 (1.437-8.040)	3.333 (1.409-7.884)	3.145 (1.346-7.352)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome
[2]Socioeconomic status

Appendix 6.34 Perinatal and neonatal characteristics by exposure group

Characteristic		Intervention % (n)	Control % (n)
Sex	Boy	50.2 (907)	50.8 (1130)
	Girl	49.8 (898)	49.2 (1096)
Season of birth[1]	Summer	33.6 (606)	30.9 (688)
	Rainy	37.6 (679)	38.1 (847)
	Winter	28.8 (520)	31.0 (691)
Estimated duration of pregnancy (months)	Mean (SD) 95% CIs[2]	9.23 (0.51) 9.18-9.28	9.27 (0.52) 9.23-9.32
	Median	9.00	9.00
	Unknown/missing	0.2 (4)	4.4 (99)
Mother perceived child to be born...	Early	3.6 (66)	3.1 (69)
	On time	93.6 (1689)	89.4 (1989)
	Late	2.7 (48)	7.2 (161)
	Unknown/missing	0.1 (2)	0.3 (7)
Maternal perception of child size at birth	Smaller than average	34.9 (631)	17.3 (384)
	Normal size	64.8 (1169)	75.2 (1675)
	Larger than average	0.2 (3)	7.4 (165)
	Missing/unknown	0.1 (2)	0.1 (2)
Birth weight (grams)	Mean (SD)	2770.18 (493.98)	2739.19 (543.30)
	95% CIs[2]	2719.54-2820.81	2689.08-2789.29
	Median	2950.00	2750.00
	Weight not taken	76.8 (1387)	71.7 (1595)
	Missing/unknown	2.8 (50)	7.3 (164)
Birth order	1st born	21.0 (379)	27.4 (610)
	2nd born	26.2 (473)	23.6 (526)
	3rd born	20.6 (372)	17.7 (394)
	4th born or more	31.9 (576)	31.2 (695)
	Missing/unknown	0.3 (5)	0.1(1)
Delivery location	Government facility	17.7 (319)	14.0 (312)
	Private facility	4.0 (72)	5.7 (127)
	Provider's home	0 (0)	0.5 (11)
	Any other home	77.0 (1390)	79.6 (1772)
	Other[3]	1.2 (22)	0.1 (2)
	Missing/unknown	0.1 (2)	0.1 (2)
Mode of delivery	Normal vaginal	97.9 (1767)	97.5 (2171)
	Vaginal (vacuum)	0.4 (6)	0.3 (6)
	Vaginal (forceps)	0.2 (4)	0 (0)
	Emergency Caesarean	0.8 (15)	1.4 (32)
	Elective Caesarean	0.1 (2)	0.7 (16)
	Caesarean (unknown)	0.5 (9)	0 (0)
	Missing/unknown	0.1 (2)	0.1 (1)
Which part of the baby came out first?	Head	98.2 (1772)	96.8 (2154)
	Feet	0.7 (12)	0.1 (2)
	Missing/unknown	1.1 (21)	3.1 (70)

[1] Summer=March to June, Rainy=July to October, Winter=November to February
[2] Confidence intervals
[3] Other includes n=1 outside, n=1 en-route to hospital, n=22 other not specified

Appendix 6.35 Recurrence of childhood illness/sickness by exposure group

Type of recurrence		Intervention % (n)	Control % (n)
History of repeated episodes (all children n=4301):			
Diarrhoea	Yes	29.7 (536)	25.3 (563)
	No	70.2 (1268)	73.4 (1635)
	Don't know/missing	0.1 (1)	1.3 (28)
Fever	Yes	33.2 (599)	39.9 (887)
	No	66.8 (1206)	58.9 (1312)
	Don't know/missing	-	1.2 (27)
Cough	Yes	31.6 (570)	30.0 (667)
	No	68.4 (1235)	68.8 (1531)
	Don't know/missing	-	1.2 (28)
Frequency of general illness/sickness:			
In the last 6 months	None	30.2 (506)	23.5 (477)
(children 6.00-35.99 months)[1]	1-2 times	44.4 (745)	45.3 (920)
	3-4 times	19.3 (324)	23.0 (466)
	5-6 times	2.9 (49)	5.7 (115)
	7+ times	1.6 (26)	1.8 (36)
	Don't know/missing	1.6 (27)	0.7 (15)
Since birth	None	39.2 (49)	42.6 (84)
(children 2.00-5.99 months)[1]	1-2 times	52.0 (65)	47.2 (93)
	3-4 times	8.0 (10)	9.1 (18)
	5-6 times	-	1.0 (2)
	7+ times	0.8 (1)	-

[1]Three children with missing age were excluded from specific age groupings

Appendix 6.36 Current maternal diet and health by exposure group: % (n) unless otherwise stated

Maternal factor		Intervention % (n)	Control % (n)
Dietary indicators			
BMI[1]	Mean (SD) 95%CI	18.52 (1.82) 18.43-18.61	18.51 (1.85) 18.43-18.59
Underweight	BMI<18.5	52.9 (890)	54.2 (1126)
Severe underweight	BMI<16.0	6.0 (101)	6.4 (132)
	Unknown/missing	0.1 (2)	-
Number of small and main meals (last 24 hours)[2]	0-1	3.9 (67)	3.4 (70)
	2	36.1 (615)	40.8 (843)
	3	53.5 (911)	46.1 (952)
	>3	6.5 (110)	9.7 (200)
Foods eaten (last 24 hours)[2,3]	Grain, roots, tubers	99.4 (1693)	98.9 (2043)
	Legumes, nuts	36.9 (629)	35.2 (726)
	Milk, yoghurt, cheese	1.9 (33)	1.5 (30)
	Flesh foods	16.8 (286)	16.9 (349)
	Eggs	1.9 (33)	2.3 (47)
	Vit A-rich fruit/veg	72.6 (1236)	76.6 (1582)
	Other fruit/veg	26.0 (443)	24.6 (509)
Number of food groups eaten (last 24 hours)[2,3]	0-1	7.4 (126)	8.7 (179)
	2	44.7 (762)	40.7 (841)
	3	34.2 (583)	38.1 (787)
	4-6	13.6 (232)	12.5 (258)
Maternal physical health			
Non-pregnancy physical problems affecting work/ activities (last 3 months)	Yes – illness	25.3 (457)	26.9 (598)
	Yes - injury	1.9 (34)	1.1 (24)
	No	72.8 (1314)	72.1 (1604)
Days affected	Mean (SD) 95%CI[4,5]	5.09 (5.14) 4.64-5.55	7.98 (10.87) 7.12-8.84
	Unknown/missing	-	0.5 (3)
Maternal mental health			
Psychological distress (last 4 weeks; (K10 score)[6]	None/mild (10-15)	91.9% (n=1658)	88.0% (n=1958)
	Moderate (16-30)	7.4% (n=134)	11.9% (n=264)
	Severe (31-50)	0.3% (n=5)	0.1% (n=3)
	Mean (sd) 95%CI[5]	11.37 (3.40) 11.21-11.53	11.84 (3.21) 11.71-11.98
	Unknown/missing	0.4 (8)	0.1 (1)
Days severely affected	Mean (SD) 95%CI[5,7,8]	2.08 (3.64) 1.72-2.45	3.25 (4.42) 2.96-3.53
	Unknown/missing	21.3 (109)	0.5 (5)
Days moderately affected [9]	Mean (SD) 95%CI[5,7,]	10.73 (12.02) 9.53-11.93	9.35 (10.94) 8.65-10.06
	Unknown/missing	21.1 (108)	0.5 (5)
Times seen a health professional in this episode[5,7]	Mean (SD) 95%CI	0.16 (0.58) 0.10-0.22	0.28 (1.34) 0.19-0.37
	Unknown/missing	22.7 (116)	0.5 (5)
Extent that these feelings are attributed to physical causes	None of the time	31.7 (162)	20.6 (192)
	A little of the time	22.7 (116)	40.9 (380)
	Some of the time	23.3 (119)	34.7 (323)
	Most of the time	2.3 (12)	2.4 (22)
	All of the time	1.2 (6)	0.9 (8)
	Unknown/missing	18.8 (96)	0.5 (5)

[1]Body Mass Index=weight (kg)/height (metres squared); excludes pregnant women
[2]Denominator is the number of respondents for whom the previous day was not a festival affecting food consumption/quantity or type (n=263/6.5% of total sample); missing cases recoded to zero (n≤13 for 14 disaggregated food items)
[3]Checklist yes/no format for a series of food groups; sourced from WHO 2010
[4]Denominator is the number respondents reporting a physical health problem (from illness/injury) in the previous 3 months
[5]Standard deviation and 95% confidence intervals
[6]Kessler Psychological Distress Scale/K-10
[7]Denominator is the number of respondents who answered 'a little of the time' to 'a lot of the time' to at least one of the 10 k-10 questions (i.e. a score >10)
[8]Severely affected = totally unable to work, study or manage day to day activities due to those feelings
[9]Moderately affected = able to work, study and manage daily activities, but had to cut-down due to those feelings

Appendix 6.37 The association between intervention exposure and maternal perception that the child was average or larger than average size at birth

Model predictors[1]	Unadjusted OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	0.388 (0.114-1.315)	0.313 (0.087-1.127)	0.328 (0.096-1.114)	0.315 (0.087-1.140)
SES Dummy variable 1 (0= lowest, 1=second lowest)[2]	0.470 (0.228-0.967)	0.829 (0.469-1.466)	0.980 (0.506-1.899)	0.859 (0.479-1.543)
SES Dummy variable 2 (0= lowest, 1=middle)[2]	0.319 (0.151-0.671)	0.511 (0.248-1.050)	0.725 (0.402-1.308)	0.514 (0.249-1.058)
SES Dummy variable 3 (0= lowest, 1=second highest)[2]	0.300 (0.120-0.747)	0.517 (0.200-1.338)	0.739 (0.353-1.547)	0.523 (0.202-1.356)
SES Dummy variable 4 (0= lowest, 1=highest)[2]	0.196 (0.063-0.611)	0.392 (0.117-1.321)	0.560 (0.223-1.407)	0.403 (0.118-1.372)
Season measured (0=winter, 1=summer)	1.616 (1.160-2.251)	1.477 (0.898-2.428)	1.506 1.027 2.211	1.431 (0.886-2.312)
Religion Dummy variable 1 (0=Sarna, 1=Hindu)	1.999(1.027-3.893)	3.659 (1.626-8.232)	3.625 (1.652-7.954)	3.685 (1.635-8.304)
Religion Dummy variable 2 (0=Sarna, 1=Christian)	17.987 (6.197-52.209)	22.404 (8.137-61.689)	18.590 (6.248-55.306)	32.695 (9.320-114.698)
Religion Dummy variable 1 (0=Sarna, 1=Muslim)	0.212 (0.080-0.561)	0.579 (0.135-2.472)	0.803 (0.222-2.902)	0.575 (0.134-2.464)
Religion Dummy variable 2 (0=Sarna, 1=Other)	2.982 (0.436-20.400)	3.218 (0.394-26.302)	4.520 (0.594-34.372)	3.225 (0.397-26.216)
Social group Dummy variable 1 (0=ST, 1=SC)[3]	0.600 (0.295-1.222)	0.334 (0.146-0.763)	0.312 (0.157-0.621)	0.353 (0.151-0.826)
Social group Dummy variable 2 (0=ST, 1=OBC)[3]	0.558 (0.373-0.836)	0.291 (0.164-0.516)	0.298 (0.167-0.534)	0.289 (0.161-0.518)
Social group Dummy variable 2 (0=ST, 1=Other)[3]	0.391 (0.124-1.234)	0.389 (0.106-1.433)	0.314 (0.101-0.979)	0.387 (0.105-1.421)
Maternal age	1.040 (1.007-1.074)	1.030 (0.999-1.062)	1.034 (1.006-1.064)	1.029 (0.998-1.062)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome
[2]Socioeconomic status
[3]ST=Scheduled Tribe, SC=Scheduled Caste, OBC=Other Backwards Class

Appendix 6.38 The association between intervention exposure and maternal perception that the child was born early

Model predictors[1]	Unadjusted OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	1.184 (0.637-2.201)	1.327 (0.710-2.480)	1.327 (0.710-2.480)	1.296 (0.682-2.465)
Income group Dummy variable 1 (0=lowest, 1=middle)	0.704 (0.482-1.026)	0.704 (0.482-1.026)	0.704 (0.482-1.026)	0.743 (0.503-1.097)
Income group Dummy variable 2 (0=lowest, 1=highest)	3.105 (1.232-7.829)	3.105 (1.232-7.829)	3.105 (1.232-7.829)	3.316 (1.324-8.305)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome
[2]Socioeconomic status

Appendix 6.39 The association between intervention exposure and child diarrhoea in the previous 14 days

Model predictors[1]	Unadjusted OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	0.851 (0.455-1.593)	0.828 (0.506-1.354)	0.867 (0.524-1.434)	0.831 (0.508-1.359)
SES Dummy variable 1 (0= lowest, 1=second lowest)[2]	0.632 (0.434-0.922)	0.780 (0.573-1.063)	0.854 (0.625-1.167)	0.770 (0.565-1.050)
SES Dummy variable 2 (0= lowest, 1=middle)[2]	0.472 (0.301-0.740)	0.643 (0.458-0.903)	0.720 (0.531-0.976)	0.644 (0.460-0.903)
SES Dummy variable 3 (0= lowest, 1=second highest)[2]	0.410 (0.255-0.658)	0.594 (0.420-0.841)	0.676 (0.480-0.953)	0.596 (0.421-0.842)
SES Dummy variable 4 (0= lowest, 1=highest)[2]	0.326 (0.193-0.552)	0.483 (0.301-0.776)	0.564 (0.359-0.885)	0.476 (0.295-0.767)
Religion Dummy variable 1 (0=Sarna, 1=Hindu)	1.948 (1.326-2.861)	2.295 (1.553-3.391)	2.381 (1.605-3.534)	2.299 (1.561-3.387)
Religion Dummy variable 2 (0=Sarna, 1=Other)	0.980 (0.617-1.557)	1.042 (0.659-1.646)	0.997 (0.631-1.575)	1.067 (0.675-1.688)
Social group Dummy variable 1 (0=ST, 1=SC)[3]	0.597 (0.354-1.009)	0.462 (0.274-0.776)	0.425 (0.255-0.706)	0.469 (0.281-0.785)
Social group Dummy variable 2 (0=ST, 1=OBC)[3]	0.609 (0.478-0.776)	0.461 (0.325-0.654)	0.439 (0.311-0.620)	0.474 (0.334-0.672)
Social group Dummy variable 2 (0=ST, 1=Other)[3]	0.815 (0.316-2.102)	0.811 (0.349-1.883)	0.771 (0.332-1.793)	0.808 (0.347-1.884)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome
[2]Socioeconomic status
[3]ST=Scheduled Tribe, SC=Scheduled Caste, OBC=Other Backwards Class

Appendix 6.40 The association between intervention exposure and child fever in the previous 14 days

Model predictors[1]	Unadjusted OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	0.694 (0.370-1.300)	0.659 (0.389-1.119)	0.673 (0.397-1.140)	0.667 (0.391-1.139)
SES Dummy variable 1 (0= lowest, 1=second lowest)[2]	0.561 (0.424-0.743)	0.695 (0.546-0.885)	0.783 (0.585-1.049)	0.700 (0.546-0.898)
SES Dummy variable 2 (0= lowest, 1=middle)[2]	0.461 (0.312-0.681)	0.616 (0.440-0.862)	0.706 (0.515-0.969)	0.622 (0.444-0.871)
SES Dummy variable 3 (0= lowest, 1=second highest)[2]	0.484 (0.315-0.744)	0.645 (0.456-0.912)	0.747 (0.521-1.070)	0.650 (0.459-0.920)
SES Dummy variable 4 (0= lowest, 1=highest)[2]	0.352 (0.187-0.663)	0.397 (0.228-0.692)	0.470 (0.277-0.797	0.400 (0.228-0.699)
Religion Dummy variable 1 (0=Sarna, 1=Hindu)	2.751 (1.742-4.344)	2.587 (1.655-4.041)	2.646 (1.703-4.110)	2.616 (1.673-4.091)
Religion Dummy variable 2 (0=Sarna, 1=Christian)	1.942 (1.040-3.627)	1.975 (1.060-3.676)	1.890 (1.028-3.473)	1.860 (1.021-3.390)
Religion Dummy variable 1 (0=Sarna, 1=Muslim)	1.206 (0.720-2.019)	1.678 (0.893-3.154)	1.601 (0.862-2.974)	1.694 (0.899-3.190)
Religion Dummy variable 2 (0=Sarna, 1=Other)	2.755 (1.186-6.396)	2.047 (0.705-5.942)	2.598 (1.015-6.647)	2.064 (0.707-6.025)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome
[2]Socioeconomic status

Appendix 6.41 The association between intervention exposure and child cough in the previous 14 days

Model predictors[1]	Unadjusted OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	0.865 (0.456-1.640)	0.799 (0.439-1.455)	0.868 (0.467-1.614)	0.809 (0.444-1.475)
SES Dummy variable 1 (0= lowest, 1=second lowest)[2]	0.692 (0.534-0.897)	0.692 (0.534-0.897)	0.792 (0.580-1.082)	0.684 (0.525-0.892)
SES Dummy variable 2 (0= lowest, 1=middle)[2]	0.538 (0.357-0.811)	0.538 (0.357-0.811)	0.637 (0.438-0.927)	0.538 (0.357-0.810)
SES Dummy variable 3 (0= lowest, 1=second highest)[2]	0.626 (0.379-1.037)	0.626 (0.379-1.037)	0.747 (0.465-1.198)	0.633 (0.383-1.046)
SES Dummy variable 4 (0= lowest, 1=highest)[2]	0.605 (0.322-1.138)	0.605 (0.322-1.138)	0.730 (0.409-1.304)	0.603 (0.319-1.140)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome
[2]Socioeconomic status

Appendix 6.42 The association between intervention exposure and maternal Body Mass Index

Model predictors[1]	Unadjusted β (95%CI)	Adjusted β (95%CI)	β (95%CI) Pooled estimate from multiple imputation models	β (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	0.006 (-0.191-0.203)	-0.019 (-0.229-0.191)	-0.003 (-0.197-0.192)	-0.020 (-0.232-0.192)
SES Dummy variable 1 (0= lowest, 1=second lowest)[2]	0.208 (0.015-0.401)	0.191 (-0.011-0.393)	0.177 (-0.018-0.371)	0.198 (-0.008-0.405)
SES Dummy variable 2 (0= lowest, 1=middle)[2]	0.174 (-0.017-0.366)	0.185 (-0.043-0.412)	0.145 (-0.043-0.334)	0.192 (-0.042-0.427)
SES Dummy variable 3 (0= lowest, 1=second highest)[2]	0.066 (-0.152-0.284)	0.005 (-0.248-0.257)	0.014 (-0.230-0.259)	0.018 (-0.231-0.267)
SES Dummy variable 4 (0= lowest, 1=highest)[2]	0.233 (0.025-0.442)	0.176 (-0.079-0.431)	0.201 (-0.048-0.450)	0.190 (-0.076-0.455)
Household status 1 (0=wife, 1=daughter in law)	-0.132 (-0.294-0.030)	-0.131 (0.307-0.044)	-0.123 (-0.286-0.040)	-0.140 (-0.313-0.034)
Household status 2 (0=wife, 1=other)	-0.449 (-0.777--0.121)	-0.387 (-0.836-0.063)	-0.460 (-0.804—0.117)	-0.356 (-0.855-0.144)
Religion Dummy variable 1 (0=Sarna, 1=Hindu)	-0.036 (-0.196-0.124)	0.079 (-0.118-0.277)	0.081 (-0.100-0.261)	0.081 (-0.124-0.285)
Religion Dummy variable 2 (0=Sarna, 1=Christian)	0.358 (0.088-0.629)	0.307 (0.037-0.577)	0.366 (0.071-0.601)	0.344 (0.069-0.618)
Religion Dummy variable 1 (0=Sarna, 1=Muslim)	0.166 (0.018-0.315)	-0.162 (-1.218-0.894)	0.276 (-0.611-1.164)	-0.171 (-1.226-0.885)
Religion Dummy variable 2 (0=Sarna, 1=Other)	0.664 (-0.532-1.861)	0.842 (-0.305-1.990)	0.636 (-0.494-1.766)	0.838 (-0.312-1.987)
Social group Dummy variable 1 (0=ST, 1=SC)[3]	-0.531 (-0.864- -0.198)	-0.698 (-1.164- -0.233)	-0.586 (-0.965- -0.207)	-0.676 (-1.156- -0.195)
Social group Dummy variable 2 (0=ST, 1=OBC)[3]	-0.107 (-0.309-0.096)	-0.164 (-0.399-0.070)	-0.188 (-0.412-0.037)	-0.167 (-0.409-0.074)
Social group Dummy variable 2 (0=ST, 1=Other)[3]	0.027 (-0.738-0.791)	-0.050 (-1.127-1.026)	-0.113 (-1.027-0.801)	-0.056 (-1.135-1.022)
Maternal education 1 (0=no schooling, 1=primary school)	-0.068 (-0.305-0.169)	0.080 (-0.154-0.314)	-0.007 (-0.253-0.239)	0.064 (-0.179-0.307)
Maternal education 2 (0=no schooling, 1=Secondary school)	0.047 (-0.099-0.194)	0.183 (-0.004-0.369)	0.115 (-0.067-0.296)	0.181 (-0.007-0.369)
Maternal education 3 (0=no schooling, 1=Higher secondary+)	0.480 (-0.058-1.017)	0.596 (0.034-1.159)	0.530 (0.002-1.057)	0.588 (0.033-1.142)
Maternal age	0.013 (0.002-0.024)	0.013 (0.002-0.025)	0.013 (0.002-0.024)	0.014 (0.001-0.026)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome
[2]Socioeconomic status
[3]ST=Scheduled Tribe, SC=Scheduled Caste, OBC=Other Backwards Class

Appendix 6.43 The association between intervention exposure and maternal psychological distress in the last four weeks

Model predictors[1]	Unadjusted OR (95%CI)	AOR (95%CI)	AOR (95%CI) Pooled estimate from multiple imputation models	AOR (95%CI) one randomly selected sibling removed from each pair
Exposure group (0=control, 1=intervention)	0.615 (0.211-1.795)	0.477 (0.161-1.415)	0.525 (0.177-1.562)	0.461 (0.155-1.367)
SES Dummy variable 1 (0= lowest, 1=second lowest)[2]	0.830(0.552-1.248)	0.833 (0.557-1.245)	0.919 (0.595-1.418)	0.827 (0.543-1.259)
SES Dummy variable 2 (0= lowest, 1=middle)[2]	0.673 (0.378-1.197)	0.664 (0.376-1.174)	0.737 (0.440-1.235)	0.636 (0.357-1.135)
SES Dummy variable 3 (0= lowest, 1=second highest)[2]	0.489 (0.258-0.925)	0.490 (0.259-0.925)	0.562 (0.304-1.038)	0.466 (0.250-0.867)
SES Dummy variable 4 (0= lowest, 1=highest)[2]	0.268 (0.109-0.662)	0.263 (0.107-0.642)	0.319 (0.133-0.765)	0.254 (0.103-0.626)
Season measured (0=winter, 1=summer)	0.579 (0.357-0.939)	0.518 (0.316-0.847)	0.564 (0.348-0.914)	0.511 (0.312-0.836)

[1]Socio-demographic predictor odds ratios in unadjusted models show their combined effect with exposure group on each outcome
[2]Socioeconomic status

Appendices: chapter 7

Appendix 7.1 Univariate estimates for potential determinants of height-for-age Z-score in children 6.00-23.99 months, and adjusted estimates for significant predictors in the listwise model, re-run in sibling-adjusted and multiple imputation datasets

Predictor	Unadjusted β (95%CI)	P	Adjusted β (95%CI): One sibling removed	P	Adjusted β (95%CI): Multiple Imputation	P
AGE AND SEX VARIABLES						
Child age (days)	n/a	n/a	-	-		
Child sex 0=boy, 1=girl	n/a	n/a	-	-		
Maternal age (years)	-0.033 (-0.051- -0.015)	<0.001	-	-	-0.026 (-0.041- -0.012)	<0.001
Paternal age (years)	-0.024 (-0.040- -0.007)	0.005	-	-		
BASIC CAUSES OF UNDERNUTRITION						
Socioeconomic quintile	Wald=12.106	0.017	-	-		
0-lowest, 1=second lowest	0.205 (-0.076-0.486)	0.153				
0-lowest, 1=middle	0.267 (-0.137-0.670)	0.195				
0-lowest, 1=second highest	0.587 (0.109-1.065)	0.016				
0-lowest, 1=highest	0.578 (0.195-0.961)	0.003				
Income group	Wald=9.859	0.007		0.022		
0=poorest, 1=middle	0.343 (0.073-0.612)	0.013	0.285 (0.065-0.505)	0.011	0.235 (0.003-0.468)	0.047
0=poorest, 1=richest	0.547 (0.163-0.931)	0.005	0.331 (-0.053-0.716)	0.091	0.226 (-0.170-0.622)	0.264
Mother's education	Wald=19.899	<0.001	-	-		
0=no schooling, 1=primary school	0.131 (-0.114-0.376)	0.296			0.109 (-0.141-0.360)	0.393
0=no schooling, 1= secondary school	0.390 (0.168-0.612)	0.001			0.177 (0.001-0.353)	0.049

0=no schooling, 1= ≥higher secondary	0.902 (0.392-1.412)	0.001			0.559 (0.115-1.004)	0.014
Father's education	Wald=17.119	0.001	-	-		
0=no schooling, 1=primary school	0.047 (-0.216-0.310)	0.728				
0=no schooling, 1= secondary school	0.253 (-0.037-0.542)	0.087				
0=no schooling, 1= ≥higher secondary	0.428 (0.223-0.634)	<0.001				
District	Wald=5.397	0.069	-	-		
0=West Singhbhum, 1=Saraikela	0.314 (0.011-0.617)	0.043				
0=West Singhbhum, 1=Keonjhar	-0.098 (-0.502-0.307)	0.636				
Religion	Wald=0.453	0.797	-	-		
0=Sarna, 1=Hindu	0.040 (-0.271-0.350)	0.803				
0=Sarna, 1= Christian/Muslim/other	-0.185 (-0.855-0.484)	0.588				
Social group	Wald=7.742	0.052	-	-		
0=Scheduled Tribe, 1=Scheduled Caste	0.373 (-0.055-0.801)	0.087				
0=Scheduled Tribe, 1=Other Backward Class	0.354 (0.078-0.630)	0.012				
0=Scheduled Tribe, 1=Other	0.106 (-0.661-0.873)	0.787				
UNDERLYING CAUSES OF UNDERNUTRITION						
Food security (household shocks in the previous 12 months)						
Disease epidemic 0=no, 1=yes	0.013 (-0.190-0.216)	0.900	-	-		
Major household health problem 0=no, 1=yes	-0.106 (-0.523-0.312)	0.620	-	-		
Crop failure 0=no, 1=yes	0.069 (-0.231-0.368)	0.653	-	-		
Damage to houses or crops by elephants 0=no, 1=yes	-0.051 (-0.414-0.312)	0.782	-	-		
Any household shock 0=no, 1=yes	-0.050 (-0.324-0.224)	0.720	-	-		
Care for children						
Early initiation of breastfeeding: 0=no, 1=yes	0.114 (-0.170-0.398)	0.431	-	-		
Bottle feeding 0=no, 1=yes	0.262 (-0.080-0.603)	0.133	-	-		
Pre-lacteal feeds 0=no, 1=yes	0.157 (-0.326-0.640)	0.523	-	-		
Colostrum discarding 0=no, 1=yes	0.138 (-0.180-0.455)	0.396	-	-		
BCG immunisation 0=no, 1=yes	0.353 (-0.025-0.731)	0.067	-	-		
DPT immunisations (3) 0=no, 1=yes	0.299 (0.021-0.578)	0.035	-	-		
Polio immunisations (3) 0=no, 1=yes	0.242 (-0.106-0.590)	0.173	-	-		
Feeding frequency during diarrhoea, fever, cough	Wald=2.490	0.288	-	-		

0=none/less, 1=same/more	0.187 (-0.061-0.435)	0.140				
0-none/less, 2=n/a (no diarrhoea, fever , cough)	0.225 (-0.063-0.512)	0.129				
Liquids given during diarrhoea, fever, cough	Wald=5.377	0.068	-	-		
0=none/less, 1=same/more	-0.091 (-0.584-0.402)	0.717				
0-none/less, 2=n/a (no diarrhoea, fever, cough)	0.148 (-0.199-0.495)	0.403				
Treatment seeking for diarrhoea, fever, cough	Wald=20.257	<0.001	-	-		
0=no, 1=yes	0.522 (0.266-0.779)	<0.001				
0=no, 1=n/a (no diarrhoea, fever or cough)	0.486 (0.256-0.715)	<0.001				
ORS given for diarrhoea (last 14 days)	Wald=5.697	0.058	-	-		
0=no, 1=yes	-0.162 (-0.643-0.318)	0.508				
0=no, 1=n/a no diarrhoea	0.141 (-0.096-0.378)	0.245				
Birth order	Wald=21.287	<0.001		0.002		
First born, 1=Second born	0.057 (-0.155-0.269)	0.599	-0.004 (-0.243-0.235)	0.973		
0=First born, 1=Third born	-0.103 (-0.428-0.223)	0.537	-0.147 (-0.490-0.196)	0.399		
0=First born, 1=≥Fourth born	-0.446 (-0.668- -0.224)	<0.001	-0.399 (-0.671- -0.126)	0.004		
Care for mothers						
Number of children born	Wald=6.751	0.034	-	-		
0=one, 1=two-three children	0.067 (-0.280-0.413)	0.706				
0=one, 1=≥4 children	-0.296 (-0.562- -0.030)	0.029				
Birth spacing	Wald=10.619	0.005		0.069		
0=<24 months, 1=≥24 months	0.464 (0.101-0.826)	0.012	0.411 (0.062-0.761)	0.021	0.444 (0.098-0.789)	0.012
0=<24 months, 1-Don't know/missing	0.452 (0.172-0.731)	0.002	0.255 (-0.090-0.600)	0.147	0.257 (-0.021-0.534)	0.070
Self-reported anaemia in pregnancy (0=no, 1=yes)	-0.280 (-0.539- -0.022)	0.033	-0.186 (-0.415-0.042)	0.110	-0.198 (-0.419-0.023)	0.080
Self-reported malaria in pregnancy (0=no, 1=yes)	-0.244 (-0.587-0.098)	0.162	-	-		
Iron tablets in pregnancy (0=no, 1=yes)	-0.006 (-0.258-0.247)	0.966	-	-		
Quantity of iron tablets in pregnancy	Wald=4.291	0.117	-	-		
0=no tablets, 1=<50 tablets	-0.133 (-0.384-0.118)	0.299				
0=no tablets, 1=≥50 tablets	0.085 (-0.216-0.385)	0.581				
Food consumption in pregnancy	0.001 (-0.284-0.286)	0.995	-	-		
(0=less, 1=same/more than usual)						
Maternal Body Mass Index	0.070 (0.020-0.120)	0.006	0.066 (0.010-0.123)	0.022	0.070 (0.017-0.124)	0.010
Physical illness/injury in the last three months			-	-		
(non-pregnancy) 0=no, 1=yes	-0.229 (-0.452- -0.005)	0.045				

Psychological distress			-	-		
(K10 scores >15: 0=no, 1=yes)	0.153 (-0.112-0.418)	0.259				
Underlying child health issues						
Repeated diarrhoea	-0.343 (-0.551- -0.135)	0.001	-0.178 (-0.330- -0.025)	0.023	-0.208 (-0.364- -0.051)	0.009
Repeated fever	-0.193 (-0.428-0.042)	0.108	-	-		
Repeated cough	-0.104 (-0.319-0.112)	0.344	-	-		
Health environment and services						
Place of delivery	Wald=14.032	0.001	-	-		
0=Home/providers home/other, 1=govt facility	0.228 (0.053-0.403)	0.011				
0=Home/providers home/other, 1=private facility	0.590 (0.246-0.935)	0.001				
Antenatal visit (0=no, 1=yes)	0.181 (-0.097-0.458)	0.202	-	-		
Postnatal visit (0=no, 1=yes)	0.129 (-0.075-0.3330	0.216	-	-		
Growth monitoring			-	-		
(0=less than once/month, 1=≥once/month	0.050 (-0.188-0.289)	0.680				
Food rations received via AWW	Wald=0.932	0.627	-	-		
0=rarely or never, 1=daily or weekly	0.090 (-0.261-0.441	0.614				
0=rarely or never, 1=monthly	0.143 (-0.182-0.468)	0.387				
Living area:			-	-		
0= >3 per sleeping room, 1=≤3 per sleeping room	0.244 (0.049-0.438)	0.014				
Cooking location	Wald=21.596	<0.001		<0.001		
0=in the house, 1=in a separate room	0.268 (0.015-0.521)	0.038	0.098 (-0.143-0.340)	0.424	0.070 (-0.173-0.313)	0.573
0=in the house, 1=outdoors	0.823 (0.476-1.171)	<0.001	0.736 (0.376-1.096)	<0.001	0.737 (0.405-1.070)	<0.001
Season of birth	Wald=7.324	0.026		0.065		
Season of birth_1: 0=winter, 1=summer	0.043 (-0.206-0.292)	0.733	0.012 (-0.251-0.275)	0.930		
Season of birth_2: 0=winter, 1=rainy	0.285 (0.035-0.535)	0.025	0.239 (-0.040-0.518)	0.093		
Source of drinking water:			-	-		
0=unimproved, 1=improved	0.153 (-0.089-0.396)	0.215				
Treatment of drinking water			-	-		
0=none, 1=physical or chemical	0.255 (0.008-0.502)	0.043				
Time taken to collect drinking water			-	-		
0=>30, 1=≤30 minutes	0.047 (-0.147-0.241)	0.633				
Disposal of children's faeces			-	-		
0=unsafe practices only, 1=some safe practices	-0.174 (-0.550-0.202)	0.364				

Hand washing agent: 0=none, 1=ash/mud/soap	0.438 (0.197-0.678)	<0.001	0.361 (0.146-0.576)	0.001	0.321 (0.104-0.539)	0.004
Hand washing occasions using soap (0=no, 1=yes)			-	-		
Before preparing food	-0.036 (-1.574-1.503)	0.964				
Before feeding a child	-0.719 (-0.898- -0.540)	<0.001				
After defecation	0.518 (0.275-0.760)	<0.001				
After cleaning a child who has defecated	0.509 (0.106-0.912)	0.013				
Before eating	0.029 (-0.299-0.357)	0.862				
Hand washing score based on the above (0-5)	0.237 (-0.007-0.480)	0.057				
IMMEDIATE CAUSES OF UNDERNUTRITION						
Dietary intake/breastfeeding (previous 24 hours)						
Predominant breastfeeding (0=no, 1=yes)	0.040 (-0.229-0.308)	0.772	-	-		
Minimum dietary diversity (0=no, 1=yes)	0.496 (0.126-0.865)	0.009	0.308 (-0.070-0.685)	0.110		
Minimum meal frequency (0=no, 1=yes)	-0.092 (-0.277-0.092)	0.327	-	-		
Consumption of iron-rich foods (0=no, 1=yes)	0.098 (-0.228-0.424)	0.556	-	-		
Age-appropriate breastfeeding (0=no, 1=yes)	-0.074 (-0.316-0.168)	0.547	-	-		
Health status						
Diarrhoea (last 14 days) 0=no, 1=yes	-0.203 (-0.383- -0.023)	0.027	-	-		
Fever (last 14 days) 0=no, 1=yes	-0.092 (-0.302-0.728)	0.394	-	-		
Cough (last 14 days) 0=no, 1=yes	-0.080 (-0.306-0.146)	0.489	-	-		
Diarrhoeal severity (last 14 days)	Wald=4.888	0.087	-	-		
0=no diarrhoea, 1=diarrhoea, no blood	-0.203 (-0.401- -0.005)	0.045				
0=no diarrhoea, 1=diarrhoea, blood present	-0.204 (-0.715-0.306)	0.433				
Cough severity (last 14 days)	Wald=1.294	0.524	-	-		
0=no, 1=yes	-0.001 (-0.324-0.322)	0.995				
0-no, 1=yes + abnormal breathing	-0.115 (-0.341-0.110)	0.891				

Appendix 7.2 Univariate estimates for potential determinants of weight-for-height Z-score in children 6.00-23.99 months, and adjusted estimates for significant predictors in the listwise model, re-run in sibling-adjusted and multiple imputation datasets

Predictor	Unadjusted β (95%CI)	P	Adjusted β (95%CI): One sibling removed	P	Adjusted β (95%CI): Multiple Imputation	P
AGE AND SEX VARIABLES						
Child age (months)	0.022 (0.003-0.040)	0.021				
Child sex 0=boy, 1=girl	n/a	n/a				
Maternal age (years)	-0.043 (-0.057- -0.029)	<0.001	-0.027 (-0.042- -0.013)	<0.001	-0.025 (-0.038- -0.012)	<0.001
Paternal age (years)	-0.025 (-0.035- -0.016)	<0.001				
BASIC CAUSES OF UNDERNUTRITION						
Socioeconomic quintile	Wald=72.643	<0.001				
0-lowest, 1=second lowest	0.120 (-0.096-0.336)	0.276				
0-lowest, 1=middle	0.157 (-0.068-0.382)	0.172				
0-lowest, 1=second highest	0.446 (0.231-0.661)	<0.001				
0-lowest, 1=highest	0.732 (0.514-0.951)	<0.001				
Income group	Wald=9.266	0.010				
0=poorest, 1=middle	0.071 (-0.161-0.303)	0.548				
0=poorest, 1=richest	0.281 (0.100-0.463)	0.002				
Mother's education	Wald=49.190	<0.001		0.005		
0=no schooling, 1=primary school	0.104 (-0.223-0.432)	0.532	0.026 (-0.296-0.347)	0.875		
0=no schooling, 1= secondary school	0.439 (0.310-0.567)	<0.001	0.219 (0.090-0.347)	0.001		
0=no schooling, 1= ≥higher secondary	0.665 (0.267-1.062)	0.001	0.265 (-0.144-0.675)	0.204		
Father's education	Wald=43.072	<0.001				
0=no schooling, 1=primary school	0.073 (-0.126-0.271)	0.472				
0=no schooling, 1= secondary school	0.083 (-0.138-0.304)	0.462				
0=no schooling, 1= ≥higher secondary	0.361 (0.238-0.483)	<0.001				
District	Wald=33.124	<0.001		<0.001		
0=West Singhbhum, 1=Saraikela	0.637 (0.417-0.857)	<0.001	0.413 (0.224-0.603)	<0.001	0.389 (0.175-0.604)	<0.001

0=West Singhbhum, 1=Keonjhar	0.148 (-0.069-0.366)	0.156	0.281 (0.074-0.489)	0.008	0.274 (0.063-0.485)	0.011
Religion	Wald=1.118	0.572				
0=Sarna, 1=Hindu	0.105 (-0.105-0.315)	0.328				
0=Sarna, 1= Christian/Muslim/other	-0.103 (-0.705-0.499)	0.737				
Social group	Wald=32.091	<0.001				
0=Scheduled Tribe, 1=Scheduled Caste	0.083 (-0.357-0.524	0.711			-0.108 (-0.637-0.421)	0.689
0=Scheduled Tribe, 1=Other Backward Class	0.460 (0.279-0.641)	<0.001			0.227 (0.055-0.400)	0.010
0=Scheduled Tribe, 1=Other	0.493 (-0.163-1.150)	0.141			0.194 (-0.284-0.672)	0.427
UNDERLYING CAUSES OF UNDERNUTRITION						
Food security (household shocks in the previous 12 months)						
Disease epidemic 0=no, 1=yes	-0.006 (-0.295-0.284)	0.970				
Major household health problem (different to epidemic) 0=no, 1=yes	-0.206 (-0.531-0.118)	0.213				
Crop failure 0=no, 1=yes	-0.128 (-0.374-0.117)	0.306				
Damage to houses or crops by elephants 0=no, 1=yes	-0.279 (-0.574-0.015)	0.063				
Any household shock 0=no, 1=yes	-0.208 (-0.428-0.012)	0.064				
Care for children						
Early initiation of breastfeeding 0=no, 1=yes	0.295 (0.097-0.494)	0.004	0.210 (0.052-0.369)	0.009	0.200 (0.047-0.353)	0.011
Bottle feeding 0=no, 1=yes	-0.128 (-0.316-0.060)	0.183				
Pre-lacteal feeds 0=no, 1=yes	0.062 (-0.090-0.214)	0.421				
Colostrum discarding 0=no, 1=yes	0.218 (-0.037-0.473)	0.094				
BCG immunisation 0=no, 1=yes	0.235 (-0.107-0.578)	0.178				
DPT immunisations (3) 0=no, 1=yes	0.148 (-0.052-0.348)	0.147				
Polio immunisations (3) 0=no, 1=yes	0.119 (-0.092-0.330)	0.268				
Feeding frequency during diarrhoea, fever, cough	Wald=11.812	0.003				
0=none/less, 1=same/more	0.307 (0.077-0.536)	0.009				
0-none/less, 2=n/a (no diarrhoea, fever , cough)	0.374 (0.110-0.638)	0.006				
Liquids given during diarrhoea, fever, cough	Wald=28.137	<0.001				
0=none/less, 1=same/more	0.000 (-0.274-0.274)	0.998				
0-none/less, 2=n/a (no diarrhoea, fever, cough)	0.472 (0.205-0.738)	0.003				
Treatment seeking for diarrhoea, fever, cough	Wald=11.540	0.003				
0=no, 1=yes	0.276 (0.018-0.534)	0.036				
0=no, 1=n/a (no diarrhoea, fever or cough)	0.462 (0.191-0.732)	0.001				
ORS given for diarrhoea (last 14 days)	Wald=26.248	<0.001				

0=no, 1=yes	0.089 (-0.253-0.430)	0.611				
0=no, 1=n/a no diarrhoea	0.501 (0.287-0.715)	<0.001				
Birth order	Wald=86.041	<0.001				
First born, 1=Second born	0.028 (-0.153-0.209)	0.762				
0=First born, 1=Third born	-0.101 (-0.341-0.139)	0.408				
0=First born, 1=≥Fourth born	-0.496 (-0.676- -0.316)	<0.001				
Care for mothers						
Number of children born	Wald=11.588	0.003				
0=one, 1=two-three children	0.136 (-0.154-0.426)	0.358				
0=one, 1=≥4 children	-0.197 (-0.431-0.036)	0.097				
Birth spacing	Wald=6.294	0.043				
0=<24 months, 1=≥24 months	0.029 (-0.121-0.178)	0.709				
0=<24 months, 1-Don't know/missing	0.222 (0.033-0.410)	0.021				
Self-reported anaemia in pregnancy (0=no, 1=yes)	-0.398 (-0.571- -0.226)	<0.001	-0.182 (-0.336- -0.028)	0.020	-0.137 (-0.273- -0.002)	0.047
Self-reported malaria in pregnancy (0=no, 1=yes)	-0.059 (-0.283-0.166)	0.610				
Iron tablets in pregnancy (0=no, 1=yes)	0.197 (0.000-0.395)	0.050				
Quantity of iron tablets in pregnancy	Wald=7.103	0.029				
0=no tablets, 1=<50 tablets	0.125 (-0.137-0.387)	0.349				
0=no tablets, 1=≥50 tablets	0.220 (0.052-0.387)	0.010				
Food consumption in pregnancy (0=less, 1=same/more than usual)	0.025 (-0.235-0.286)	0.849				
Maternal Body Mass Index	0.072 (0.046-0.099)	<0.001	0.063 (0.032-0.093)	<0.001	0.063 (0.034-0.092)	<0.001
Physical illness/injury in the last three months (non-pregnancy) 0=no, 1=yes	-0.194 (-0.350- -0.031)	0.019				
Psychological distress (K10 scores >15: 0=no, 1=yes)	-0.555 (-0.837- -0.273)	<0.001			-0.235 (-0.470-0.001)	0.051
Underlying child health issues						
Repeated diarrhoea	-0.400 (-0.599- -0.201)	<0.001				
Repeated fever	-0.203 (-0.381- -0.026)	0.025				
Repeated cough	-0.245 (-0.428- -0.062)	0.009	-0.245 (-0.379- -0.110)	<0.001	-0.186 (-0.305- -0.068)	0.002
Health environment and services						
Place of delivery	Wald=11.996	0.002				
0=Home/providers home/other, 1=govt facility	0.211 (-0.006-0.428)	0.057			0.180 (0.018-0.343)	0.030

0=Home/providers home/other, 1=private facility	0.441 (0.186-0.696)	0.001			0.061 (-0.170-0.293)	0.603
Antenatal visit (0=no, 1=yes)	0.295 (0.120-0.470)	0.001				
Postnatal visit (0=no, 1=yes)	0.250 (0.047-0.454)	0.016				
Growth monitoring (0=less than once/month, 1=≥once/month	-0.029 (-0.221-0.164)	0.770				
Food rations received via AWW	Wald=2.354	0.308				
0=rarely or never, 1=daily or weekly	-0.196(-0.532-0.141)	0.255				
0=rarely or never, 1=monthly	-0.120 (-0.332-0.091)	0.264				
Living area: 0= >3 per sleeping room, 1=≤3 per sleeping room	0.342 (0.206-0.478)	<0.001	0.114 (0.016-0.212)	0.022	0.123 (0.027-0.219)	0.012
Season of birth	Wald=2.595	0.273				
0=winter, 1=summer	0.092 (-0.082-0.265)	0.300				
0=winter, 1=rainy	0.157 (-0.035-0.349)	0.108				
Source of drinking water 0=unimproved, 1=improved	0.385 (0.221-0.550)	<0.001	0.184 (0.086-0.282)	<0.001	0.208 (0.097-0.319)	<0.001
Treatment of drinking water 0=none, 1=physical or chemical	0.213 (0.045-0.380)	0.013				
Time taken to collect drinking water 0=>30, 1=≤30 minutes	0.162 (-0.081-0.406)	0.192				
Disposal of children's faeces 0=unsafe practices only, 1=some safe practices	0.061 (-0.289-0.411)	0.732				
Hand washing agent (0=none, 1=ash/mud/soap)	0.261 (0.058-0.464)	0.012	0.150 (0.010-0.289)	0.035	0.100 (-0.018-0.218)	0.098
Hand washing occasions when soap is used						
Before preparing food (0=no, 1=yes)	0.011 (-0.682-0.703)	0.976				
Before feeding a child (0=no, 1=yes)	-0.232 (-0.387- -0.077)	0.003				
After defecation (0=no, 1=yes)	0.205 (-0.162-0.572)	0.273				
After cleaning up a child who has defecated (0=no, 1=yes)	0.390 (0.148-0.633)	0.002				
Before eating (0=no, 1=yes)	0.094 (-0.120-0.309)	0.389				
Hand washing score based on above five occasions (0-5)	0.179 (-0.001-0.360)	0.052				
IMMEDIATE CAUSES OF UNDERNUTRITION						
Dietary intake (previous 24 hours)						
Predominant breastfeeding (0=no, 1=yes)	-0.185 (-0.430-0.060)	0.139				
Minimum dietary diversity (0=no, 1=yes)	0.388 (0.135-0.641)	0.003				

Minimum meal frequency (0=no, 1=yes)	0.140 (-0.004-0.284)	0.056				
Consumption of iron-rich foods (0=no, 1=yes)	0.313 (0.115-0.512)	0.002	0.281 (0.125-0.436)	<0.001	0.228 (0.081-0.376)	0.002
Age-appropriate breastfeeding (0=no, 1=yes)	0.031 (-0.158-0.219)	0.748				
Health status						
14 day diarrhoeal prevalence	-0.468 (-0.646- -0.289)	<0.001				
14 day fever prevalence	-0.314 (-0.490- -0.138)	<0.001	-0.181 (-0.348- -0.014)	0.033	-0.207 (-0.366- -0.048)	0.011
14 day cough prevalence	-0.176 (-0.405-0.052)	0.131				
Diarrhoeal severity (last 14 days)	Wald=36.629	<0.001		<0.001		
0=no diarrhoea, 1=diarrhoea, no blood	-0.445 (-0.637- -0.254)	<0.001	-0.290 (-0.477- -0.102)	0.002	-0.281 (-0.473- -0.108)	0.001
0=no diarrhoea, 1=diarrhoea, blood present	-0.596 (-0.832 - -0.359)	<0.001	-0.438 (-0.659- -0.217)	<0.001	-0.420 (-0.644- -0.195)	<0.001
Cough severity (last 14 days)	Wald=3.334	0.189				
0=no, 1=yes	-0.089 (-0.425-0.247)	0.604				
0-no, 1=yes + abnormal breathing	-0.216 (-0.451-0.018)	0.071				

Appendix 7.3 Univariate estimates for potential determinants of weight-for-age Z-score in children 6.00-23.99 months, and adjusted estimates for significant predictors in the listwise model, re-run in sibling-adjusted and multiple imputation datasets

Predictor	β (95%CI)	P	Adjusted β (95%CI): One sibling removed	P	Adjusted β (95%CI): Multiple Imputation	P
AGE AND SEX VARIABLES						
Maternal age (years)	-0.038 (-0.058- -0.018)	<0.001				
Paternal age (years)	-0.023 (-0.038- -0.008)	0.003				
BASIC CAUSES OF UNDERNUTRITION						
Socioeconomic quintile	Wald=51.713	<0.001		0.022		
0-lowest, 1=second lowest	0.322 (0.042-0.603)	0.024	0.232 (0.006-0.457)	0.044	0.221 (-0.010-0.451)	0.061
0-lowest, 1=middle	0.331 (0.026-0.635)	0.033	0.183 (0.011-0.354)	0.037	0.196 (0.005-0.387)	0.044
0-lowest, 1=second highest	0.594 (0.248-0.939)	0.001	0.193 (-0.061-0.446)	0.136	0.230 (-0.038-0.497)	0.092
0-lowest, 1=highest	0.827 (0.511-1.144)	<0.001	0.112 (-0.183-0.406)	0.458	0.183 (-0.126-0.491)	0.246
Income group	Wald=24.158	<0.001		0.053		
0=poorest, 1=middle	0.224 (-0.013-0.461)	0.064	0.158 (-0.032-0.347)	0.103		
0=poorest, 1=richest	0.616 (0.355-0.878)	<0.001	0.202 (-0.081-0.485)	0.162		
Mother's education	Wald=56.025	<0.001		0.025		
0=no schooling, 1=primary school	0.191 (-0.067-0.449)	0.147	0.122 (-0.123-0.368)	0.329	0.109 (-0.131-0.349)	0.375
0=no schooling, 1= secondary school	0.537 (0.359-0.716)	<0.001	0.207 (0.045-0.368)	0.012	0.214 (0.054-0.373)	0.009
0=no schooling, 1= ≥higher secondary	0.921 (0.453-1.388)	<0.001	0.336 (-0.053-0.724)	0.090	0.426 (0.022-0.829)	0.039
Father's education	Wald=52.924	<0.001				
0=no schooling, 1=primary school	0.052 (-0.182-0.286)	0.664				
0=no schooling, 1= secondary school	0.199 (-0.016-0.414)	0.070				
0=no schooling, 1= ≥higher secondary	0.489 (0.331-0.646)	<0.001				
District	Wald=42.141	<0.001		<0.001		
0=West Singhbhum, 1=Saraikela	0.533 (0.365-0.700)	<0.001	0.365 (0.191-0.540)	<0.001	0.325 (0.147-0.502)	<0.001
0=West Singhbhum, 1=Keonjhar	0.042 (-0.323-0.407)	0.822	0.188 (-0.095-0.470)	0.193	0.217 (-0.057-0.490)	0.120
Religion	Wald=1.323	0.516				

0=Sarna, 1=Hindu	0.083 (-0.201-0.367)	0.568
0=Sarna, 1= Christian/Muslim/other	-0.165 (-0.504-0.173)	0.338
Social group	Wald=15.163	0.002
0=Scheduled Tribe, 1=Scheduled Caste	0.224 (-0.192-0.641)	0.291
0=Scheduled Tribe, 1=Other Backward Class	0.452 (0.206-0.698)	<0.001
0=Scheduled Tribe, 1=Other	0.451 (0.008-0.893)	0.046
UNDERLYING CAUSES OF UNDERNUTRITION		
Food security (household shocks in the previous 12 months)		
Disease epidemic 0=no, 1=yes	0.032 (-0.162-0.226)	0.748
Major household health problem (different to epidemic) 0=no, 1=yes	-0.197 (-0.527-0.132)	0.241
Crop failure 0=no, 1=yes	-0.015 (-0.309-0.279)	0.921
Damage to houses or crops by elephants 0=no, 1=yes	-0.295 (-0.630-0.039)	0.084
Any of the above household shocks 0=no, 1=yes	-0.173 (-0.412-0.065)	0.154
Care for children		
Early initiation of breastfeeding: 0=no, 1=yes	0.218 (-0.059-0.496)	0.123
Bottle feeding 0=no, 1=yes	0.120 (-0.160-0.401)	0.400
Pre-lacteal feeds 0=no, 1=yes	0.112 (-0.151-0.376)	0.403
Colostrum discarding 0=no, 1=yes	0.263 (-0.027-0.554)	0.076
BCG immunisation 0=no, 1=yes	0.191 (-0.308-0.689)	0.453
DPT immunisations (3) 0=no, 1=yes	0.220 (-0.006-0.446)	0.056
Polio immunisations (3) 0=no, 1=yes	0.272 (0.075-0.469)	0.007
Feeding frequency during diarrhoea, fever and/or cough	Wald=11.144	0.004
0=none/less, 1=same/more	0.340 (0.096-0.583)	0.006
0-none/less, 2=n/a (no diarrhoea, fever or cough)	0.371 (0.123-0.620)	0.003
Liquids given during diarrhoea, fever and/or cough	Wald=22.999	<0.001
0=none/less, 1=same/more	0.041 (-0.379-0.460)	0.850
0-none/less, 2=n/a (no diarrhoea, fever or cough)	0.454 (0.139-0.768)	0.005
Treatment seeking for diarrhoea, fever and/or cough	Wald=18.368	<0.001
0=no, 1=yes	0.442 (0.146-0.738)	0.003
0=no, 1=n/a (no diarrhoea, fever or cough)	0.546 (0.296-0.797)	<0.001
ORS given for diarrhoea (last 14 days)	Wald=25.213	<0.001
0=no, 1=yes	-0.416 (-0.452-0.360)	0.824

0=no, 1=n/a no diarrhoea	0.413 (0.170-0.656)	0.001				
Birth order	Wald=49.052	<0.001		<0.001		
0=First born, 1=Second born	0.012 (-0.161-0.186)	0.888	0.010 (-0.140-0.161)	0.895	0.009 (-0.131-0.150)	0.895
0=First born, 1=Third born	-0.149 (-0.437-0.139)	0.310	-0.083 (-0.358-0.191)	0.552	-0.062 (-0.334-0.210)	0.655
0=First born, 1=≥Fourth born	-0.581 (-0.808- -0.354)	<0.001	-0.384 (-0.578- -0.190)	<0.001	-0.365 (-0.552- -0.178)	<0.001
Care for mothers						
Number of children born	Wald=5.125	0.077				
0=one, 1=two-three children	0.152 (-0.124-0.429)	0.281				
0=one, 1=≥4 children	-0.192 (-0.473-0.088)	0.179				
Birth spacing	Wald=11.141	0.004				
0=<24 months, 1=≥24 months	0.158 (-0.044-0.359)	0.125				
0=<24 months, 1-Don't know/missing	0.284 (0.104-0.463)	0.002				
Self-reported anaemia in pregnancy (0=no, 1=yes)	-0.407 (-0.611- -0.203)	<0.001	-0.195 (-0.406-0.016)	0.071	-0.179 (-0.366- 0.009)	0.062
Self-reported malaria in pregnancy (0=no, 1=yes)	-0.116 (-0.349-0.116)	0.327				
Iron tablets in pregnancy (0=no, 1=yes)	0.059 (-0.210-0.187)	0.665				
Quantity of iron tablets in pregnancy	Wald=5.178	0.075				
0=no tablets, 1=<50 tablets	-0.084 (-0.323-0.156)	0.493				
0=no tablets, 1=≥50 tablets	0.124 (-0.151-0.400)	0.377				
Food consumption in pregnancy 0=less, 1=same/more than usual	0.036 (-0.205-0.276)	0.771				
Maternal Body Mass Index	0.098 (0.064-0.133)	<0.001	0.083 (0.043-0.123)	<0.001	0.087 (0.048-0.125)	<0.001
Physical illness/injury (last three months (non-pregnancy) 0=no, 1=yes	-0.154 (-0.352-0.043)	0.126				
Psychological distress (K10 scores >15: 0=no, 1=yes)	-0.202 (-0.546-0.141)	0.249				
Underlying child health issues						
Repeated diarrhoea	-0.492 (-0.670- -0.315)	<0.001	-0.180 (-0.327- -0.034)	0.016	-0.203 (-0.351- -0.054)	0.008
Repeated fever	-0.200 (-0.366- -0.034)	0.018				
Repeated cough	-0.233 (-0.429- -0.037)	0.020	-0.210 (-0.330- -0.091)	0.001	-0.207 (-0.312- -0.101)	<0.001
Health environment and services						
Place of delivery	Wald=40.912	<0.001		0.092		
0=Home/providers home/other, 1=govt facility	0.272 (0.061-0.483)	0.012	0.092 (-0.050-0.234)	0.202	0.130 (-0.017-0.277)	0.075
0=Home/providers home/other, 1=pvte facility	0.685 (0.465-0.904)	<0.001	0.146 (-0.044-0.335)	0.132	0.151 (-0.015-0.316)	0.083
Antenatal visit (0=no, 1=yes)	0.241 (0.016-0.465)	0.036				

Postnatal visit (0=no, 1=yes)	0.200 (0.026-0.375)	0.025				
Growth monitoring						
0=less than once/month, 1=≥once/month	-0.051 (-0.272-0.171)	0.655				
Food rations received via the AWW	Wald=0.992	0.609				
0=rarely or never, 1=daily or weekly	0.003 (-0.306-0.311)	0.987				
0=rarely or never, 1=monthly	-0.105 (-0.472-0.261)	0.574				
Living area:						
0= >3 per sleeping room, 1=≤3 per sleeping room	0.315 (0.142-0.488)	<0.001				
Season of birth	Wald=8.364	0.015		<0.001		
0=winter, 1=summer	0.058 (-0.149-0.265)	0.583	-0.029 (-0.249-0.192)	0.800		
0=winter, 1=rainy	0.257 (-0.003-0.518)	0.052	0.239 (-0.076-0.553)	0.136		
Cooking location	Wald=11.142	0.004				
0=in the house, 1=in a separate room	0.359 (0.136-0.581)	0.002				
0=in the house, 1=outdoors	0.379 (0.042-0.716)	0.027				
Source of drinking water						
0=unimproved, 1=improved	0.326 (0.108-0.544)	0.003				
Treatment of drinking water						
0=none, 1=physical or chemical	0.344 (0.156-0.533)	<0.001				
Time taken to collect drinking water						
0=>30, 1=≤30 minutes	0.143 (-0.077-0.363)	0.202				
Disposal of children's faeces						
0= unsafe practices only, 1=some safe practices	-0.006 (-0.353-0.341)	0.974				
Hand washing agent (0=none, 1=ash/mud/soap)	0.478 (0.236-0.721)	<0.001	0.367 (0.227-0.507)	<0.001	0.344 (0.214-0.475)	<0.001
Hand washing occasions when soap is used						
Before preparing food (0=no, 1=yes)	0.581 (0.203-0.959)	0.003				
Before feeding a child (0=no, 1=yes)	-0.488 (-0.655- -0.321)	<0.001				
After defecation (0=no, 1=yes)	0.419 (0.102-0.736)	0.010				
After cleaning up a child who has defecated (0=no, 1=yes)	0.630 (0.389-0.871)	<0.001				
Before eating (0=no, 1=yes)	0.057 (-0.224-0.338)	0.691				
Hand washing score based on above five occasions (0-5)	0.255 (0.020-0.490)	0.034				
IMMEDIATE CAUSES OF UNDERNUTRITION						
Dietary intake (previous 24 hours)						
Predominant breastfeeding (0=no, 1=yes)	-0.308 (-0.509- -0.107)	0.003	-0.196 (-0.418-0.025)	0.083	-0.172 (-0.367-0.024)	0.085

Minimum dietary diversity (0=no, 1=yes)	0.524 (0.289-0.759)	<0.001				
Minimum meal frequency (0=no, 1=yes)	0.148 (0.026-0.269)	0.017				
Consumption of iron-rich foods (0=no, 1=yes)	0.413 (0.168-0.659)	0.001	0.373 (0.127-0.619)	0.003	0.340 (0.101-0.580)	0.005
Age-appropriate breastfeeding (0=no, 1=yes)	-0.021 (-0.262-0.220)	0.863				
Health status						
14 day diarrhoeal prevalence	-0.428 (-0.601- -0.255)	<0.001				
14 day fever prevalence	-0.248 (--0.417- -0.078)	0.004				
14 day cough prevalence	-0.198 (-0.462-0.066)	0.141				
Diarrhoeal severity (last 14 days)	Wald=44.758	<0.001		0.001		
0=no diarrhoea, 1=diarrhoea, no blood	-0.397 (-0.591- -0.204)	<0.001	-0.167 (-0.374-0.040)	0.113	-0.156 (-0.362-0.051)	0.140
0=no diarrhoea, 1=diarrhoea, blood present	-0.604 (-0.867- -0.341)	<0.001	-0.360 (-0.630- -0.090)	0.009	-0.361 (-0.626- -0.095)	0.008
Cough severity (last 14 days)	Wald=6.046	0.049				
0=no, 1=yes	-0.021 (-0.396-0.354)	0.912				
0-no, 1=yes + abnormal breathing	-0.279 (-0.537- -0.022)	0.034				

Appendix 7.4 Univariate estimates for potential determinants of mid-to-upper-arm circumference in children 6.00-23.99 months, and adjusted estimates for significant predictors in the listwise model, re-run in sibling-adjusted and multiple imputation datasets

Predictor	Unadjusted β (95%CI)	P	Adjusted β (95%CI) One sibling removed	P	Adjusted β (95%CI) Multiple Imputation	P
AGE AND SEX VARIABLES						
Child sex	-0.296 (-0.436- -0.156)	<0.001	-0.286 (-0.395- -0.177)	<0.001	-0.284 (-0.391- -0.176)	<0.001
Child age (months)	0.022 (0.014-0.030)	<0.001	0.011 (0.003-0.019)	0.010	0.012 (0.004-0.020)	0.004
Maternal age (years)	-0.034 (-0.048- -0.020)	<0.001			-	-
Paternal age (years)	-0.020 (-0.029- -0.011)	<0.001			-	-
BASIC CAUSES OF UNDERNUTRITION						
Socioeconomic quintile	Wald=25.697	<0.001			-	-
0-lowest, 1=second lowest	0.148 (-0.089-0.385)	0.222				
0-lowest, 1=middle	0.173 (-0.003-0.349)	0.054				
0-lowest, 1=second highest	0.391 (0.148-0.635)	0.002				
0-lowest, 1=highest	0.656 (0.369-0.943)	<0.001				
Income group	Wald=32.100	<0.001		<0.001		
0=poorest, 1=middle	0.270 (0.023-0.517)	0.032	0.183 (0.063-0.304)	0.003	0.179 (0.052-0.306)	0.006
0=poorest, 1=richest	0.683 (0.443-0.922)	<0.001	0.221 (0.060-0.383)	0.007	0.213 (0.055-0.372)	0.008
Maternal education	Wald=58.038	<0.001			-	-
0=no schooling, 1=primary school	0.187 (-0.152-0.526)	0.279				
0=no schooling, 1= secondary school	0.462 (0.307-0.617)	<0.001				
0=no schooling, 1= ≥higher secondary	0.761 (0.432-1.091)	<0.001				
Father's education	Wald=71.949	<0.001		0.004		
0=no schooling, 1=primary school	0.157 (-0.061-0.376)	0.159	0.133 (-0.037-0.303)	0.126	0.130 (-0.040-0.300)	0.145
0=no schooling, 1= secondary school	0.134 (-0.069-0.338)	0.196	0.131 (-0.054-0.316)	0.165	0.112 (-0.080-0.304)	0.264
0=no schooling, 1= ≥higher secondary	0.454 (0.325-0.582)	<0.001	0.212 (0.093-0.331)	<0.001	0.189 (0.054-0.323)	0.006
District	Wald=14.157	0.001		0.001		
0=West Singhbhum, 1=Saraikela	0.536 (0.255-0.817)	<0.001	0.374 (0.130-0.617)	0.003	0.377 (0.263-0.491)	0.001

0=West Singhbhum, 1=Keonjhar	0.203 (-0.099-0.505)	0.188	0.361 (0.155-0.568)	0.001	0.360 (0.149-0.571)	0.001
Religion	Wald=5.448	0.066			-	-
0=Sarna, 1=Hindu)	0.267 (0.042-0.493)	0.020				
0=Sarna, 1= Christian/Muslim/other	0.059 (-0.212-0.329)	0.671				
Social group	Wald=43.607	<0.001		<0.001		
0=Scheduled Tribe, 1=Scheduled Caste	0.260 (-0.229-0.748)	0.297	0.086 (-0.601-0.772)	0.807	0.077 (-0.595-0.748)	0.828
0=Scheduled Tribe, 1=Other Backward Class	0.590 (0.401-0.779)	<0.001	0.340 (0.195-0.485)	<0.001	0.328 (0.181-0.475)	<0.001
0=Scheduled Tribe, 1=Other	0.397 (-0.198-0.991)	0.191	0.053 (-0.524-0.630)	0.857	0.051 (-0.228-0.331)	0.854
UNDERLYING CAUSES OF UNDERNUTRITION						
Food security (household shocks in the previous 12 months)					-	-
Disease epidemic 0=no, 1=yes	0.050 (-0.200-0.300)	0.695			-	-
Major household health problem 0=no, 1=yes	-0.254 (-0.688-0.160)	0.229				
Crop failure 0=no, 1=yes	-0.001 (-0.382-0.380)	0.995			-	-
Damage to houses or crops by elephants 0=no, 1=yes	-0.200 (-0.445-0.046)	0.111			-	-
Any of the above household shocks 0=no, 1=yes	-0.096 (-0.349-0.157)	0.456			-	-
Care for children						
Early initiation of breastfeeding: 0=no, 1=yes	0.019 (-0.212-0.250)	0.873			-	-
Bottle feeding 0=no, 1=yes	-0.039 (-0.300-0.222)	0.770			-	-
Pre-lacteal feeds 0=no, 1=yes	0.012 (-0.283-0.307)	0.938			-	-
Colostrum discarding 0=no, 1=yes	0.208 (-0.003-0.419)	0.054			-	-
BCG immunisation 0=no, 1=yes	0.413 (0.048-0.777)	0.026			-	-
DPT immunisations (3) 0=no, 1=yes	0.321 (0.095-0.548)	0.005			-	-
Polio immunisations (3) 0=no, 1=yes	0.347 (0.060-0.635)	0.018			-	-
Feeding frequency during diarrhoea, fever, cough	Wald=7.193	0.027			-	-
0=none/less, 1=same/more	0.241 (-0.056-0.538)	0.112				
0-none/less, 2=n/a (no diarrhoea, fever, cough)	0.360 (0.095-0.625)	0.008				
Liquids given during diarrhoea, fever, cough	Wald=29.174	<0.001			-	-
0=none/less, 1=same/more	-0.018 (-0.469-0.433)	0.938				
0-none/less, 2=n/a (no diarrhoea, fever or cough)	0.418 (0.052-0.785)	0.025				
Treatment seeking for diarrhoea, fever and/or cough	Wald=57.539	<0.001			-	-
0=no, 1=yes	0.644 (0.416-0.872)	<0.001				
0=no, 1=n/a (no diarrhoea, fever or cough)	0.698 (0.514-0.883)	<0.001				
ORS given for diarrhoea (last 14 days):	Wald=31.501	<0.001			-	-

0=no, 1=yes	0.049 (-0.311-0.408)	0.790				
0=no, 1=n/a no diarrhoea	0.447 (0.174-0.720)	0.001				
Birth order	Wald=85.855	<0.001		<0.001		
0=First born, 1=Second born	-0.036 (-0.191-0.119)	0.650	-0.037(-0.215-0.142)	0.688	-0.036 (-0.200-0.129)	0.671
0=First born, 1=Third born	-0.233 (-0.444- -0.022)	0.031	-0.164 (-0.357-0.028)	0.095	-0.129 (-0.325-0.067)	0.197
0=First born, 1=≥Fourth born	-0.550 (-0.678- -0.423)	<0.001	-0.353 (-0.488- -0.219)	<0.001	-0.304 (-0.439- -0.169)	<0.001
Care for mothers						
Number of children born	Wald=7.916	0.019			-	-
0=one, 1=two-three children	0.174 (-0.150-0.497)	0.293				
0=one, 1=≥4 children	-0.150 (-0.402-0.102)	0.244				
Birth spacing	Wald=43.076	<0.001		0.003		
0=<24 months, 1=≥24 months)	0.303 (0.173-0.434)	<0.001	0.212 (0.089-0.335)	0.080	0.230 (0.114-0.345)	<0.001
0=<24 months, 1-Don't know/missing)	0.504 (0.345-0.663)	<0.001	0.161 (-0.019-0.340)	0.001	0.156 (-0.023-0.334)	0.087
Self-reported anaemia in pregnancy (0=no, 1=yes)	-0.323 (-0.622- -0.024)	0.034			-	-
Self-reported malaria in pregnancy (0=no, 1=yes)	-0.188 (-0.441-0.064)	0.144			-	-
Iron tablets in pregnancy (0=no, 1=yes)	0.231 (0.003-0.458)	0.047			-	-
Quantity of iron tablets in pregnancy	Wald=10.783	0.005			-	-
0=no tablets, 1=<50 tablets	0.066 (-0.109-0.241)	0.461				
0=no tablets, 1=≥50 tablets	0.281 (0.039-0.523)	0.023				
Food consumption in pregnancy					-	-
0=less, 1=same/more than usual	0.071 (-0.172-0.315)	0.566				
Maternal Body Mass Index	0.075 (0.054-0.096)	<0.001	0.062 (0.034-0.090)	<0.001	0.064 (0.038-0.091)	<0.001
Physical illness/injury in the last three months					-	-
(non-pregnancy): 0=no, 1=yes	-0.145 (-0.337-0.046)	0.137				
Psychological distress (K10 scores >15: 0=no, 1=yes)	-0.302 (-0.649-0.045)	0.088			-	-
Underlying child health issues						
Repeated diarrhoea	-0.450 (-0.652- -0.248)	<0.001			-	-
Repeated fever	-0.240 (-0.419- -0.060)	0.009			-	-
Repeated cough	-0.267 (-0.475- -0.060)	0.011	-0.215 (-0.339- -0.091)	0.001	-0.201 (-0.318- -0.084)	0.001
Health environment and services						
Place of delivery	Wald=34.603	<0.001				
0=Home/providers home/other, 1=govt facility	0.273 (0.101-0.446)	0.002			0.124 (-0.003-0.251)	0.056
0=Home/providers home/other, 1=pvte facility	0.656 (0.395-0.916)	<0.001			0.060 (-0.178-0.299)	0.585

Antenatal visit (0=no, 1=yes)	0.336 (0.167-0.506)	<0.001			-	-
Postnatal visit (0=no, 1=yes)	0.125 (-0.066-0.315)	0.200			-	-
Growth monitoring					-	-
0=less than once/month, 1=≥once/month	-0.040 (-0.290-0.210)	0.755				
Food rations received via AWW	Wald=1.812	0.404			-	-
0=rarely or never, 1=daily or weekly	0.131 (-0.216-0.479)	0.459				
0=rarely or never, 1=monthly	-0.023 (-0.313-0.267)	0.877				
Living area:						
0= >3 per sleeping room, 1=≤3 per sleeping room	0.325 (0.170-0.479)	<0.001			0.085 (-0.011-0.181)	0.084
Cooking location	Wald=7.180	0.028			-	-
0=in the house, 1=in a separate room	0.296 (0.076-0.517)	0.169				
0=in the house, 1=outdoors	0.178 (-0.075-0.431)	0.008				
Season of birth	Wald=6.747	0.034			-	-
0=winter, 1=summer	0.098 (-0.044-0.239)	0.176				
0=winter, 1=rainy	0.142 (0.033-0.250)	0.010				
Source of drinking water					-	-
0=unimproved, 1=improved	0.233 (0.080-0.386)	0.003				
Treatment of drinking water					-	-
0=none, 1=physical or chemical	0.335 (0.040-0.630)	0.026				
Time taken to collect drinking water	-0.089 (-0.296-0.117)	0.395			-	-
0=>30, 1=≤30 minutes						
Disposal of children’s faeces					-	-
0=unsafe practices only, 1=some safe practices	0.065 (-0.216-0.347)	0.648				
Hand washing agent: 0=none, 1=ash/mud/soap	0.500 (0.259-0.741)	<0.001	0.399 (0.242-0.556)	<0.001	0.375 (0.214-0.537)	<0.001
Hand washing occasions when soap is used					-	-
Before preparing food (0=no, 1=yes)	0.212 (-0.322-0.746)	0.437				
Before feeding a child (0=no, 1=yes)	-0.422 (-0.580- -0.263)	<0.001				
After defecation (0=no, 1=yes)	0.437 (0.168-0.706)	0.001				
After cleaning up a child who has defecated (0=no,1=yes)	0.431 (0.110-0.752)	0.009				
Before eating (0=no, 1=yes)	-0.037 (-0.275-0.200)	0.759				
Hand washing score based on above five occasions (0-5)	0.165 (-0.058-0.388)	0.148				
IMMEDIATE CAUSES OF UNDERNUTRITION						
Dietary intake (previous 24 hours)						

Predominant breastfeeding (0=no, 1=yes)	-0.239 (-0.405- -0.074)	0.005			-	-
Minimum dietary diversity (0=no, 1=yes)	0.431 (0.192-0.671)	<0.001			-	-
Minimum meal frequency (0=no, 1=yes)	0.102 (-0.015-0.220)	0.088			-	-
Consumption of iron-rich foods (0=no, 1=yes)	0.277 (0.084-0.470)	0.005	0.315 (0.104-0.525)	0.003	0.265 (0.061-0.470)	0.015
Age-appropriate breastfeeding (0=no, 1=yes)	0.101 (-0.045-0.247)	0.176			-	-
Health status						
14 day diarrhoeal prevalence	-0.428 (-0.598- -0.257)	<0.001	-0.273 (-0.415- -0.131)	<0.001	-0.275 (-0.404- -0.146)	<0.001
14 day fever prevalence	-0.291 (-0.475- -0.106)	0.002	-0.178 (-0.317- -0.039)	0.012	-0.183 (-0.315- -0.050)	0.007
14 day cough prevalence	-0.287 (-0.538- -0.036)	0.025			-	-
Diarrhoeal severity (last 14 days)	Wald=22.791	<0.001			-	-
0=no diarrhoea, 1=diarrhoea, no blood	-0.454 (-0.646- -0.263)	<0.001				
0=no diarrhoea, 1=diarrhoea, blood present	-0.277 (-0.546- -0.009)	0.043				
Cough severity (last 14 days)	Wald=13.659	0.001		0.002		
0=no, 1=yes	0.015 (-0.283-0.312)	0.923	0.087 (-0.108-0.282)	0.380	0.070 (-0.113-0.253)	0.455
0-no, 1=yes + abnormal breathing	-0.426 (-0.679- -0.172)	0.001	-0.178 (-0.330 - -0.026)	0.022	-0.180 (-0.338- -0.023)	0.025

Appendices: chapter 8

Appendix 8.1 Topic guide for focus group discussions

Focus Group Discussions with Tribal and Non-Tribal Childbearing Women in three districts of Jharkhand and Orissa, Eastern India

OBJECTIVES OF THE FOCUS GROUPS:
To find out how women obtain food for themselves and their children/families to find out whether there are any seasonal differences in nutrition and/or feeding practices
To understand the nature of any common food rituals that take place in the women's villages/hamlets and whether specific food rules apply to pregnant, post-partum or breastfeeding compared to other times
To explore whether there are any food/drink rituals that involve infants or young children
To explore what Women commonly feed their children at different ages
To gain insight into common food handling practices in the Women's villages/hamlets
To find out whether women perceive there to be a problem of infant and young child malnutrition in their village/hamlet, and if so, what do they think are the most important causes of undernutrition in their area

THANK PARTICIPANTS FOR COMING
INTRODUCE YOURSELF
REMIND PARTICIPANTS ABOUT THE PURPOSE OF THE FOCUS GROUP DISCUSSION

1. **Would you mind telling me which tribal group (if any) you belong to?**
2. **First of all I'd like to <u>ask you generally about the ways that you obtain food for yourselves and your families to eat</u>.**
   - Can you describe some of the ways that people typically obtain food for themselves and their children/families?
   - What kind of challenges to people face when trying to get food for themselves and their families?
   - What are typical local food choices at different times of year?
   - What are people's experiences of accessing food markets? (probe - how do people get there? What kind of distances do people have to travel? What is the terrain like?)
   - Have people noticed any patterns or changes in food prices (probe: have there been changes recently? Are certain changes expected in different seasons?)
   - Have people noticed any changes in the availability of different foods that were not expected for the time of year?
   - Have people experienced times of food shortage? If so, what do people do to cope with/adapt to those circumstances?
3. **Now I'd like to ask you <u>generally about local food customs in your village</u>.**

- Are there any common food rituals that take place in your village/hamlet? (e.g. associated with festivals, religious occasions or cultivation?)

4. **Now I would like to ask you about some of the <u>ways that mothers feed their infants and young children in your village/hamlet</u>**
   - What are typical local food choices for children under 5? Probe: what about children aged less than 6 months? Probe: what about 6-23 months? What about 24-36 months?
   - What are some commonly held beliefs that affect feeding of infants and young children. Probe: are there any beliefs about heavy or thin children? Are there beliefs about how to feed infants and young children who become ill?
   - Are there any special rituals involving foods or beverages that include babies and young children?
5. **Now I would like to ask you about <u>some of the common food handling practices that occur in your village/hamlet</u>**
   - How is food commonly prepared and cooked in your community? (probe for practices around infant feeding e.g. hand washing before food preparation, boiling of water, sterilising of bottles etc)
   - Do you know of any common food preparation practices that may lead to illness?
6. **Now I would like to ask you about <u>your perception of the nutrition of infants and young children in your village/hamlet</u>** ***[This is a very sensitive issue, but a very important one - extra probes/extra time for this question may be required]***
   - In your view, are there many infants and young children living in your village/hamlet that are very thin and/or small for their age?
     - If so, what do you feel are the important causes?
     - In your view, what needs to be done to reduce this problem?
   - How do you feel about children being weighed and measured by Anganwadi workers or other community health workers?
     - Do you have any specific beliefs about children being weighed and measured?
7. **Is there anything that you would like to add? Or anything that you think should have been discussed that hasn't been? Do you have any questions that you would like to ask?**

TAKE TIME TO ANSWER PARTICIPANTS' QUESTIONS. WHEN THE DISCUSSION IS FINISHED, THANK PARTICIPANTS FOR THEIR TIME.