The association between paternal labour migration and the growth of the left-behind children in the plains of Nepal

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Scenes from the life of a left-behind woman.

Painting by artist Madhumala at the Janakpur Women's Development Center

Declaration

I, Laura Busert-Sebela confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Abstract

Background

Nepal has a high prevalence of child stunting and international labour migration, but little is known about how the fathers' migration affects the growth of left-behind children.

Objectives

1) To identify the determinants of infant growth in Dhanusha district, Nepal.
2) To determine the association between paternal labour migration and the growth of the left-behind children in Dhanusha district, Nepal.

Methods

I used data from a previous birth cohort study (*n*=602) conducted in Dhanusha district. Children were enrolled at birth in 2012 and measured every 28 days until they were two years. I followed up this cohort in 2018 when the children were six years. I collected data on the household migration history to determine the children's exposure to migration during their lifetime and during pregnancy. The main outcome was child length/height-for age *z*-score. I also measured children's body circumferences, skinfold thicknesses, body composition, tibia length and grip strength at the 2018 follow-up as secondary outcomes.

I used mixed-effects linear regression to 1) examine the impact of household and maternal factors, season, feeding practices and infection on infant growth, and to 2) determine the association between exposure to paternal international labour migration and the growth of the left-behind children.

Results

1) Maternal factors related to both the environment in-utero (low birthweight) and in postnatal life (education, adolescent pregnancy) were the most important determinants of infant growth.
2) There was no indication of a positive association between paternal labour migration and any measure of child growth. Under some circumstances such as very young age and shortly after the fathers' departure, there was a negative

association between labour migration and the growth of the left-behind children.

Conclusions

There is a need for interventions to support pregnant women and mothers with small babies, especially if their husband just left for work overseas.

Impact statement

My thesis offers rare insights into the association between the father's international labour migration and the growth of their children that are left behind in the home communities in a population of Nepal that has very high levels of labour migration and is also severely affected by child malnutrition.

The systematic review (Chapter 2) provides a comprehensive overview of the existing evidence on the impact of parental migration on the left-behind children's nutritional status, and highlights gaps in the literature. This is of interest for both researcher and policymakers.

I present a comprehensive profile (Chapter 5) of a birth cohort which includes representative and longitudinal data on growth trajectories, feeding practices, infections, and socio-economic status of households with small children in Dhanusha district. I also provide a detailed migration profile from this district which has the highest number of international migrants in the country. This descriptive information can inform regional policymakers and program implementers.

My analysis on the determinants of infant growth (Chapter 6) highlights the importance of maternal factors, both in utero and in postnatal life. These findings call for more public health interventions targeting girls and women, and should comprise the pre-natal period, pregnancy, and postnatal life. This can inform researchers in the development of new interventions, but also guide policy makers in the formulation and enforcement of policies such as those protecting children from early marriage and promoting school education for girls.

At the core of my thesis is the analysis on the association between fathers' international labour migration and the growth of the left-behind children (Chapter 7). My study adds to the very scarce body of evidence from labour-sending and remittance-dependant countries. It also provides a more nuanced analysis due to longitudinal data with frequent measurements and detailed migration history. I was able to address two important moderating factors, child age and duration of fathers' absence, which allowed me to identify circumstances under which left-behind children and mothers appear to be particularly vulnerable. These findings can help program implementers in this area to adjust their services, so that left-behind children are better protected from the possibly harmful effects of migration. In a more general sense, these findings also add to the existing evidence of a labour migration governance in Nepal that is not designed to serve migrants and their families, but the economic interest of the labour recruitment sector and overseas employers.

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Dedication

For Levi

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Contents

List of Figures

List of Tables

Abbreviations and terms

ANC	antenatal care
ASIS	anterior superior iliac spine
BIA	bioelectrical impedance analysis
BIC	Bayesian information criterion
BMI	body mass index
BMIZ	body mass index *z*-score
CHNS	China Health and Nutrition Survey
CI	confidence interval
DAG	directed acyclic graph
Dalit	lowest ranking group in the Indian caste system
Dhanusha	district in the central plains region of Nepal
DHS	demographic health survey
EED	environmental enteric dysfunction
FANTA	Food and Nutrition Technical Assistance Project
FM	fat mass
FMI	fat mass index
FMZ	fat mass *z*-score
GAM	general additive models
GBP	Great Britain Pound
GCC	Gulf Cooperation Council (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates)
GDP	gross domestic product
GMS	Growth Monitoring Study
GNI	gross national income

GoN	Government of Nepal
HAZ	height-for-age *z*-score
ILO	International Labour Organization
IOM	International Organization for Migration
IQR	interquartile range
IRMS	isotope ratio mass spectrometry
IUGR	intrauterine growth restriction
IYCF	infant and young child feeding
Janajati	indigenous ethnic groups in Nepal
LAZ	length-for-age *z*-score
LM	lean mass
LMI	lean mass index
LMICs	low- and middle-income countries
LMZ	lean mass *z*-score
MGRS	Multicentre Growth Reference Study
MI	multiple imputations
MICS	Multiple Indicator Cluster Survey
MIRA	Mother and Infant Research Activities
MUAC	mid-upper arm circumference
NICE	National Institute for Clinical Excellence
NLFS	Nepal Labour Force Survey
NLSS	Nepal Living Standards Survey
NPR	Nepalese Rupee
ODA	official development assistance
ODK	Open Data Kit

OR	odds ratio
ORS	oral rehydration salts
PLA	participatory learning and action
RMSE	root-mean-square error
RR	risk ratio
SD	standard deviation
SE	standard error
SDG	Sustainable Development Goal
SGA	small-for-gestational age
SMD	standardised mean difference
TBW	total body water
TEM	technical error or measurement
Terai	plains of Nepal, south of the Himalayan foothills
UAE	United Arab Emirates
UCL	University College London
UNDP	United Nations Development Programme
USD	United States dollar
VDC	Village Development Committee
WASH	water, sanitation, and hygiene
WAZ	weight-for-age *z*-score
WHO	World Health Organization
WHZ	weight-for-height *z*-score

1 Introduction

Summary

This thesis aims to determine the association between paternal labour migration and the growth of left-behind children in Dhanusha district, Nepal.

In this chapter I provide an introduction to the two themes of my thesis: Children left behind through labour migration, and child growth. I then list the three objectives through which I work towards achieving the thesis aim. The final section of this chapter provides the conceptual framework explaining the assumed pathways through which paternal labour migration can affect the left-behind child's growth.

1.1 Labour migration and left-behind children

The public discourse on migration is dominated by the very polarized topic of refugees and asylum seekers who come to high-income countries. Yet, the majority (169 million) of the 272 million international migrants reported in 2019 are labour migrants (IOM, 2021). Labour migration is defined as the "movement of persons from one State to another, or within their own country of residence, for the purpose of employment" (IOM, 2019). The (recorded) remittances that these labour migrants from low-and middle-income countries sent back to their homes made up USD 540 billion in 2020, but unrecorded remittance flows are not captured and the actual volume of remittances is likely much higher (IOM, 2021). Globally, the annual volumes of remittances have long surpassed that of official development assistance (ODA) and are now more than three times the volume of those government aid flows (IOM, 2021). The economies of many countries are highly dependent on remittance inflows. One of those countries is Nepal where remittances made up 24% of the gross domestic product in 2020 (World Bank Group, 2022). It has been estimated that around one fifth of the poverty reduction occurring in Nepal between 1995 and 2004 can be attributed to remittances (Lokshin, Bontch-Osmolovski, & Glinskaya, 2010).

It is reasonable to assume that many prospective labour migrants are motivated to seek employment elsewhere by the hope that the remittances that they send home can help them secure a better future for their children. These so-called “left-behind children”, children who are raised in their home while one or both of their parents migrated abroad or within the country, are left in the care of a remaining parent, relatives, or neighbours. There are no global estimates available on the number of left-behind children, but the number is expected to be in the hundreds of millions. In China alone, 69 million children are left behind in rural areas while one or both parents work in the city (UNICEF, 2018). In Nepal, one in five children has at least one parent living abroad (National Planning Commission [Nepal], 2020a). Similar numbers are reported in other labour-sending countries such as the Philippines (27%) (Reyes, 2008).

Despite the large number of children affected by parental migration, there is limited evidence on the impact that parents’ absence has on them. On the one hand, the additional income from remittances can help poor households secure the material welfare of children. On the other hand, the process of migration and the parental absence are associated with both financial and social costs that can negatively impact the left-behind children. The potential impacts span over all domains of child wellbeing: mental health, abuse and neglect, education, substance abuse, child labour, gender roles, nutrition, and health care usage (BRAC, 2017; Cortés, 2007, 2008). UNICEF reports found that the nature of migration and the circumstances for left-behind children are very heterogenous between countries and thus the observed impacts are mixed (Cortés, 2007, 2008). While in areas such as schooling, access to healthcare, child labour, and gender roles, both positive and negative effects have been observed, parental migration appeared to have largely negative effects on the children’s emotional and psychological wellbeing, and risk of abuse and neglect (BRAC, 2017; Cortés, 2007, 2008; UNICEF Tajikistan, 2011; Vladicescu, Cantarji, & Jigău, 2008). This thesis focuses on child growth as an outcome of paternal labour migration.

1.2 Child growth

Child growth as a reflection of their environment

> *"A child's growth rate reflects, perhaps better than any other single index, his state of health and nutrition; and often indeed his psychological situation also. Similarly, the average values of children's heights and weights reflect accurately the state of a nation's public health and the average nutritional status of its citizens, when appropriate allowance is made for differences, if any, in genetic potential. This is especially so in developing or disintegrating countries."* (Eveleth & Tanner, 2011)

This statement very aptly describes the value of growth studies to monitor the wellbeing of a population. In other words, mean height is a powerful indicator of the "cumulative nutritional, hygienic, disease and stress experience" of populations (Tanner, 1992). Thus, the secular trends in height observed in many populations over the past centuries reflect their improvements in health, prosperity and social equality (Cole, 2000; Stulp & Barrett, 2016). At the same time, differences in height between groups of one population reflect the prevailing inequalities in health and wealth (Cole, 2000).

The role of genetics

Genetics also play an important role in height, but to a larger extent in affluent populations where the limiting influence of environmental factors such as hygiene and nutrition are smaller compared to low-income settings (Stulp & Barrett, 2016). The well-documented increase in mean height observed in many populations since the 19th century, however, is unlikely to be due to genetics. Firstly, these changes happened over too short a time span for the gene pool to change substantially. Secondly, children from affluent families in low-income countries grow similarly to those in high-income countries (Cole, 2000). The World Health Organization (WHO) Multicentre Growth Reference Study (MGRS) was guided by and confirmed this rationale when they pooled growth data of children from five different countries, who lived under relatively affluent conditions and whose mothers followed feeding recommendations, to construct the WHO Growth Standards. They found that in the first five years of life, children who are raised in favourable environments grow very similarly in height (WHO Multicentre Growth Reference Study Group & de Onis, 2007).

Stunting

The observed increase in mean height in most European countries since the 19th century has been argued to constitute a reduction in stunting (Cole, 2000). Stunting is understood to be a failure to reach one's genetic growth potential due to a suboptimal environment (de Onis & Branca, 2016) and means that a child is too short for their age. In technical terms, stunting is defined as standing height (or recumbent length for children under two years) more than two standard deviations (SD) below the age- and sex-standardised median of a reference group, typically the 2006 WHO Growth Standards (de Onis & Branca, 2016). This cut-off point is useful because it is a widely adopted standard indicator and easy to measure, but it brushes over the fact that there are not two distinct groups, one stunted and the other "normal". Instead, there is a gradation in growth faltering and even children who do not fall under the stunting threshold may have experienced growth faltering and could have developed better in an environment that fully catered to their needs (de Onis & Branca, 2016). The number of children who have experienced growth faltering is therefore much larger than those defined as stunted.

The first 1000 days

It is widely acknowledged that growth faltering already begins in utero and mostly happens until about age two years, a period summarised in the catchphrase "1000 days" (Martorell, 2017; Victora, de Onis, Hallal, Blossner, & Shrimpton, 2010). This period in a child's life is characterised by rapid growth and development and is sensitive to insults such as deficient nutrition, infections, inadequate stimulation and care (Martorell, 2017). Similarly, there is evidence to suggest that most of the secular trends in height happened in the first two years of life (Cole, 2000). These observations have led to a prioritisation of this period as a "window of opportunity" for growth promoting interventions (Victora et al., 2010), but it has been argued that other periods such as maternal preconception nutrition and the pubertal growth phase pose additional windows of opportunity where interventions to promote growth (height), improved maternal perinatal outcomes, and health for the next generation (offspring outcomes) might be effective and should not be neglected (Leroy & Frongillo, 2019; Prentice et al., 2013).

Why child growth matters

The prevention of child stunting has been the focus of many nutrition initiatives and is enshrined in the Sustainable Development Goal (SDG) 2 to “end all forms of malnutrition”, including stunting (United Nations, 2017). But why should we care about the length of children? Firstly, as mentioned earlier, growth faltering is a useful indicator of deficits in the children’s environment and can be used to call for action to improve the nutrition, health, hygiene, and psychosocial situation in this population. In which aspects of the children’s life they experience most deprivation and which factors contribute most to their growth faltering differs between settings and thus research on the determinants of growth faltering can arrive at different conclusions depending on the context. Growth faltering or stunting is associated with adverse short- and long-term outcomes such as higher mortality in early childhood, delayed child development and poor schooling outcomes, reduced work capacity, and thus lower productivity and earnings as adults compared to non-stunted children (Black et al., 2013; Grantham-McGregor et al., 2007; McDonald et al., 2013; Sudfeld et al., 2015). It is unlikely that stunting is the primary direct cause of these outcomes, instead stunting and these adverse outcomes share common causes such as inadequate nutrition, care, and frequent infections (Leroy & Frongillo, 2019). Early growth patterns in weight and low weight-for-height (wasting) have also been linked to body composition (Jonathan C.K. Wells, 2017) and risk of chronic disease (de Onis & Branca, 2016; Mwene-Batu et al., 2022; Mwene-Batu, Bisimwa, et al., 2021; Mwene-Batu, Lemogoum, et al., 2021; Stewart, Iannotti, Dewey, Michaelsen, & Onyango, 2013) in adulthood, but there is not enough evidence to support a direct causal role of growth faltering or stunting itself in the development of chronic disease (de Onis & Branca, 2016; Leroy & Frongillo, 2019). Instead, there is strong evidence that growth faltering in childhood occurs following a period of loss in body weight or wasting (Schoenbuchner et al., 2019) and it is possible that the association between stunting and higher risk of mortality and morbidity occurs because stunting signals the damage of former wasting.

Secondly, growth faltering in girls increases the risk of obstructed labour in womanhood which seriously impacts maternal mortality and morbidity. Stunted children grow up to be short adults (Adair et al., 2013) and short women tend to have a smaller pelvic inlet. Short stature in women thus increases the risk of cephalopelvic disproportion, a mismatch between the size of the mother's pelvis and the size of the baby's head, which in turn increases the risk of dystocia (difficult labour) (Jonathan C. K. Wells, 2017). Obstructed labour contributes significantly to maternal mortality and morbidity. Three percent of all maternal deaths worldwide were due to obstructed labour (Say et al., 2014), which makes up 40% of the total years lived with disability due to maternal disorders (Vos et al., 2017).

Thirdly, maternal short stature, a result of childhood growth faltering, plays a causal role in the development of adverse birth outcomes and contributes to the intergenerational cycle of growth faltering. Babies of short mothers are more likely to experience intrauterine growth restriction (IUGR) and be born small-for-gestational age (SGA) (Kozuki et al., 2015). Globally, 5.5 million SGA births were attributable to maternal short stature; short stature and SGA have the highest prevalence in South Asia (Kozuki et al., 2015). Short mothers are also more likely to have preterm births (Kozuki et al., 2015). Being SGA and preterm birth are both associated with increased risk of infant mortality and adverse outcomes in adult life (Allotey et al., 2018; Barker, Osmond, Golding, Kuh, & Wadsworth, 1989; Katz et al., 2013; Mwaniki, Atieno, Lawn, & Newton, 2012). The prenatal period is critical for child growth and development and much of the growth deficit observed in infancy has its roots in this period. Being preterm and/or SGA is associated with higher odds of stunting and 20% of the stunting observed in children under five years can be attributed to being SGA (Christian 2013).

In summary, child growth signals past experiences, predicts future successes, and is an important health outcome in its own right.

1.3 Thesis aim and objectives

Aim

The overarching aim of this thesis is to determine the association between paternal labour migration and the growth of left-behind children in Dhanusha district, Nepal.

Objectives

I will achieve this through the following objectives

1. To summarize the existing evidence on the effects of parental labour migration on the nutritional status of left-behind children and adolescents in low- and middle-income countries.
2. To identify determinants of infant growth in Dhanusha district, Nepal.
3. To determine the association between paternal labour migration and the growth of the children left behind in Dhanusha district, Nepal.

Thesis outline

The final section of **Chapter 1** is a conceptual framework explaining the assumed pathways through which paternal labour migration can affect the left-behind children's nutritional status.

Chapter 2 presents a systematic review summarising the existing evidence on the effects of parental migration on the nutritional status of children and adolescents left behind in the home (Objective 1).

In **Chapter 3** I describe the research context in Nepal, and in particular Dhanusha district. I first provide a general overview of the country Nepal. Second, I describe trends in child and maternal malnutrition, and the proximal and distal determinants of child stunting in Nepal. Third, I characterise the history and current situation of labour migration in Nepal.

The methods of my data collection are detailed in **Chapter 4**.

I provide a cohort profile of the Growth Monitoring Study (GMS) in **Chapter 5**. I describe the home environment, growth and nutritional status, body composition, child feeding and diet, illness, and migration patterns.

The following two chapters present the main results. In **Chapter 6** I identify the determinants of infant growth in the GMS cohort (Objective 2). In **Chapter 7** I quantify the association between paternal labour migration and the growth of the left-behind children in the GMS cohort (Objective 3).

In the final **Chapter 8**, drawing on the findings in my study and its limitations, I point out research needs to better understand the experiences of left-behind women and children. I further suggest interventions to better support mothers and mothers-to-be. I conclude with recommendations for policy and programmes to better serve migrants and their families.

1.4 Conceptual framework

In this section I explain my assumptions about the pathways through which parental, and in particular paternal, labour migration can affect the nutritional status of the children that are left behind. The pathways mentioned in the literature may be categorised as (I) financial pathways, (II) absence of the migrated parent, and (III) social remittances. Before explaining in detail how these operate, I briefly outline what generally motivates households in low-income settings to send one of their members overseas for work, and what may determine the individual decision to migrate in a given setting. I visualise my assumptions in a conceptual framework (Figure 1.1) where each box in the ‘Determinants of migration’ and ‘Pathways’ domain represents one of the paragraphs below. The pathways discussed here can affect a wide range of mediating factors which in turn can affect the immediate causes of child malnutrition, illness and diet (Black et al., 2008).

Although the mechanisms in this chapter can be applied to different contexts, I focus on those that are relevant to the Nepali context and, where possible, cite evidence from this or culturally comparable countries.

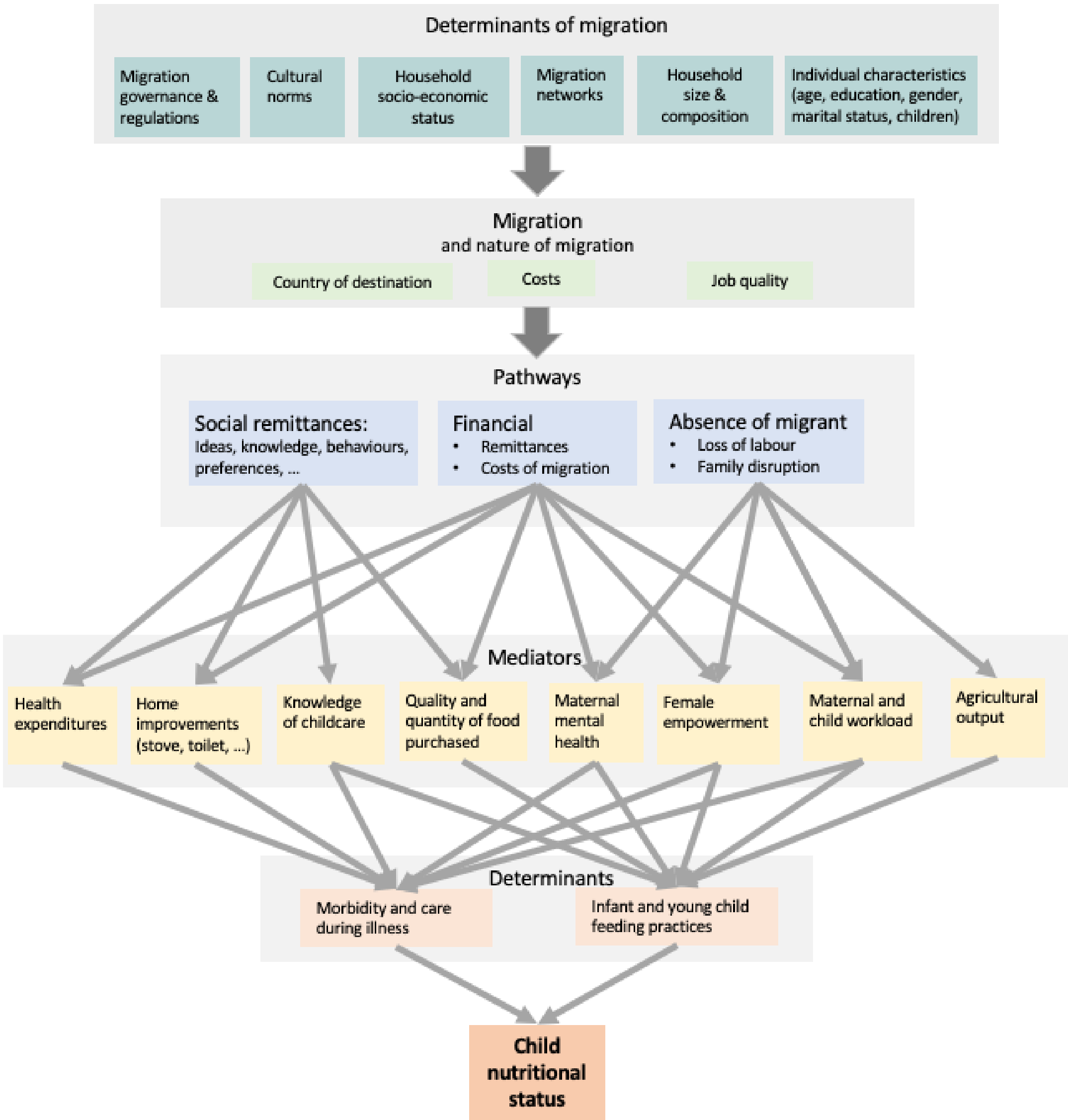


Figure 1.1: Conceptual framework on the impact of parental migration on child nutritional status.

Determinants of labour migration

According to the New Economics of Labour Migration theory, migrants in low-income settings often do not take the decision to migrate in isolation, but together with other members of the household that stay at home (Stark & Bloom, 1985). The risks (costs) and economic benefits (remittances) of migration are shared by the whole household. Sending one of their members away for work is viewed as a means to diversify household income and reduce income risks, overcome the credit constraints faced in many low-income settings, and increase the absolute and relative household wealth. A 2014 survey of 350 Nepali returnee migrants from Qatar found that they earned a median monthly income of USD 339 (GBP 203/ NPR 33,900[1]) abroad, more than three times the USD 109 (GBP 65/ NPR 10,900) that they earned before leaving Nepal (Martin, 2016) and about twice the median monthly earnings reported by the Nepalese Government in 2017 (NPR 15 208/ GBP 104[1]) (Central Bureau of Statistics [Nepal], 2019)

Migration governance and regulations

At the macro level, policies and institutions can both facilitate and deter migration and the specific policies governing labour migration in Nepal will be explained in detail in Chapter 3.3. The Nepali Foreign Employment Act, which governs labour migration in Nepal, provides an example of how national legislation can impact migration flows. At its inception in 1985 it was intended to control outmigration and prevent the pool of qualified labour from leaving the country. Since then the policy has seen a drastic turnaround and the current Foreign Employment Act 2007 aims to promote foreign employment and protect the rights and interests of migrant workers (Sijapati & Limbu, 2017). Additionally, bilateral agreements between labour sending and receiving countries ensure that both national interests are served and help to maintain an orderly stream of labour. An exceptional bilateral agreement is the Treaty of Peace and Friendship between the governments of Nepal and India. This treaty ensures the free movement of people and has certainly facilitated the flow of both seasonal and long-term labour between the countries.

Cultural norms

In communities with a strong past and present migrant outflow, leaving the home to seek work elsewhere can become normative, and a “culture of migration” (Kandel & Massey, 2002) may emerge. This has been described in Nepal where participants in a qualitative study expressed the pressure and expectation within the community to migrate (Adhikari & Hobley, 2015). Similarly, a lack of migration history in the closer community can lower migration rates compared to those in the wider environment. This was observed by Williams, Bhandari, et al. (2020) who found that the *Terai Janajati* in

[1] Using the following 2014 exchange rates:
NPR to GBP: 0.007
NPR to USD: 0.01
USD to GBP: 0.60

Chitwan are less likely to migrate than other ethno-castes in the area, and attribute this to the fact that they still live in their ancestral homeland and do not have a migration history.

Socio-economic status

It is not equally beneficial or feasible for all households in a given setting to send a member overseas for work. As will be elaborated later in this chapter, international labour migrants face considerable initial costs and not all can afford to make this investment. Poorer households might therefore decide to send a member for work to other regions within Nepal, or to India for which the administrational and financial barriers are much lower. On the other hand, households that are relatively well off and live comfortably may choose not to send any of their members away to engage in strenuous physical or degrading work. Socio-economic status, which in Nepal is also associated with caste and/or ethnicity, also influences the choice of destination and hence earning potential. Using data from the central *Terai* region, Williams, Bhandari, et al. (2020) find that the disadvantaged Dalit are more likely to migrate to India and Gulf countries, whereas high-caste Brahmin and Chhetri are more likely to migrate to wealthy Western countries. The latter destinations also have high educational requirements so that only the wealthiest and most educated are eligible to migrate. Using the Nepal Living Standards Survey 2003/04, Y. B. Gurung (2012) found that both the decision to migrate and the choice of destination were associated with household wealth in terms of landholding. There were fewer migrants among the poorer quintiles and, if they migrated, they tended to seek temporary labour in other rural areas within Nepal and to a lesser extent to India, whereas people in the better off quintiles tended to migrate to other countries.

Migration networks

Social networks of former and current migrants can help prospective migrants gain a realistic idea about the costs and benefits of working overseas, and the information obtained can lower the risks and costs of the migration process and living overseas. Additional to providing information, current or former migrants can give loans to prospective migrants and help them finance their migration. A large body of research demonstrates that people with migrants in their household or community are more likely to migrate themselves (see for example Kandel & Massey, 2002; Williams, Hughes, et al., 2020) and that the choice of destination is also heavily influenced by that of their peers (Williams, Hughes, et al., 2020). This pattern can be observed on a national level in Nepal where some provinces and districts have a much higher number of labour migrants and migrants tend to move to the same destinations as their peers. Most international migrant workers, not counting those going to India, come from Provinces one and two, and with more than 14 000 labour approvals issued in 2018/19 the highest number comes from Dhanusha district (Government of Nepal, 2020). In the same year, many districts in the Karnali province, on the contrary, had less than one hundred migrants each and the report by the Government of Nepal (2020) states that migration from this area tends to focus on India and is unrecorded.

Household size and composition

Several studies have observed that household size and composition are associated with the likelihood of a household member migrating for work. In India, the likelihood of a household member engaging in seasonal migration increases with household size and authors attributed this to a surplus of labour available in larger households (Deshingkar & Start, 2003; Dodd, Humphries, Patel, Majowicz, & Dewey, 2016; Mosse et al., 2002). Conversely, one can assume that smaller households are often not in a position to send any of their members away to seek foreign employment because they cannot dispense with the labour at home. An alternative interpretation is that this association is not causal, but that as household size and especially the number of working-age men increases, the probability of at least one member migrating also increases.

A similar pattern was observed in Nepal by Nepal and Knerr (2017) who found that households living as extended families in the districts Sunsari and Jhapa are more likely to have a migrant household member than nuclear families. The same study found that a higher number of working-age men in the household is associated with a higher likelihood of receiving remittances.

Another study in Nepal, on the contrary, found the association to work in the opposite direction. Contrary to his hypothesis, Y. B. Gurung (2012) found smaller households (1-5 members) to be slightly more likely to migrate than medium sized (6-7) ones. His explanation that these small households might be young families that only recently became their own household and are in need for money seems plausible in the Nepali context.

Individual characteristics

Additional to the determinants operating on the societal and household level, there are a range of individual characteristics that influence the likelihood of migration. Gender may be one of the most important determinants of (documented) migration in Nepal. Globally, the gender ratio of migrant workers is nearly even, with only slightly more men engaged in labour migration (ILO, 2018). In Nepal, however, the vast majority of (documented) migrant workers are men, and women only make up about five percent of the total migrant population (Government of Nepal, 2020). This gender disparity is partly attributed to the various migration bans and restrictions that the Government of Nepal had placed on women for many years, limiting the age, working sector and destination countries of prospective female migrants. These restrictions followed public concern over reports of exploitation, abuse and even death of female Nepali workers, particularly in Arab states, but were partially lifted in 2015 (ILO, 2015). It should be noted here, however, that the actual prevalence of female labour migrants has been considerably higher than reported in official statistics since many women resorted to irregular migration, bypassing regulations and becoming vulnerable to exploitation (ILO, 2015). Some of this gender disparity could also be explained by patriarchal norms that prevent women from seeking employment away from their home. Differences in gender norms could explain the geographical variability in the migration gender ratio in Nepal: While only 0.5% of (documented) migrants are women in Dhanusha district, the prevalence is as high as 36% and 32% in Sindhupalchowk and Kathmandu, respectively (Government of Nepal, 2020). This probably reflects the relative freedom of movement for hills women compared to those of the *Terai*.

Another important determinant of migration is age: Migrant workers from Nepal, as elsewhere, tend to be between 25 and 35 years (Government of Nepal, 2020). It is furthermore likely that people in Nepal choose to migrate around key events in their lives when they are in need for money, e.g., after marriage, having a baby or wishing to separate from the parental home.

Nature of migration

Labour migrants from one country of origin can have markedly different experiences while arranging for and during their stay abroad, and in the same way the effects of labour migration may be different for the families who stay behind. The country of destination, the type of job and quality of employment, and the costs and earnings are important moderators that influence the outcomes of labour migration through their impact on the pathways, in particular on 'social remittances' and financial pathways.

Financial pathways

Remittances

The most obvious potential positive effect of labour migration on the household at home is higher income through remittances. Firstly, the money that migrants send back relaxes budget constraints in their homes and can thus enable their families to purchase a higher quantity and quality of food. At the same time, food has been observed to have a low elasticity of demand, meaning that as income rises, the proportion of income spent on food falls (Engel's Law, *Dictionary of the Social Sciences*, 2002). Secondly, diversifying the income away from other income sources makes the household less vulnerable to economic shocks and smoothes their consumption during periods of food shortages. This has been observed in El Salvador, where the HAZ of children in remittance-receiving households was less negatively affected by the food price crisis than that of children with no access to remittances (de Brauw, 2011).

A systematic review on the effects of remittances on diet and nutrition found mixed results for studies comparing food expenditures between remittance and non-remittance receiving households (Thow, Fanzo, & Negin, 2016): While two studies in Indonesia (Adams & Cuecuecha, 2010) and Moldova (Vladicescu et al., 2008) found that remittances were associated with higher food expenditures, three studies in the Philippines (A. Quisumbing & McNiven, 2010), Mali (Perakis, 2011) and Ecuador (Ponce, Olivie, & Onofa, 2011) observed no change in food expenditure through remittances. In line with the above mentioned economic theory, studies in Mexico (Kaiser & Dewey, 1991) and Nepal (Roshini, 2009) found a negative association between remittances and the proportion of income spent on food, but only in the season winter (Mexico), and if both sender and receiver of remittances were female (Nepal). These studies, however, do not investigate the total amount of money spent on food, so it is nevertheless possible that the increased income through remittances has a positive net effect on food expenditures.

In terms of quality and quantity of food consumed, the studies identified in the review by Thow et al. (2016) also had diverging findings. A study in Nigeria (Babatunde & Qaim, 2010) found remittance-receiving households had a higher consumption of calories and iron rich foods, but no differences in dietary diversity. In contrast, a small study in Kenya (Onyango, Tucker, & Eisemon, 1994) observed that female-headed remittance-receiving households had higher dietary diversity, but no difference in macronutrient intakes. A qualitative study from Nepal found that remittances were associated with a higher intake of low quality purchased food and reductions in home production of food (Devkota, Poudel, Khanal, & KC, 2013).

In line with the mixed findings on the above outcomes, the results of studies investigating the effects of remittances on nutritional status were also not entirely conclusive. Only three (Antón, 2010; Babatunde & Qaim, 2010; de Brauw, 2011) out of nine studies found lower risks of undernutrition (stunting, wasting, or underweight) for children in remittance-receiving households, but the majority of studies (Bronte-Tinkew & DeJong, 2004; Davis & Brazil, 2016; Frank & Hummer, 2002; Nepal National Planning Commission, 2013; Onyango et al., 1994; Ponce et al., 2011) found no difference between groups. Two studies from Mexico found a higher risk of overweight in adult women (Creighton, Goldman, Teruel, & Rubalcava, 2011; Riosmena, Frank, Akresh, & Kroeger, 2012).

Besides the direct purchase of food, the additional income from remittances can also be spent on other nutrition-relevant investments such as improved sanitation and medical expenditures. Using data from the Nepal Living Standards Survey, Thapa and Acharya (2017) found that in remittance-receiving households, a larger proportion of total spending went into health-related expenditures which could be assumed to have positive effects upon child nutritional status. Using the same dataset, Chezum, Bansak, and Giri (2018) found that an increase in remittance income is associated with increases in healthcare spending in Nepal, and that medical spending is more responsive to remittance income than domestic wage income. A study using data from the 2014 Nepal Multiple Indicators Cluster survey, however, found no differences in health care seeking between left-behind children under five years and those who lived with their parents (Kunwar, Vajdic, & Muscatello, 2020).

Costs of migration

Another financial aspect of labour migration to which less attention is often paid is the substantial costs facing prospective labour migrants. A survey of 350 Nepali returnee migrants from Qatar found that they paid a total of USD 1,055 on average for broker, transport, medical tests, passport, visa, and insurance, with by far the largest share going to brokers (Martin, 2016). This is nearly ten times the monthly income that they reportedly earned before going to Qatar (USD 109) and seven times the national median monthly earnings in Nepal (NPR 15,208/ USD 152) (Central Bureau of Statistics [Nepal], 2019). More recent surveys among returnee migrants roughly confirmed this estimate of the costs of migration (Amnesty International, 2017; Blitz Media, 2022). A small survey found that only 2% of Nepalese households financed migration through their family's existing funds and most received money from a relative who was already a labour migrant (34%), or took out a loan from traditional moneylenders (20%) or a bank (19%) (Sijapati et al., 2017). Another survey found the percentage of migrants who resort to moneylenders for a loan even higher (60%) while only 4% took out a loan from a bank (Blitz Media, 2022). For the poor and landless, moneylenders are the only way to obtain a loan and they tend to charge extremely high interest rates which often culminate in severe indebtedness of the client. In the survey reported in Sijapati et al. (2017), 20% of respondents reported a net loss incurred through migration.

Absence of the migrant

Loss of labour

On the consumption side, sending a family member abroad means one person less to feed at home; on the production side, however, it means the loss of labour and/or a carer for the child. The migrant is usually an able-bodied and productive member of the family, so their absence most likely has negative consequences for food production and income generation at home (Zezza, Carletto, Davis, & Winters, 2011).

In theory, remittances could offset the constraints caused by the loss of labour by providing the financial means to hire external labour or invest in mechanisation of agriculture. A systematic review on the impact of labour migration on rural areas in developing countries found that this idea is supported by only two out of the seven studies (Obi, Bartolini, Brunori, & D'Haese, 2020). Five studies concluded that migration of males increased the workload of left-behind women and children. Specific to the Nepali context, a qualitative study by Adhikari and Hobley (2015) showed that while some women exchanged farming activities with small businesses, the workload for poorer women increased and they were forced to adopt coping strategies such as reducing livestock. Similarly, a small survey in the hill region of Nepal observed a feminization of agriculture and reduction in cultivation of subsistence crops through the absence of male migrants (Maharjan, Bauer, & Knerr, 2013). Other studies from Nepal had diverging conclusions regarding the effects of labour migration on agricultural output, depending on the outcome measure used: Using the Nepal Living Standards Survey (NLSS) III 2010/11, Kapri and Ghimire (2020) found that migration was positively associated with agricultural productivity measured as output per labour-hour. Using the same dataset, Tuladhar, Sapkota, and Adhikari (2014) observed a negative association between migration and paddy yield per hectare. It is reasonable to assume that the mother’s increased workload and a potentially reduced output in subsistence agriculture compromise her ability to adequately care for the child and provide reasonable food security, which in turn can have negative effects on the child’s nutritional status. The loss of the migrant’s labour at home not only has implications for the child through the care that they receive, but also for their own workloads: A study in China found that left-behind children had to work more hours at home than their peers whose parents had not migrated (de Brauw & Mu, 2011).

Besides being burdened with an increased workload, left-behind women face further stressors related to the husband’s labour migration. In a qualitative study in Nepal (Adhikari & Hobley, 2015), left-behind women reported problems having to raise their children alone, e.g. managing teenage behaviours and assuring school attendance. In nuclear families, emergencies such as the mother’s sickness posed major problems as women had to find someone to look after the small children and the household. In joint families, an absent husband may mean that there is no-one to negotiate on the wife's behalf or protect her from abusive in-laws (Clarke, Saville, Bhandari, et al., 2014). Another reason for elevated stress levels is financial difficulties if remittance levels are low, as well having to deal with and being monitored by persistent moneylenders (Adhikari & Hobley, 2015). Women also felt that they were under constant scrutiny of the community and that they had to be careful not to behave in a way that could suggest they were having an affair (Adhikari & Hobley, 2015). It is likely that these manifold stressors negatively impact the mother's ability to adequately care for her children. Experimental work has shown that there is a causal association between maternal stress and infant weight gain, mediated by changes in breastmilk composition or intake (Mohd Shukri et al., 2019).

Several studies have observed that while unpaid work at home increases, waged work of wives left behind decreases (Binzel & Assaad, 2011; Mendola & Carletto, 2008; Mu & van de Walle, 2009). On the one hand, a higher share of mother's time spent at home can have positive implications for the care that children receive, and may explain the longer duration of breastfeeding in remittance-receiving households observed during the Bosnian conflict (Andersson, Paredes-Solís, Legorreta-Soberanis, & Cockcroft, 2010). On the other hand, assuming that relative income determines some of the family member's bargaining power at home (Harris-Fry et al., 2022), male migration, through its effect on women's participation in the paid labour force, is likely to lead to a loss of bargaining power for women (Antman, 2013) which in turn has been associated with poor child nutritional status (A. R. Quisumbing & Smith, 2007). This mechanism, however, is likely to be of smaller relevance in Nepal where the female labour force participation rate is only 26%, meaning that only a quarter of the working-age women are employed or looking for work (Central Bureau of Statistics [Nepal], 2019).

In countries like Nepal with a high number of predominantly male migrants, the absence of males can change the social context and norms in the household and maybe even communities as a whole. In such patriarchal societies where women typically have low bargaining power, male outmigration could arguably lead to a transfer of power and responsibilities to women and empower them. Quantitative and qualitative evidence from South Asia, however, often concludes that male migration rarely leads to empowerment of women left behind (Ahmed, 2020; Fakir & Abedin, 2020; Mahapatro, 2018).

Family disruption

The absence of a family member causes major disruption in the household, in particular in the time immediately after departure. First of all, the composition of the household changes and this can also have implications for its social hierarchy. The migrant may be the most educated and a person of authority in the household and their absence can create a power shift. Secondly, household routines have to change, and responsibilities have to be reallocated. Thirdly, related to the financial issues outlined above, the migrant has to establish themselves in the country of destination and it may take some time until they can send substantial remittances that outweigh the costs of migration. Until then, the family may have to cope with a strained household budget (Davis & Brazil, 2016) and it is likely that children in the household will be affected by these disruptions.

Overall, migration is a stressful experience for the migrant and for those left behind. Family members and in particular the migrant's children may experience emotional distress as they miss the person who left. Higher levels of tension linked to general disruptions in the home, financial difficulties, emotional distress, and increased workload may increase the spouse's general level of stress and can even compromise their mental health (Clarke, Saville, Bhandari, et al., 2014).

Social remittances

A third pathway through which migration can affect child nutrition is "social remittances", which Levitt (1998) defines as the "ideas, behaviors, identities, and social capital that flow from receiving to sending-country communities". Migrants may adopt the host country's social norms and values, including notions of gender identity and women's roles in the family and society at large. This could for example influence patterns of decision-making within the household which, as mentioned above, can impact the nutritional status of children (A. R. Quisumbing & Smith, 2007). The rapid spread of smartphones and rapidly expanding mobile data networks even in low-resource settings facilitate the regular exchange and maintaining the connection with those left behind.

Following up on Levitt's early work, Levitt and Lamba-Nieves (2011) revisit the evidence around social and economic remittances and find that these are often targeted at human capital, especially education and health, in the home communities. Changes in health-related knowledge and practices can also affect nutrition of left-behind children. Investigating the social aspects of migration in relation to infant health, Frank (2005) found that mothers in Mexico whose partner is a labour migrant in the US have lower rates of smoking, are more likely to exercise and to have healthy weight gain during pregnancy. There is a dearth of evidence on the role of social remittances in Nepal. Typical low wage labourers in common migration destinations such as Gulf states live in organised accommodation and tend to stay among themselves with relatively little cultural assimilation into the host country. Similarly, female domestic workers are predominantly confined to their employers' home and might have little opportunities to be exposed to external influences. Given the lack of integration in the host society amongst Nepali migrants, the flow of "social remittances" may be limited. Nevertheless, it is possible that the exposure to more developed infrastructure, health services and sanitation impact the workers' attitudes and aspirations towards these.

In summary, this framework explained my assumptions as to (1) what influences fathers' decision to migrate for work, and (2) how their migration can affect the nutritional status and growth of the left-behind children. The initially described determinants of labour migration support my later analysis (Chapter 7) by helping me to identify potential confounding factors in the association between paternal labour migration and child growth. I structured the possible mechanisms linking paternal labour migration and child growth into three pathways: financial pathways, absence of the migrant, and social remittances. I presented the existing evidence on those mechanisms and considered to what extent this may be applicable to the Nepali context. This supports my later analysis by providing context and guidance in the interpretation of the findings.

2 Systematic review on the effects of parental migration on the nutritional status of the left-behind children and adolescents in low- and middle-income countries

Summary

This systematic review summarises the existing evidence on the effects of parental migration on the nutritional status of children left behind in the home. We identified 29 studies using data from eleven countries, but the overwhelming evidence comes from China. We found that left-behind children are at a higher risk of wasting and stunting than children whose parents did not migrate. There was no evidence of a difference in terms of overweight and obesity, underweight, or anaemia between the study groups.

2.1 Introduction

Background

There were an estimated 272 million international migrants in 2019, the majority of which, 169 million, were labour migrants (IOM, 2021). Most of the labour migrants (85%) are in their prime age (25 to 64 years) (ILO, 2021) and many of them may leave behind children in their home communities. Although there are no estimates available for the number of left-behind children, it is likely to be in the hundreds of millions. In China alone, there were an estimated 69 million children left behind in rural areas (UNICEF, 2018).

Little is known about the effects of parental migration on the nutritional status of left-behind children. One systematic review investigated the effect of remittance income on nutrition in the home countries (Thow et al., 2016), but this study did not consider non-financial pathways through which parental migration affects families at home. This review also only considered studies published in English language and hence did not include the vast body of evidence from China.

Objective

To summarise the evidence of the effects of parental migration on the nutritional status of the left-behind children and adolescents in low- and middle-income countries (LMICs).

Own contribution

This study is part of a larger systematic review looking at the effects of parental migration on a broad range of child and adolescent health outcomes (Fellmeth and Rose-Clark et al. 2018). Other authors developed the search strategy and obtained the references. I developed and pre-tested the data extraction sheet and risk of bias tool in collaboration with one other author (G. Fellmeth). I screened titles and abstracts of 6547 references (80.4% of all identified English language references), screened full texts of all nutrition-related English language references (62 articles, 24% of all English language references included for full text screening), and extracted the data of all English language studies with nutrition outcomes (15 studies, 26% of all included studies in English language). Screening and data extraction were done in duplicate with other authors. The nutrition studies published in Chinese language were screened and extracted by other authors (C. Zhao and Y. Zheng). I further conducted meta-analyses and wrote up the results and discussion presented in this thesis. Finally, I alone conducted a second search update in January 2021.

2.2 Methods

Criteria for considering studies for this review

Eligible for inclusion were observational studies with the following criteria.

Participants

Children and adolescents up to the age of 19 years living in LMICs, as defined by the World Bank, were eligible. To be included, >50% of the participants in the study sample had to be aged 0-19 years and/or the mean or median age had to be less than 19 years.

From here onwards, I will use the term children to refer to both children and adolescents.

Exposure

1) One or both parents migrated internally within a country, or internationally
2) for a period longer than six months (median/mean duration of absence in the left-behind children group is more than 6 months and/or and more than 50% of parents were absent for more than 6 months). Although this cut-off is somewhat arbitrary, it is used by convention in migration research (see for example Gao et al., 2010; Romano & Traverso, 2019; Wickramage, Siriwardhana, Vidanapathirana, et al., 2015). If studies did not report the duration of migration, we decided to include those studies but downgraded the study quality in the domain “1. Definition of cases (left-behind children)”.
3) the children did not go with the parent(s)

Comparison group

Children whose parents are not migrants.

Outcomes

The outcomes in this review include measures of under- and overnutrition, and anaemia. Outcomes included within under- and overnutrition are

4) Stunting, defined as height-for-age *z*-score (HAZ) <-2 SD
5) Wasting, defined as weight-for-height *z*-score (WHZ) <-2 SD, and/or bilateral pitting oedema
6) Underweight, defined as weight-for-age *z*-score (WAZ) <-2 SD
7) Overweight, defined as WHZ >2 SD for children under 5 years, and body mass index-for-age *z*-scores (BMIZ) >1 SD for children 5-19 years
8) Obesity, defined as WHZ >3 SD for children under 5 years, and BMIZ >2 SD for children 5-19 years
9) Low birthweight, defined as birthweight less than 2500 grams
10) HAZ, WAZ, WHZ, BMIZ, birth weight (g) as continuous outcomes

Anaemia was defined using haemoglobin concentration cut-offs defined by the WHO: 110 g/l for children under 5 years, 115 g/l for children between five and eleven years, 120 g/l for children 12 to 14 years and female (non-pregnant) adolescents aged 15 and above, and 130 g/dl for male adolescents aged 15 and above (WHO, 2011).

Search methods for identification of studies

We searched MEDLINE, Embase, CINAHL, The Cochrane Library, Web of Science, PsychINFO, Global Index of Medicus, Scopus and Popline for evidence up to April 27, 2017. The search was updated twice, first by the whole author team to include literature published up to Sept 5, 2018, and then again by myself only to include literature published up to Jan 20, 2021. We used search strategies tailored to each database, incorporating the concepts LMICs, children, parents and migration. Additionally, we searched reference lists of relevant systematic reviews, the grey literature of relevant international organisations for studies not identified in the database searches. No language restrictions were used.

Data collection and analysis

Selection of studies

We used the online-tool Covidence (Veritas Health Innovation, n.d.) for title and abstract screening. We independently screened the title and abstracts of studies, and I together with one other author (K. Ricci or W. Lertgrai) screened the full texts of remaining articles with nutrition-related outcomes. Discrepancies were resolved by discussion with a third reviewer.

Data extraction and management

Together with one other author (G. Fellmeth) I developed an excel data extraction form based on a Cochrane Public Health review (von Philipsborn et al., 2019) that I co-authored. I piloted an initial draft form using a selection of three included studies and then amended this in consultation with other members of the review team. Together with one other author (K. Ricci or O. Mohamed-Ahmed) I independently extracted data in duplicate. Discrepancies in extracted data were resolved by checking against the study reports, discussion and coming to a consensus. We sought key data missing from reports of included studies by contacting study authors.

Assessment of risk of bias in included studies

I, together with the other author doing the data extraction of the respective study, independently assessed the risk of bias using an adapted version of the Newcastle Ottawa Scale (G. Wells et al., n.d.), incorporating items from the National Institute for Clinical Excellence (NICE) Quality Appraisal Checklist (NICE Public Health, 2012).

1) Were left behind children well defined?
2) Were children in the control group well described/defined?
3) Was selection bias minimised?
4) Were the outcome measures and procedures reliable?
5) Were all outcome measures reported?
6) Was the study sufficiently powered to detect a difference, if one exists?
7) Were the statistical analyses clear and presented with a measure of precision?
8) Was incomplete outcome data adequately addressed?
9) Were potential confounders adequately addressed?

If a study was at high or unclear risk of bias across five or more domains, it was determined to be at high overall risk of bias.

Data synthesis

I included all studies in a random-effects meta-analysis if they reported results in an appropriate format, i.e. raw proportions or unadjusted odds ratios. I used unadjusted study outcomes for two reasons. Firstly, the covariates applied varied considerably between studies, which limits the comparability of study results. Secondly, many studies reported adjusted odds ratios and due to the so-called non-collapsibility of odds ratios, adjusted estimates can differ from unadjusted ones even in the absence of confounding (Greenland, Robins, & Pearl, 1999). I used the R package `meta` (Balduzzi, Rucker, & Schwarzer, 2019) to calculate pooled risk ratios with 95% confidence intervals for binary outcomes. No English language study reported continuous outcome data in the appropriate format to be included in the meta-analysis. If a study reported data at multiple time points, I included data collected at the longest follow-up time, so as to maximise time for nutritional outcomes to become apparent. Lack of appropriate data precluded some studies from inclusion in the meta-analysis, I therefore additionally synthesized adjusted outcomes of all included studies in a harvest plot. Risk of publication bias was assessed using funnel plots. The studies identified in the search updates are only reported narratively.

2.3 Results

Search results

The flow of records through the systematic review process is shown in Figure 2.1. The electronic searches yielded 10284 records from all databases. After automatic and manual de-duplication, 8019 records entered the title and abstract screening stage. We identified an additional 30 records from other sources. In the title and abstract screening stage, 396 studies were assessed as potentially eligible and we obtained the corresponding full-text reports, where possible. Of these, 111 studies met the inclusion criteria, 285 were excluded. Primary reasons for exclusion are summarised in Figure 2.1. Twenty-nine of the included studies reported nutrition outcomes; 97 studies reported other outcomes and their results are not reported in detail here.

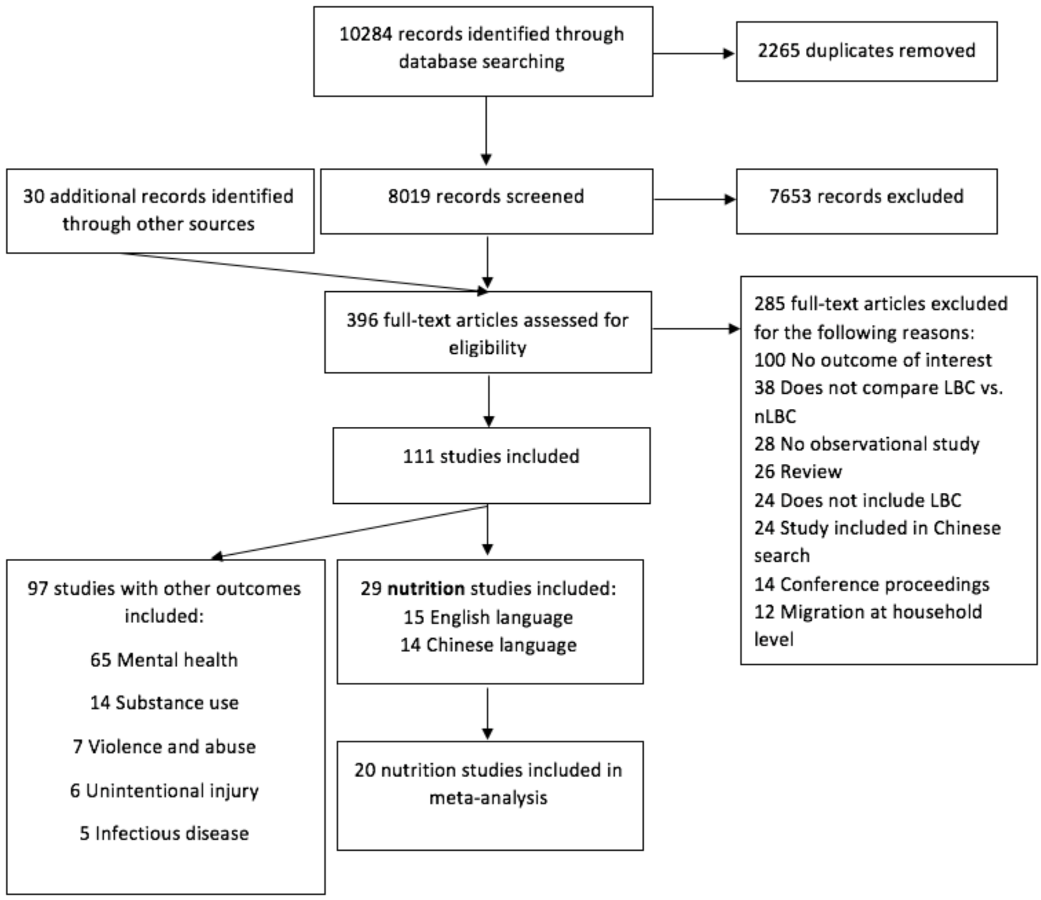


Figure 2.1: Study flow diagram.

Included studies

Key characteristics of included studies are summarised in Table 2.1. The 29 included studies used data from 11 countries. None of the studies were from Nepal. Timing of data collection ranged between 1988 and 2013, with most studies using data collected after 2000. Most studies (25, 86%) used cross-sectional data and the four studies using longitudinal data only had two observations per child. In all studies, the reason for parents' migration was work, 23 studies (including all 21 from China) looked at internal migration, four at international labour migration, one at both, and one did not specify where parents migrated to.

Table 2.1: Characteristics of included studies.

Characteristic		*n* (%)*	Studies
Country			
	China	21 (72)	Ban et al. (2017); C. Chen, He, Wang, Deng, and Jia (2011); I. Chen, Wang, and ZY (2010); Chen JY et al. (2012); S. Chen, Liao, and He (2013); Z. Chen (2009); Feng, Zhang, Xian, and Li (2010); Gao et al. (2010); Li, Yang, and Zhang (2011); Mo et al. (2016); Mou, Luo, Li, Shuai, and Liu (2009); Mu and de Brauw (2015); Pan and Chen (2014); Tao, Yu, Gao, and Xue (2016); Wang, He, Fang, and Li (2011); Wen, Wang, and Liu (2008); Xia, ZG., SH., GH, and J. (2011); Xie et al. (2013); Yan, Wang, and Xin (2013); Yu, Liu, Yu, and al. (2013); Zhou et al. (2015)
	Mexico	3 (10)	Frank (2005); Lu (2015); Schmeer (2013)
	Vietnam	2 (7)	C. V. Nguyen (2016), Graham and Jordan (2013)
	Ethiopia	1 (3)	C. V. Nguyen (2016)
	India	1 (3)	C. V. Nguyen (2016)
	Peru	1 (3)	C. V. Nguyen (2016)
	Guatemala	1 (3)	Davis and Brazil (2016)
	Kenya	1 (3)	Onyango et al. (1994)
	Indonesia	1 (3)	Lu (2015)
	Philippines	1 (3)	Graham and Jordan (2013)
	Sri Lanka	1 (3)	Wickramage, Siriwardhana, Vidanapathirana, et al. (2015)
Destiny of migration			
	International	4 (14)	Davis and Brazil (2016); Frank (2005); Schmeer (2013); Wickramage, Siriwardhana, Vidanapathirana, et al. (2015)
	Both international and internal	1 (3)	Lu (2015)

	Not specified	1 (3)	C. V. Nguyen (2016)
	Internal	23 (79)	All remaining studies
Study design			
	Longitudinal	4 (14)	Lu (2015); Mu and de Brauw (2015); C. V. Nguyen (2016); Schmeer (2013)
	Cross-sectional	25 (86)	All remaining studies
Total		**29 (100)**	

* Some studies included data from more than one country.

Study quality

Eight (28%) of the 29 included studies were at high or unclear risk of bias across five or more of the nine domains of study quality (Figure 2.2). Risk of bias varied across domains: While all except one study were adequately powered, only about half of the studies (14, 48%) adequately addressed potential confounders. Furthermore, only about half of the studies (14, 48%) clearly defined left-behind children. The most frequent reason for downgrading was that the minimum or mean duration of absence was not specified, and also few studies did not specify whether it was one or both parents who were absent. The vast majority of studies did not report missing data and how this was addressed.

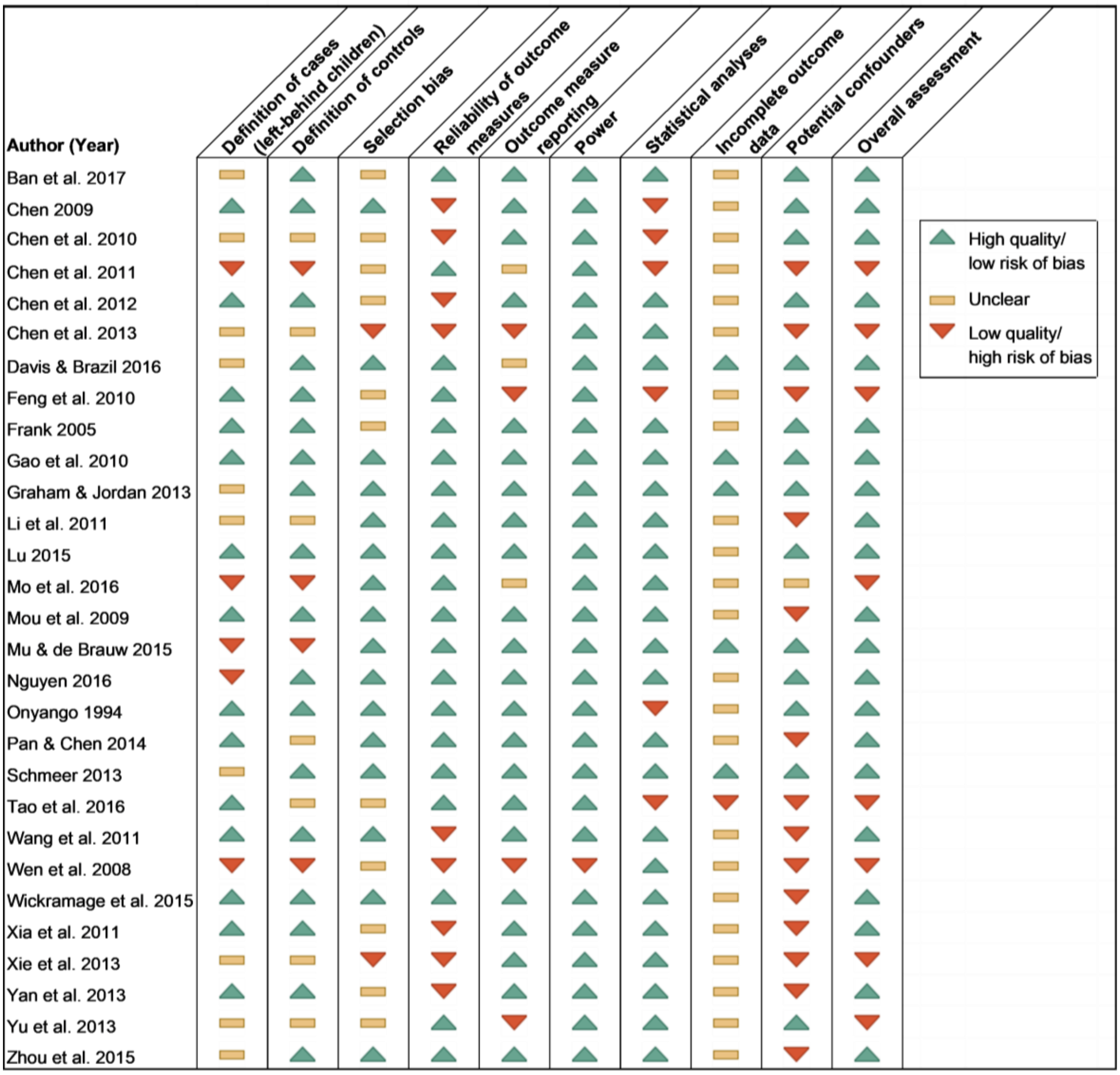
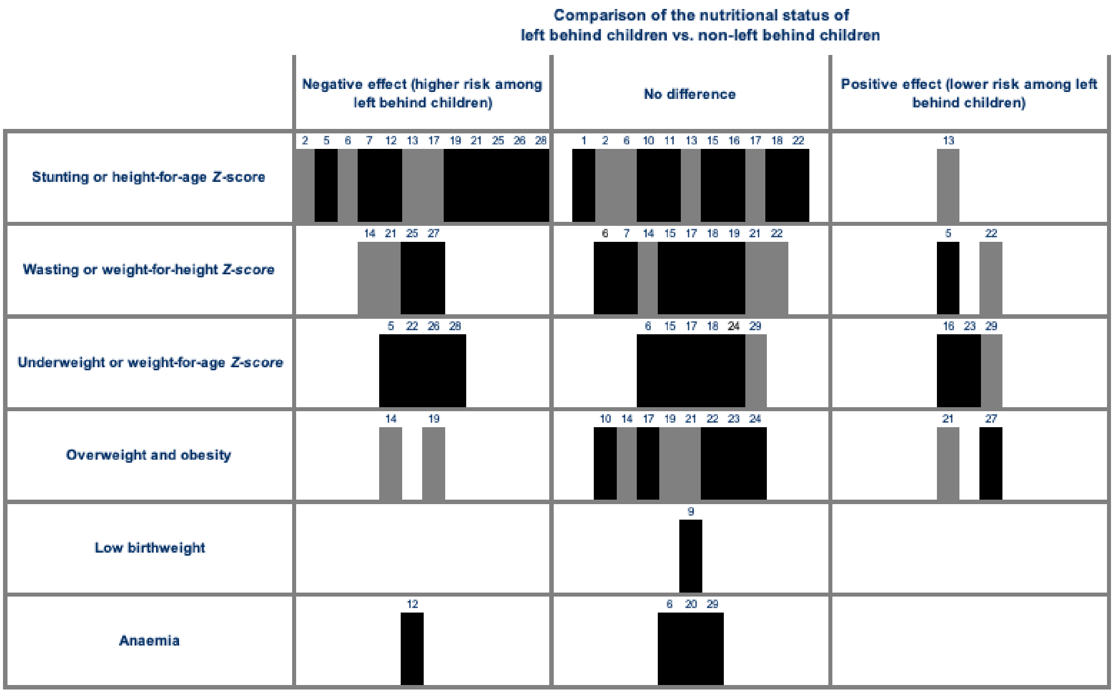


Figure 2.2: Study quality assessment.



Legend of the Harvest Plot: Each black bar represents the nutrition outcome reported by an individual study included in the systematic review. Grey bars represent studies which found varying directionality of outcomes between different population subgroups (eg. a higher risk among girls who were left behind but no differences among boys who were left behind compared to children of non-migrant parents).

Study IDs		
1 Ban et al. 2017	11 Graham & Jordan 2013	21 Tao et al. 2016
2 Chen 2009	12 Li et al. 2011	22 Wang et al. 2011
3 Chen et al. 2010	13 Lu 2015	23 Wen et al. 2008
4 Chen et al. 2011	14 Mo et al. 2016	24 Wickramage et al. 2015
5 Chen et al. 2012	15 Mou et al. 2009	25 Xia et al. 2011
6 Chen et al. 2013	16 Mu & de Brauw 2015	26 Xie et al. 2013
7 Davis & Brazil 2016	17 Nguyen 2016	27 Yan et al. 2013
8 Feng et al. 2010	18 Onyango 1994	28 Yu et al. 2013
9 Frank 2005	19 Pan & Chen 2014	29 Zhou et al. 2015
10 Gao et al. 2010	20 Schmeer 2013	

Figure 2.3: Harvest plot of nutrition outcomes among left-behind children compared to children of non-migrant parents included in the systematic review.

Impact of parental migration on left-behind children's nutritional status

Stunting

Twenty-four studies, using data from 28 populations (datasets), investigated the impact of parental migration on children's HAZ or stunting. In seven studies, authors found no difference between groups, in eight studies, authors found that left-behind children were more likely to be stunted or had a lower HAZ than children of non-migrants (Figure 2.3). In four studies, authors found differential effects when they stratified their sample by certain characteristics such as age or destination of migration. In one Chinese study

(Zhou et al., 2015), a higher HAZ was observed among left-behind children aged 3 to 5 years compared to children of the same age whose parents are not migrants, while no differences between groups were found among children aged 8 to 10. In Indonesia and Mexico, differentiating between internal and international showed that Indonesian children of internal migrants had a higher HAZ than children of non-migrants, whereas in Mexico only children of international migrants had a higher HAZ than children whose parents did not migrate (Lu, 2015).

Meta-analysis of 16 studies showed that left-behind children had a higher risk of stunting (RR 1.12 [1.00-1.26]) (Figure 2.4) Heterogeneity was substantial (τ^2=0.0275, p<0.01). The funnel plot did not indicate publication bias (Figure 2.9).

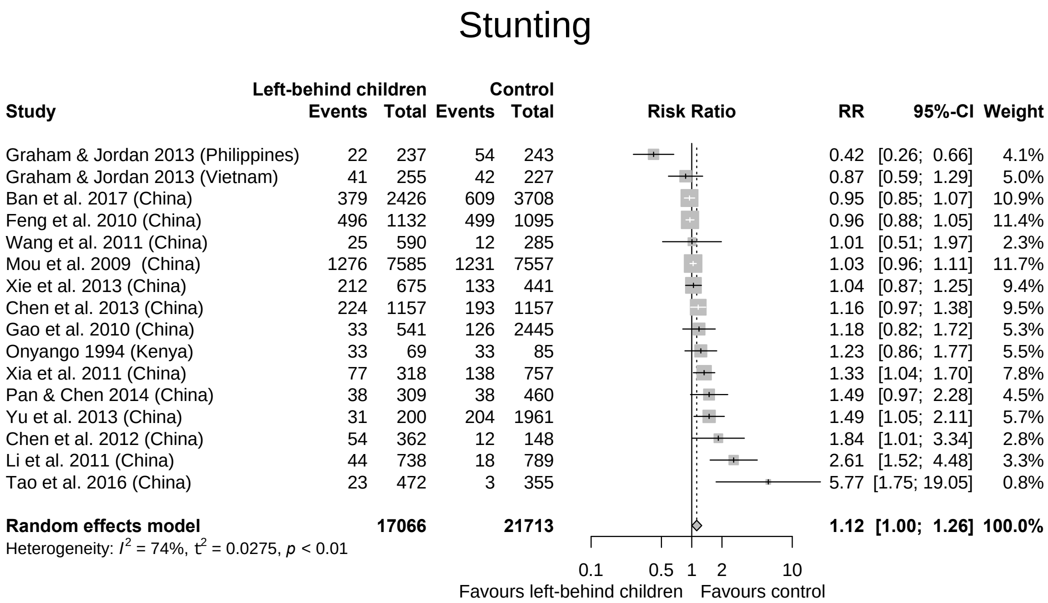


Figure 2.4: Forest plot of relative risks of stunting.

Wasting

Twelve studies from seven countries had wasting or WHZ as outcomes. Half of the studies found no difference between left-behind children and children of non-migrants, two found a higher risk among left-behind children and one a protective effect from having a parent working away from home (Chen 2012). In three Chinese studies stratifying the sample by certain characteristics such as carer or child gender revealed differences between left-behind children and children of non-migrating parents: Left-behind girls were at higher risk of wasting than non-left-behind girls (Tao et al., 2016), and left-behind children who were looked after by a grandparent had higher odds of wasting, but children who stayed with a remaining parent were not different to children of non-migrant parents (Mo et al., 2016).

Nine studies were included in the meta-analysis for wasting (Figure 2.5). I found that left-behind children had a higher risk of wasting compared to children whose parents were not migrants (RR 1.13 [1.02-1.24]). Heterogeneity was small (τ^2=0, p=0.66). The funnel plot did not indicate publication bias (Figure 2.9).

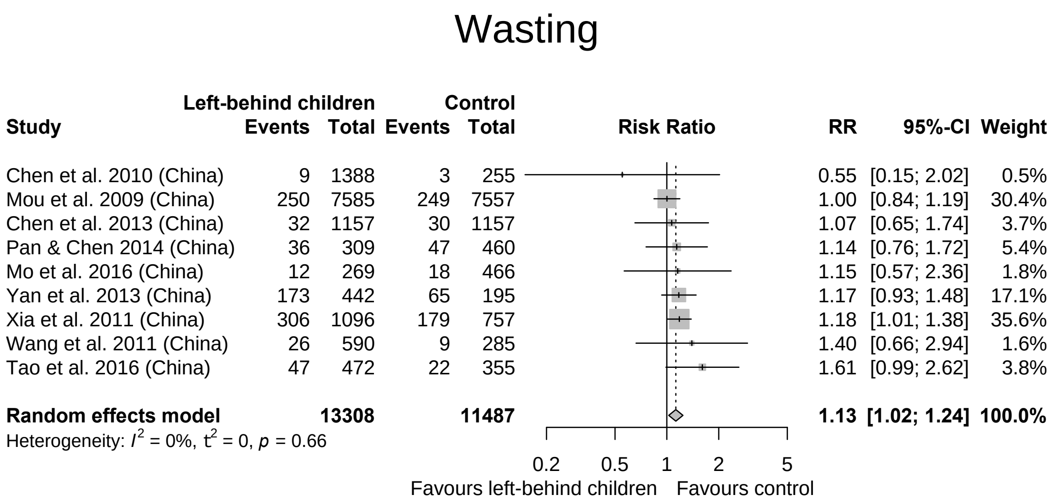


Figure 2.5: Forest plot of relative risks of wasting.

Underweight

Thirteen studies using data from seven countries compared left-behind children and children of non-migrants by underweight or WAZ. Four Chinese studies found that left-behind children had worse outcomes (Chen JY et al., 2012; Wang et al., 2011; Xie et al., 2013; Yu et al., 2013), whereas two studies, also from China, found that left-behind children had a lower risk of underweight (Wen et al., 2008) or that the children's WAZ increased after their parents sought work away from home (Mu & de Brauw, 2015). In one Chinese study stratifying the sample by age revealed that the younger group of left-behind children (3 to 5 years) had a higher WAZ than children of non-migrants in that age group, but no difference was observed among older children (8 to 10 years) (Zhou et al., 2015). Five studies found no difference between left-behind children and children of parents who are not migrants.

The meta-analysis of nine studies for underweight (RR 1.10 [0.88-1.38] τ^2=0.0801, p<0.01) found no differences between groups (Figure 2.6). The funnel plot did not indicate publication bias (Figure 2.9).

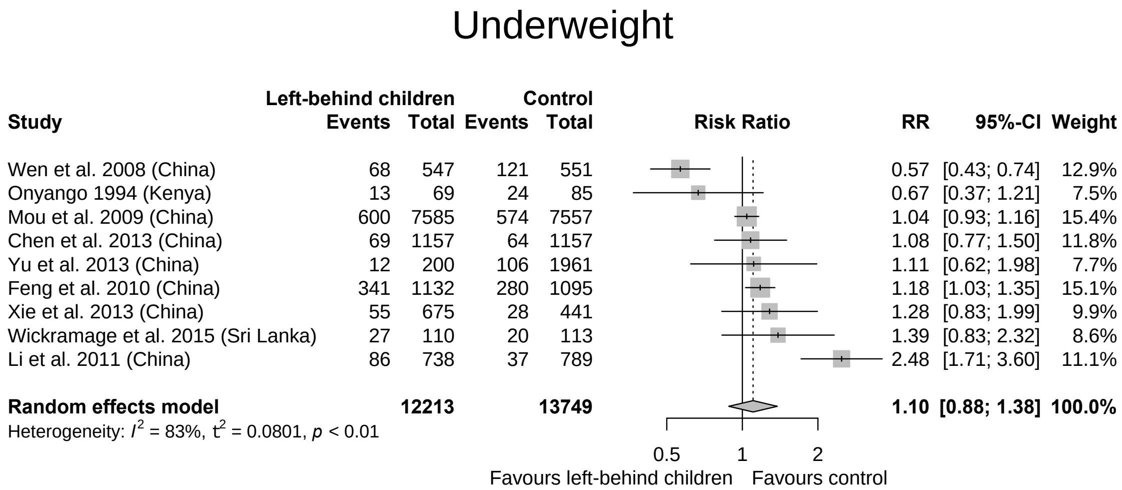


Figure 2.6: Forest plot of relative risks of underweight.

Overweight and obesity

Nine studies compared left-behind children and children whose parents did not migrate by overweight and/or obesity status. Five studies found no difference between groups, one study observed a higher risk among left-behind children and three studies found different directionality among subgroups. After stratifying the sample by gender, one study found that male left-behind children had a lower risk of overweight and obesity than children of non-migrants (Tao et al., 2016). In the subgroup of left-behind children cared for by grandparents, Mo et al. (2016) found higher odds of overweight, but not obesity, compared to children of parents who are not migrants. Nine studies provided the data to be included in the meta-analysis (Figure 2.7). I found no difference between groups (RR 0.94 [0.74 to 1.19], τ^2=0.0800, p<0.01). The funnel plot did not indicate publication bias (Figure 2.9).

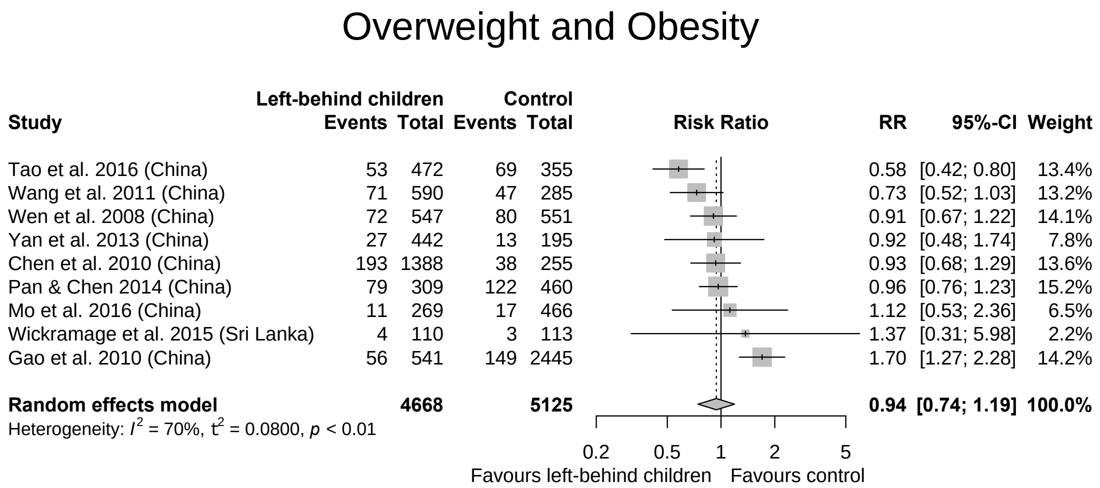


Figure 2.7: Forest plot of relative risks of overweight and obesity.

Anaemia

Five studies investigated differences in the occurrence of anaemia. Three studies found no difference, one study found a higher risk among left-behind children, and one study did not report whether there were significant differences (Feng et al., 2010). A meta-analysis of three studies found no difference between groups (RR 1.18 [0.91 to 1.54], τ^2=0.0478, p<0.01) (Figure 2.8). The funnel plot did not indicate publication bias (Figure 2.9).

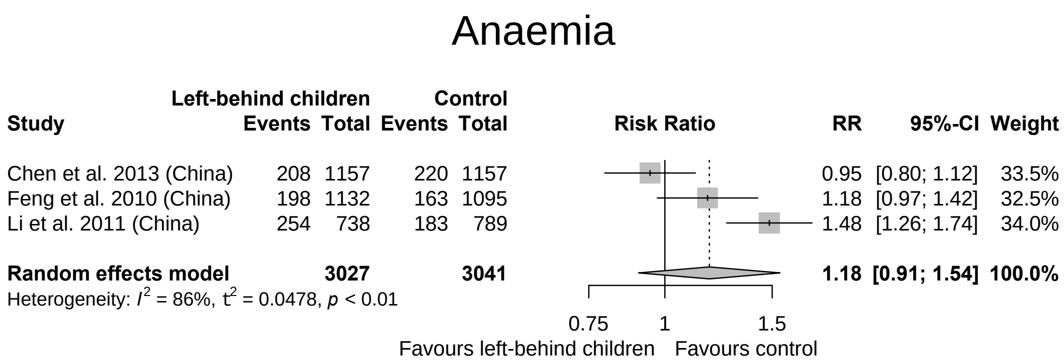


Figure 2.8: Forest plot of relative risks of anaemia.

Low birthweight

One Mexican study investigated whether babies of migrant fathers were more or less likely to have low birthweight, but found no association (Frank, 2005).

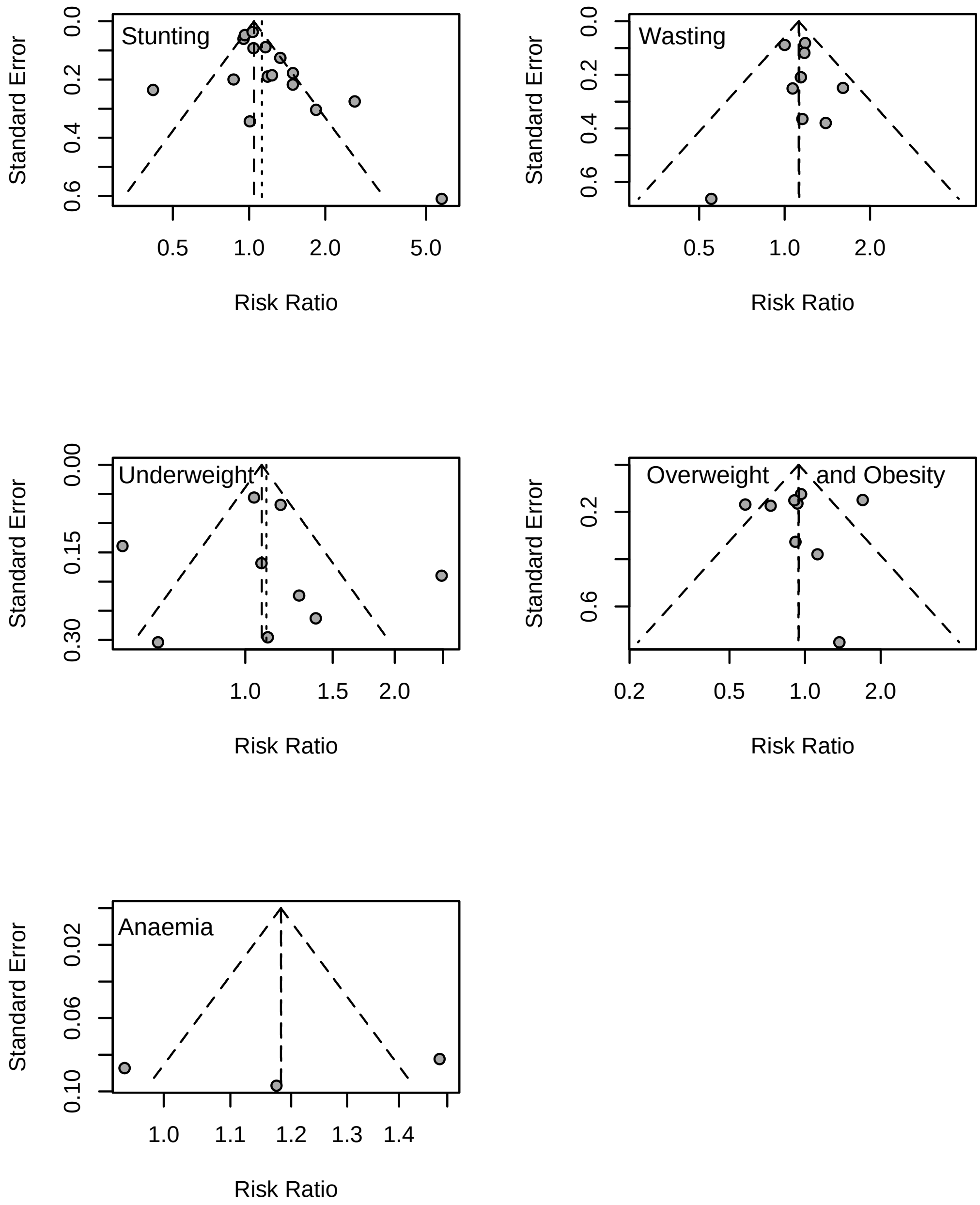


Figure 2.9: Funnel plots

Continuous outcomes

Only a few studies reported results for continuous outcomes and in the appropriate format that allowed them to be included in meta-analyses. Because all of these studies were published in Chinese language and hence screened and extracted by other authors, I did not include them in my own meta-analysis for this thesis. Briefly, meta-analyses revealed no differences between left-behind children and children of non-migrant parents in terms of HAZ (RR -0.47 [-0.95-0.01], four studies), WHZ (-0.02 [-0.09-0.05], three studies), and WAZ (-0.32 [-0.69-0.05], two studies). The results are published in detail in Fellmeth and Rose-Clarke et al. (2018).

Search updates

The two search updates identified six additional studies with nutrition outcomes from Nepal (Kunwar et al., 2020), Bangladesh (Islam, Khan, & Mondal, 2019) and China (Li & Zhang, 2018; Shi et al., 2020; Tian, Ding, Shen, & Wang, 2017; Wu & Guo, 2020). An analysis of the 2014 UNICEF Nepal Multiple Indicator Cluster Survey (MICS), a cross-sectional, nationally representative dataset, found no differences in stunting, wasting and underweight between left-behind children and children of non-migrants, both in the adjusted and unadjusted analyses (Kunwar et al., 2020). Using the 2012/13 MICS dataset from Bangladesh, Islam et al. (2019) found lower risk of stunting, wasting and underweight among left-behind children in the unadjusted analyses, but after controlling for potential confounders these differences between study groups disappeared. The studies by Tian et al. (2017) and Wu and Guo (2020) both analyse data from the China Health and Nutrition Survey (CHNS, 2004-2015) conducted in twelve Chinese provinces. Wu and Guo (2020) analysed all five cross-sectional waves and found that the differences in nutritional status between left-behind children and children of non-migrants depend on who takes care of the child in the migrant's absence: If only the mother migrates, and the father stays behind with the children there is a higher risk of stunting and underweight compared to children whose parents are not migrants. There are no differences in the risks of stunting or underweight if only the father migrates and the mother stays with the children compared to children of non-migrants. Children who are left behind by both parents – and typically looked after by grandparents - have a lower risk of underweight compared to children of non-migrants, but the risk of stunting is not different. Tian et al. (2017) extracted participants with two consecutive measurements from the CHNS database in order to obtain longitudinal data. They found that left-behind children had lower HAZ and WAZ at both baseline and follow-up compared to children whose parents did not migrate. Shi et al. (2020) analysed cross-sectional data and found that in the adjusted analyses, children whose father migrated and who were taken care of by their mother had higher HAZ and lower risk of stunting compared to children whose parents were not migrants. They also found that children whose both parents migrated had lower risk of anaemia compared to children whose parents did not migrate. A study by Li and Zhang (2018, in Chinese) found that the proportion of stunting and wasting was higher among children of migrant parents than children whose parents lived at home with them.

Impacts of parental migration on other domains of child and adolescent health

The other health domains covered in the systematic review by Fellmeth and Rose-Clarke et al. (2018) were mental health, unintentional injuries, infectious disease, substance use, unprotected sex, early pregnancy, and verbal, physical, and sexual abuse. We identified a total of 97 non-nutrition studies that fulfilled the inclusion criteria. Most studies (65) investigated the mental health impacts on left-behind children. They found that compared to children of non-migrants, left-behind children were at increased risk of depression (RR 1.52 (95% CI 1.27–1.82), nine studies included in meta-analysis) and had higher depression scores (standardised mean difference (SMD)[2] 0.16 [0.10–0.21], 17 studies), higher risk of anxiety (RR 1.85 [1.36–2.53], 11 studies; SMD 0.18 [0.11–0.26], 17 studies), suicidal ideation (RR 1.70 [1.28–2.26], three studies), and conduct disorder (SMD 0.16 [0.04–0.28], six studies). Fourteen studies reported on substance use and found a higher risk among left-behind children (RR 1.24 [1.00–1.52], 14 studies). No differences were identified between left-behind children and children of non-migrants for unintentional injury (six studies), abuse (seven studies), or diarrhoea (five studies). No studies reported outcomes for other infectious diseases, self-harm, unprotected sex, or early pregnancy.

[2] "The standardized mean difference (SMD) is used as a summary statistic in meta-analysis when the studies all assess the same outcome, but measure it in a variety of ways (for example, all studies measure depression but they use different psychometric scales). In this circumstance it is necessary to standardize the results of the studies to a uniform scale before they can be combined. The SMD expresses the size of the intervention effect in each study relative to the between-participant variability in outcome measurements observed in that study." (Higgins et al., 2021, Chapter 6.5)

2.4 Discussion

Summary of findings

This systematic review suggests that left-behind children are at a higher risk of stunting (12%) and wasting (13%) compared to their peers whose parents did not migrate. I found no differences in terms of underweight, overweight and obesity, low birthweight, and anaemia.

Overall completeness and applicability of evidence

All the studies included in this review investigate the effects of labour migration and no study dealt with forced migration, probably because parents rarely leave behind their children in the situation of an armed conflict or natural disaster. The vast majority of studies included in this review come from China and deal with internal, rural-to-urban migration. While there is a relatively solid evidence base for this specific context, this review revealed a major research gap for international labour migration and countries other than China. This is remarkable considering that globally there are an estimated 169 million *international* labour migrants (IOM, 2021). It is furthermore notable that the major labour sending countries in terms of the amount of remittances received (as % of GDP), namely Tonga (39%), Kyrgyz Republic (31%), Tajikistan (27%), Lebanon (26%), Samoa (25%), Somalia (25%), or Nepal (24%) (World Bank Group, 2022), are greatly underrepresented with only one study from Nepal (Kunwar et al., 2020) identified in the search update.

The two search updates identified six additional studies, including from Nepal and Bangladesh that were not previously included in the systematic review. Generally, the findings mirror that of the meta-analysis in that left-behind children either have a similar or slightly higher risk of nutritional disorders.

How the parents' migration affects the children at home most likely depends on various mediating and moderating factors. Mediating factors in the association between parental migration and child nutrition include the volume of remittances and how they are spent, and the risks and costs of migration. For internal migrants such as in China, for example, the costs of migration will be relatively small compared to international migrants who often have to take up loans to pay for broker fees and visas such as in the

Nepalese context described in the conceptual framework in Chapter 1.4. Potential moderating factors include child age and sex, the duration of absence and frequency of home visits, and whether father, mother or both go away and the person who looks after the child in the absence of the parent(s). In the Chinese context, for example, it may be possible for parents to visit their children in the home provinces at regular intervals, while the costs and administrative hurdles of international travel are higher for international migrants so that these sometimes do not come home for the whole duration of their migration stint. Since such migration patterns differ between countries, findings from China, which dominate this systematic review, probably have limited generalisability in other contexts.

Certainty of the evidence

Statistical heterogeneity was often high, suggesting that there are other factors that influence the results. It is likely that so-called 'clinical' heterogeneity, which is the variability in exposure (parental migration) and participants (Higgins et al., 2021, Chapter 10.10), is the main cause of the differences in results. While we tried to use a rigorous definition of left-behind children, it still allowed for variability in the exposure to parental migration in important aspects that might explain some of the differences observed in the studies' results. In some cases, only one parent was absent while the other stayed at home with the child. Furthermore, the typical duration of absence, which most authors did not specify, and the frequency with which parents visited their home will have varied between settings. It is likely that this difference in exposure accounts for a large part of the statistical heterogeneity. Additionally, the age of participants varied between studies and research suggests that age is an important moderating factor in the association between parental migration and child nutritional status. One Chinese study (Zhou et al., 2015) found that the left-behind children aged 3 to 5 years had lower WAZ, HAZ and BMIZ than children of non-migrants, while no differences were found among children aged 8 to 10 years. Methodological heterogeneity, the variability in study design, outcome measurement tools and risk of bias, is the other potential cause of the statistical heterogeneity observed (Higgins et al., 2021, Chapter 10.10). The studies were similar in design and used standard outcome measurement tools, so this is unlikely to explain the high variability in study results. Risk of bias varied between studies and quality domains, and it is difficult to assess to what extent this led to differences in study results and could have biased my findings. Most studies did not specify missing data and how it was addressed. As I cannot know whether missingness occurred completely at random it is difficult to determine in what direction, if at all, missing data could have biased my results. Another domain in which many studies scored poorly was controlling for potential confounders. This, however, would not have biased the results of my meta-analysis as I used unadjusted effect estimates.

There were methodological considerations that prevented me from using adjusted effect estimates in the meta-analyses, but others would argue that it is preferable to use adjusted results (Higgins et al., 2021, Chapter 6.3) and thus this could be considered a limitation of my analysis. In the context of my research question, controlling for covariates can be expected to be important because it is likely that the association between parental labour migration and child nutrition is confounded through factors such as socioeconomic status. Omitting confounding factors from the analysis can lead to over- or underestimation of the association and leads to biased estimates. In the Filipino population in Graham and Jordan (2013), for example, migrant fathers had higher education than non-migrant fathers and after controlling for this selection into migration, the difference between children of migrant fathers and children of non-migrants disappeared. The selection into migration is very context dependent. For example, while in some countries only those with better education and higher socio-economic status (and hence lower risk of child undernutrition) have the possibility of seeking work elsewhere, in other countries labour migration is an income generation strategy only for the poor and uneducated (with higher risk of child undernutrition). Therefore, it is difficult to estimate whether omitting potentially confounding factors from the meta-analyses could have led to an under- or overestimation of the association between migration and child nutrition. Another weakness in the evidence which limits causal inference is the lack of longitudinal data.

A major strength of this is review is its comprehensiveness, covering all LMICs and the major languages. Half of the studies in this review were found because we included studies published in Chinese language. Funnel plots showed no indication of publication bias.

Conclusions

Labour migration is a growing phenomenon driven by the global need for cheap labour and poverty in the home setting. Typically, these migrants leave their poor communities to work in precarious jobs in more affluent cities and countries. While the role of labour migration for economies in both sending and hosting communities is gaining importance on the development agenda, the children that these migrants leave behind in their home communities receive much less attention. While labour migration clearly can be economically beneficial for families, it may be at the expense of the well-being of the children staying behind. This review has shown that though there are research gaps, the evidence clearly shows left-behind children can have unmet health needs that need to be addressed.

The International Organization for Migration (IOM) suggests a multidimensional intervention framework, with engagement from governments, industry, civil society, and migrant families themselves. Suggested interventions include for example community-level mobilisation of education officers and health workers to identify vulnerable children, and support systems for elderly carers (Wickramage, Siriwardhana, & Peiris, 2015). In China, a trial tested a conditional cash transfer programme to incentivise caregivers of left-behind children to attend nutrition education workshops and accompany the children to basic public health services. The results show that the intervention group had higher nutrition knowledge and food practice scores (Y. Zhang et al., 2018).

This review has uncovered an important research gap outside of China. Future research should focus on the big population of left-behind children in the major labour-sending countries with high levels of child malnutrition, such as Nepal. Only one study from Nepal, using cross-sectional secondary data, was identified in this systematic review. This study is certainly an important first step to better understand the situation in this country, but like many studies included in this review it did not address potential moderating and mediating factors in the association between parental migration and child nutrition, probably because the available data did not allow it. Longitudinal primary studies designed specifically for this research are needed to better understand the processes through which parental migration can benefit or harm the children's well-being, and how policy and programmes can better serve migrant families.

3 Study setting and context

Summary

In this chapter I describe the research setting in Nepal, and Dhanusha district in particular. These contextual factors will help justify the methodological decisions made during study conception and later facilitate the interpretation of findings.

First, I give an overview of Nepal's geography, demography, and developmental status. Second, I describe trends in child and maternal malnutrition, and the proximal and distal determinants of child stunting in Nepal. Third, I characterise the country's history of labour migration, changes in migration patterns, and policies governing labour migration. Lastly, I briefly describe the study site Dhanusha district.

3.1 Overview of Nepal's geography, population, development

Geography and climate

The Federal Democratic Republic of Nepal is a landlocked country situated between India and China (Figure 3.1). With 147,181 km^2 (Ministry of Health and Population [Nepal], New ERA, & ICF International Inc., 2012) and a population of 26.5 million (as per the last census in 2011, Central Bureau of Statistics [Nepal], 2012) it is small compared to its large neighbours, but it has a very diverse geography and climate. Its elevation spans from just 90 metres above sea level in the south to as high as 8,848 metres (Mount Everest) in the Himalayas in the north of the country. Nepal is divided into three ecological zones: *Terai* (*Madhesh* or plains), hills (*Pahadi*) and mountains (*himal*). The mountain zone (from 4 877 metres altitude) makes up 35% of the total land area (Ministry of Health and Population [Nepal] et al., 2012), but as per the last census in 2011, less than seven percent of the population live in this rather harsh environment with subarctic and arctic climate (Central Bureau of Statistics [Nepal], 2012). The hill zone ranges in altitude from 610 to 4876 metres and encompasses temperate and cold climate (Ministry of Health and Population [Nepal] et al., 2012). It accounts for 43% and 42% of the total population and area, respectively. The *Terai* zone is the most densely populated with 50% of the population living in an area that makes up 23% of the country (Central Bureau of Statistics [Nepal], 2012; Ministry of Health and Population [Nepal] et al., 2012). The *Terai* is the most fertile part of the country. It has tropical and subtropical climate and temperatures range from 1°C in winter to 44°C in summer (Ministry of Health and Population [Nepal] et al., 2012).

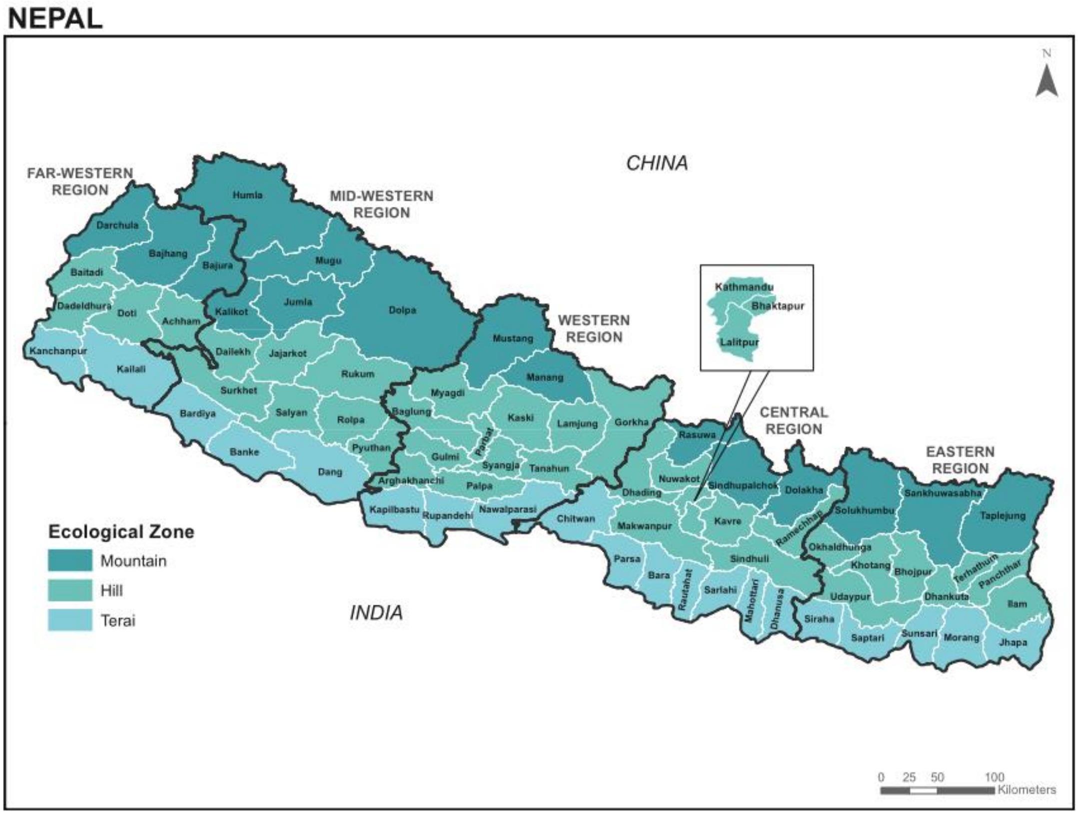


Figure 3.1: Map of Nepal: Ecological zones and districts (Source: Nepal Demographic and Health Survey (NDHS) 2011, Ministry of Health and Population [Nepal] et al., 2012)

Administrative division

Nepal was declared a Federal Democratic Republic through the 2015 Constitution. It is divided into seven provinces (Figure 3.2) with a total of 77 districts, 16 of them in the mountain region, 40 in the hill region and 21 in the *Terai* region. The districts are further divided into 276 urban- and 460 village- municipalities (numbering 736 municipalities in total). Furthermore, there are eleven sub-metropolitan cities and six metropolitan cities (Central Bureau of Statistics [Nepal], 2020).

This system was established in 2017 and replaces the former administrative structure that divided the country into five developmental regions and fourteen administrative zones. These developmental regions were divided into a total of 75 districts. Districts were further divided into 3633 Village Development Committees (VDCs) and 130 municipalities, which were again sub-divided into wards, the smallest units at the time (Central Bureau of Statistics [Nepal], 2013).

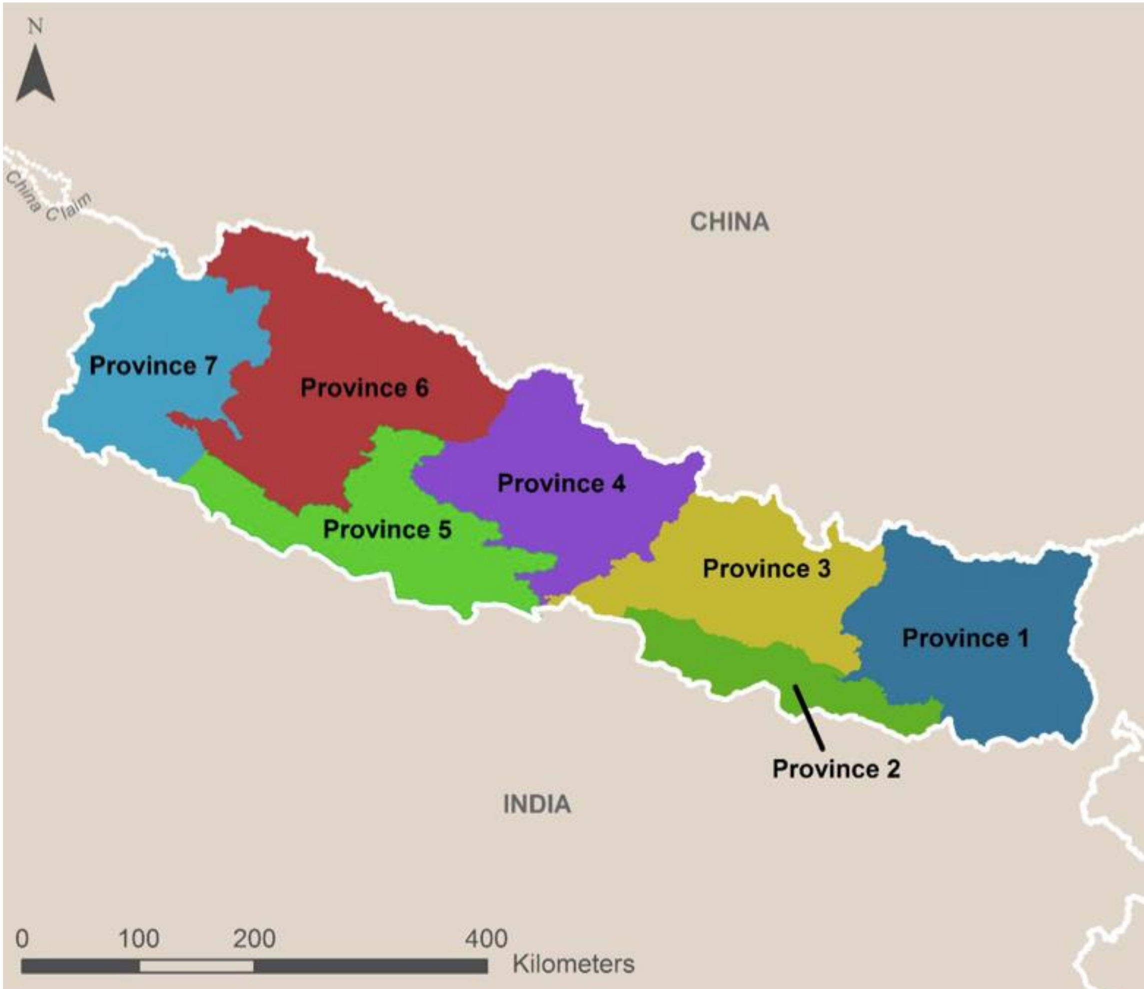


Figure 3.2: Map of Nepal: Provinces. (Source: Nepal Demographic and Health Survey 2016, Ministry of Health and Population [Nepal], New ERA, & Inc., 2017)

This change in administrative division is relevant in the context of this thesis because the Growth Monitoring Study (GMS), on which this thesis builds, started in 2012 and sampled participants based on VDCs.

Economy and human development

Nepal's economy is highly reliant on remittances, which make up 24% of the gross domestic product (GDP) (World Bank Group, 2022). Almost two thirds of the population work in agriculture (World Bank Group, 2019b), but only 21% of GDP are generated in this sector (World Bank Group, 2019a). Nepal has high capacity for hydropower, but political uncertainty and a difficult business climate have hindered foreign investment. The 2015 earthquake damaged much of Nepal's infrastructure and slowed its economic development (CIA, 2021).

The World Bank announced in 2020 that Nepal's classification by income level is to change from a low income country to a lower-middle income country, based on the gross national income (GNI) (World Bank Group, 2020).

Nepal's Human Development Index[3] value is 0.602 which places it in the medium human development category and on rank 142 of 189 (least developed) (UNDP, 2020b). In recent years, Nepal has made considerable progress on many indicators included in the Sustainable Development Goals (SDGs). In the following paragraphs, I describe Nepal's developmental progress along selected SDG indicators that are relevant to better understand the context of this thesis.

The proportion of people living on 1.9 USD (purchasing power parities[4] value) or less has dropped from 36% in 2015 to 15% in 2019 (National Planning Commission [Nepal], 2020b). While 30% of the population were multidimensionally poor[5] in 2014, this dropped to 17% in 2019 (SDG 1: End poverty) (National Planning Commission [Nepal], 2021).

Generally speaking, the progress on indicators related to health and well-being (SDG 3) has been slow: The maternal mortality ratio (number of maternal deaths per 100,000

[3] The HDI is a summary measure for assessing long-term progress in three basic dimensions of human development: a long and healthy life, access to knowledge and a decent standard of living (UNDP, 2020b)
[4] Purchasing power parities (PPPs) are the rates of currency conversion that try to equalise the purchasing power of different currencies, by eliminating the differences in price levels between countries. (OECD data, n.d.)
[5] The Multidimensional Poverty Index (MPI) is a poverty measure that reflects the deprivations that poor people face in the areas of health, education and living standards. The Global MPI used here reflects the proportion of people in a population that are multidimensionally poor (Multidimensional Poverty Peer Network, n.d.).

live births) remained high at 239 in 2016 when the most recent data were available (Ministry of Health and Population [Nepal] et al., 2017) - and is unlikely to have met the target of 125 for 2019 (National Planning Commission [Nepal], 2020b). The adolescent birth rate (number of births among women under 20 years per 1,000 women in that age group) was 63 in 2019 (National Planning Commission [Nepal], 2020a) and missed its target of 56 (National Planning Commission [Nepal], 2020b). There have been improvements in antenatal care and child mortality. Three out of four pregnant women (78%) attended four or more antenatal care visits (National Planning Commission [Nepal], 2020a), which is a good progress from the 60% in 2015 (National Planning Commission [Nepal], 2015, 2020b). The under-five mortality rate (number of children who died before their fifth birthday per 1,000 live births) dropped from 38 to 28, and the neonatal mortality rate (number of deaths in the first 28 days of life per 1,000 live births) dropped from 23 to 16 (National Planning Commission [Nepal], 2015, 2020a).

In terms of education (SDG 4) the progress has been mixed: While enrolment rates are high, especially in primary education, and close to reaching their targets, the learning achievements are discouragingly low and speak for the lack of quality in education: Learning scores in different subjects only reach between 35% and 41%, much lower than the targeted 55% to 66% (National Planning Commission [Nepal], 2020b). Illiteracy among women stayed the same (41% in 2011, 40% in 2016), but the considerably lower level of illiteracy (19%) among younger women (15-19 years) is promising (Ministry of Health and Population [Nepal] et al., 2012; Ministry of Health and Population [Nepal] et al., 2017). In Province 2, where the GMS cohort is located, the proportion of female illiteracy is considerably higher than the national average at 69% (Ministry of Health and Population [Nepal] et al., 2017). This is important in the context of this thesis as maternal education and literacy are important determinants of child nutrition and health in general.

The progress on gender equality (SDG 5) has been slow. The Gender Inequality Index[6] only improved from 0.49 to 0.48, far below the target of 0.38 (National Planning

[6] The Gender Inequality Index is a composite measure reflecting inequality in achievement between women and men in three dimensions: reproductive health, empowerment and the labour market (UNDP, 2020a).

Commission [Nepal], 2020b). The 2016 DHS report describes that since 2011 the proportion of women who had experienced physical violence since age 15 remained unchanged at 22%. The risk of violence during pregnancy is highest for adolescent mothers (age 15-19, 10%), women who are divorced, separated, or widowed (10%), and women in Province 2 (9%). The practice of child marriage remains common: 11.6% of women interviewed were married by the age of 15, 49% by the age of 18. Disaggregating the data by the women's age shows that there is a trend away from early marriage. For example, the proportion of women married by age 15 was 16% among women aged 45-49, but only 4% among women aged 15-19 (Ministry of Health and Population [Nepal] et al., 2017).

Progress in terms of water and sanitation (SDG 6) has been mixed. The Multiple Indicators Cluster Surveys (MICS) from 2014 and 2019 state that almost all households (93% and 97%, respectively) have drinking water sources that can be classified as "improved". However, it appears that this classification is not very meaningful in the Nepali context as the drinking water in three out of four households nevertheless contains E. coli bacteria (National Planning Commission [Nepal], 2015, 2020a). The use of improved, non-shared, toilet facilities almost doubled between 2011 (38%) and 2016 (62%) (Ministry of Health and Population [Nepal] et al., 2017).

Finally, the situation regarding the SDG Decent Work and Economic Growth (SDG 8) is relevant for this thesis to better understand the high numbers of migrant workers from Nepal. According to the 2017/18 Nepal Labour Force Survey (NLFS) (Central Bureau of Statistics [Nepal], 2019), the unemployment rate, defined as the proportion of the labour force that is actively trying to find work, is 11% and highest in Province 2 at 20%. More than two thirds (69%) of job seekers were young people aged 15-34 years.

The situation in the Covid-19 pandemic

It should be noted here that the information for all these indicators is from 2019 or earlier. At the time of writing this thesis (March 2021) the global Covid-19 pandemic has been going on for one year during which national and local lockdowns had been imposed worldwide, often for several months at a time, to slow the spread of the disease. It has become apparent that the pandemic and the resulting lockdowns have had severe side-effects on the most vulnerable populations and may have undone many efforts working towards the SDGs. For example, one study found that institutional deliveries decreased by 52% by the end of the lockdown in May 2020, and that existing inequalities were exacerbated. While the relatively advantaged Hill Brahmin / Chhetri ethnic groups increased the use of childbirth services, attendance by the disadvantaged *Madheshi* decreased (A. KC et al., 2020). Similarly, the adjusted risk ratio for preterm birth was 1.30, 1.46 for institutional stillbirth, and 3.15 for institutional neonatal mortality during the lockdown period compared with before lockdown. It is very likely that indicators in other areas of health and development were similarly negatively affected.

Caste and ethnicity

The last Nepal census in 2011 lists 123 languages spoken as mother tongue, the largest being Nepali (45%), followed by Maithili (12%) which is spoken in the Eastern *Terai* and Bihar state of India. The population is predominantly Hindu (81%), Buddhist (9%) and Muslim (4%) (Central Bureau of Statistics [Nepal], 2012). Although Nepal has been a secular state since 2006, the Hindu caste system has shaped the country's social structure. Caste and/or ethnicity are major determinants of people's social position, identity, and life prospects. Another factor that has had a major impact on people's lives and prospects is their regional identity, as the Kathmandu-based government has historically marginalised the *Terai/Madheshi* groups inhabiting the plains region along the border to India, and most *Janajati* (indigenous) groups (Bennett, Dilli, & Pav, 2008).

An analysis of the 2006 DHS data disaggregated by caste, ethnicity and regional identity shows inequalities in wealth, education and health (Bennett et al., 2008). High caste Brahmin/Chhetri and the Newar ethnic group, the traditional inhabitants of the Kathmandu valley, typically enjoy greater wealth and asset ownership than other groups. Dalits are the lowest ranking group in the caste system and also occupy the lowest wealth quintiles and have lower proportions of asset ownership. Interestingly, Hill/Mountain groups have higher proportions in the lower and upper wealth quintiles, whereas *Terai/Madhesi* groups have higher representation in the middle quintiles. Similarly, Dalits and particularly those from the *Terai* have the highest levels of illiteracy and neonatal mortality. Muslims are the second largest minority religious group (4%, Central Bureau of Statistics [Nepal], 2012) who mostly reside in the Terai and are marginalised in many aspects of life. Muslims have the highest levels of severe stunting (height-for-age *z*-score <-3 SD), the highest unmet need for family planning and the highest infant mortality rate (Bennett et al., 2008).

3.2 Child and maternal nutrition in Nepal

Child stunting, wasting and underweight

Nepal has seen drastic improvements in child undernutrition over the past two decades, but levels remain high. The Nepal Demographic Health Survey (DHS) of 1996 reported that 48.4% of children under five years were stunted and that the mean HAZ was -2.0 (Table 3.1). In 2016, prevalence of stunting was down to 35.8% and mean HAZ had improved to -1.5. Prevalence of underweight even improved by 19.9 percentage points (p.p.) and weight-for-age *z*-score (WAZ) by 0.6. Looking at the absolute change in wasting or weight-for-height *z*-score (WHZ), we see that it only improved by 1.5 p.p. or 0.2, but the change relative to the generally lower levels of wasting is nevertheless considerable.

Table 3.1: Nutritional status of Nepalese children under five years in 1996 and 2016

	1996	2016	Absolute change	Relative change
Height-for-age *z*-score (HAZ)	-2.0	-1.5	0.5	25%
Stunting (HAZ < -2 SD)	48.4%	35.8%	-12.6 p.p.	-26%
Weight-for-height *z*-score (WHZ)	-0.8	-0.6	0.2	25%
Wasting (WHZ < -2 SD)	11.2%	9.7%	-1.5 p.p.	-13.4%
Weight-for-age *z*-score (WAZ)	-1.9	-1.3	0.6	31.6%
Underweight (WAZ < -2 SD)	46.9%	27.0%	-19.9 p.p.	-42.4%

Source: Data are from Nepal Demographic Health Surveys (Ministry of Health and Population [Nepal] et al., 2017; Ministry of Health and Population [Nepal], New ERA, & Macro International Inc., 1997). Note: p.p. = percentage point.

Headey and Hoddinott (2015) used Nepal DHS data to analyse changes in HAZ between 2001 and 2011 and visualised the two HAZ trajectories as shown in Figure 3.3. The intercept and slope of a growth curve can provide important information on the nature of growth faltering in a population. The intercept indicates the size at birth and to what extent growth faltering has already occurred in utero. Small size at birth can be caused by maternal short stature and underweight (Victora et al., 2021). The slope of the curve indicates the timing and severity of postnatal growth faltering. In the Nepal example, the slopes in the first six months are relatively flat, coinciding with the exclusive breastfeeding period. Between six and approximately 24 months the curves fall much more steeply, which suggests that much of the growth faltering occurs at the age when children's nutritional needs exceed that of breast milk alone and complementary foods are introduced, and when children's increased mobility brings about more exposure to pathogens. After 24 months the curves stay on approximately the same level until the children reach five years of age. Comparing the two curves from 2001 and 2011 shows that much of the improvement in HAZ is already present at birth, which suggests that this is a result of better maternal nutrition. Additionally, the slope after six months is flatter in 2011 than 2001 which might be a result of better complementary feeding practices, food security and cleaner environments.

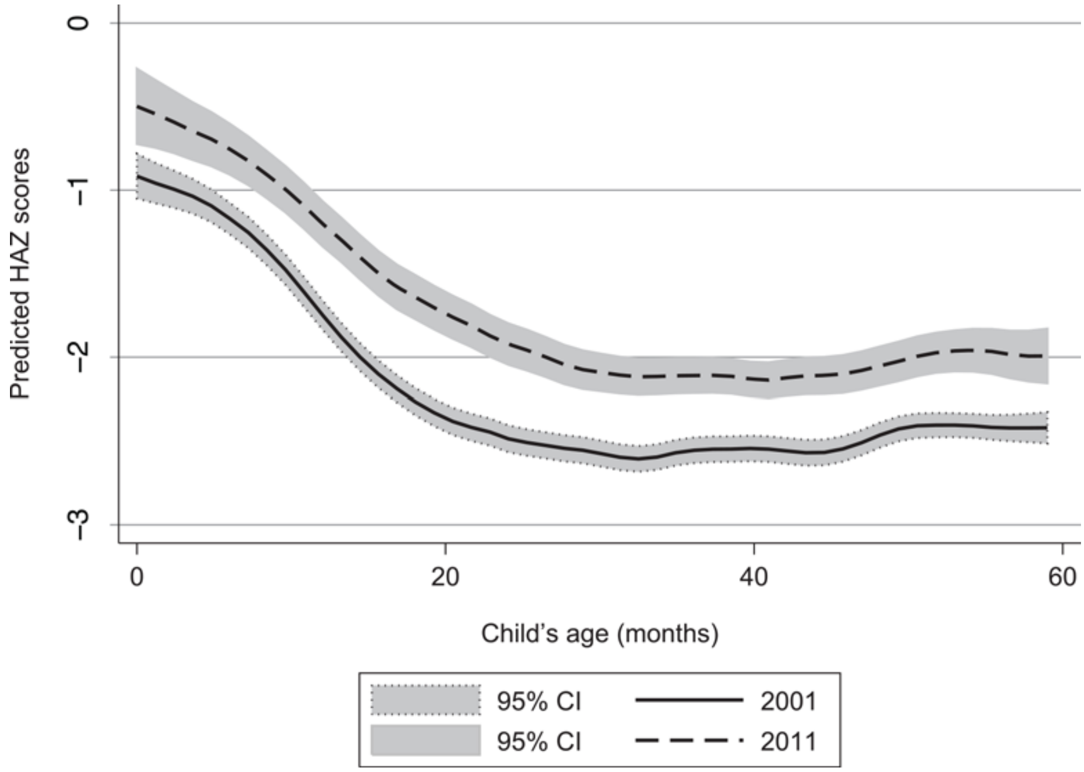


Figure 3.3: Shifts in height-for-age *z*-scores (HAZs), by child's age, from 2001 to 2011. Data from Nepal Demographic Health Surveys. Figure source: Headey and Hoddinott (2015)

Determinants of nutritional status in children

Infant and young child feeding practices

Breastfeeding and complementary feeding practices are often the immediate determinants of infant nutritional status and growth. The World Health Organization (WHO) defined eight core infant and young child feeding (IYCF) indicators for children under two years (WHO, 2010)[7]. Table 3.2 presents these age-specific indicators, their definitions and how they changed between 1996 and 2016. Where possible, data were gathered directly from the respective DHS reports (Ministry of Health and Population [Nepal] et al., 2017; Ministry of Health and Population [Nepal] et al., 1997) and if the reports did not state them, they were gathered from Hanley-Cook et al. (2020) who had calculated indicators using DHS raw data.

The progress on these indicators has been mixed, with breastfeeding practices improving or stagnating at an acceptable level and many complementary feeding practices improving but to a still unsatisfactorily low level. Early initiation of breastfeeding improved impressively from 18.1% to 55.9%. Exclusive breastfeeding declined from 71% to 66.1%, but nevertheless remains above the WHO target of 50% (WHO, 2014). Children who were not exclusively breastfed received other milk (9.8%), non-milk liquids (11.8%) or complementary foods (11.5%) additional to breastmilk (Ministry of Health and Population [Nepal] et al., 2017). The vast majority of children (>90%) continue to be breastfed at one year. Introduction of complementary foods used to be very late with only 54.3% of children between six and eight months having been introduced to solid, semi-solid or soft foods in 1996. This proportion increased considerably to 84.2% in 2016. Less than half of the children aged six to 23 months (45.8%) were fed at least four food groups per day in 2016 (indicator not available in 1996). Disaggregation by age shows that dietary diversity increases as children grow up. At age six to eight months only 20.4% receive a sufficiently diverse diet, but this increases to 58.6% when the children are 18 to 23 months old (Ministry of Health and Population [Nepal] et al., 2017). The percentage of children fed the minimal number of

[7] The 2008/2010 WHO/UNICEF IYCF indicators presented here were replaced in April 2021, during the writing of this thesis, by a revised set of indicators (WHO & UNICEF, 2021). I am presenting the 2008/2010 indicators as they have been described in the DHS reports and were used in the decomposition analysis by Hanley-Cook, Argaw, Dahal, Chitekwe, and Kolsteren (2020)

times per day increased only slightly from 65.8% in 1996 to 71.2% in 2016. Only little more than one third of the children aged six to 24 months (36.4%) received an acceptable diet in 2016 (indicator not available in 1996). In Province 2, where the GMS is located, these indicators are much worse than the national average. Minimum dietary diversity, minimum meal frequency and minimum acceptable diet were only 28.1%, 62.4% and 20.8% respectively (Ministry of Health and Population [Nepal] et al., 2017). Only 38.9% of children between six and 24 months consumed iron-rich foods in 2016 (indicator not available in 1996).

Table 3.2: Infant and Young Child Feeding (IYCF) core indicators in Nepal in 1996 and 2016

Indicator	Definition	1996	2016	Absolute change	Relative change
1. Early initiation of breastfeeding	Proportion of children born in the last 24 months who were put to the breast within one hour of birth	18.1	55.9	37.8 p.p.	209%
2. Exclusive breastfeeding under six months	Proportion of infants 0–5 months of age who are fed exclusively with breast milk	71	66.1	-4.9 p.p.	-7%
3. Continued breastfeeding at one year	Proportion of children 12–15 months of age who are fed breast milk	90.5	98.1	7.6 p.p.	8%
4. Introduction of solid, semi-solid or soft foods	Proportion of infants 6–8 months of age who receive solid, semi-solid or soft foods	54.3	84.2	29.9 p.p.	55%
5. Minimum dietary diversity	Proportion of children 6–23 months of age who receive foods from 4 or more food groups (out of 7 food groups)	-	45.8	-	-
6. Minimum meal frequency	Proportion of breastfed and non-breastfed children 6–23 months of age who receive solid, semi-solid, or soft foods (but also	65.8	71.2	5.4 p.p.	8%

	including milk feeds for non-breastfed children) the minimum number of times or more. For breastfed children: 6-8 months: ≥2 times, 9-23 months: ≥3 times For non-breastfed children 6-23 months: ≥ 4 times				
7. Minimum acceptable diet	Proportion of children 6–23 months of age who receive a minimum acceptable diet (apart from breast milk). For breastfed children: at least minimum dietary diversity and at least minimum meal frequency For non-breastfed children: at least two milk feedings and at least minimum dietary diversity and at least minimum meal frequency	-	36.4	-	-
8. Consumption of iron-rich or iron-fortified foods	Proportion of children 6–23 months of age who receive an iron-rich food or iron- fortified food that is specially designed for infants and young children, or that is fortified in the home.	-	38.9	-	-

Source: Indicators and definitions from WHO (2010). Data are from reports of Nepal Demographic Health Surveys (Ministry of Health and Population [Nepal] et al., 2017; Ministry of Health and Population [Nepal] et al., 1997) and if not reported in the right format they were gathered from Hanley-Cook et al. (2020). Note: p.p. = percentage point

There are many widespread cultural beliefs, but also lack of knowledge, that deter age-appropriate infant feeding. Delaying breastfeeding and giving prelacteal feeds such as honey and clarified butter (ghee) is rooted in the Hindu culture (Laroia & Sharma, 2006), which can explain the initially very low proportion of mothers who breastfeed their child within one hour after birth. Qualitative research in Far Western Nepal showed a widespread consensus among mothers about the value of breastfeeding and the majority knew the recommended duration of exclusive breastfeeding. In practice, however, mothers often fed animal milk or water during the first six months out of concern that their breastmilk was insufficient or that the baby could be thirsty (Locks et al., 2015). Complementary foods are usually based predominantly on grains and pulses such as rice, *lito* (roasted cereal and lentil porridge) and *jaulo* (rice and pulse porridge), whereas animal source foods are commonly believed to be unhealthy for children under 12 months (Cunningham, Headey, Singh, Karmacharya, & Rana, 2017; Locks et al., 2015). Poverty, seasonality, lack of availability and religious dietary restrictions for high caste groups further limit the intake of nutritious foods and dietary diversity for children and adults (Locks et al., 2015).

Using five rounds of Nepal DHS data (1996-2016), Hanley-Cook et al. (2020) investigated to what extent these IYCF practices are associated with child linear growth in terms of HAZ and stunting in children under two years. They found that complementary feeding practices, especially timely introduction of complementary foods and minimum dietary diversity, predicted higher HAZ and lower odds of stunting, whereas there was no association with the three breastfeeding indicators. Authors further used decomposition analysis to determine the contribution of age-appropriate feeding practices to the improvements in linear growth observed in Nepal over those two decades. They found that feeding practices as measured by IYCF indicators only made very modest contributions to increases in HAZ. Among children aged six to eight months, timely introduction of complementary foods explained 0.08 SD in HAZ, but all other indicators ranged only between 0.00 and 0.02 SD in HAZ. A decomposition analysis by Conway et al. (2020) using the same data source but also including older children, however, found that breastfeeding practices explained 8% of improvements in HAZ in children under five years.

Infections

Recurrent infections early in a child's life is another important cause of child undernutrition (Black et al., 2013; Leroy & Frongillo, 2019), with diarrhoea possibly being the most important one. Diarrhoea in children under five years is a major cause of morbidity and mortality in Nepal. The Nepal DHS reports that 8% of children had diarrhoea in the two weeks preceding the survey. Diarrhoea burden is the highest among children aged six to eleven months (15%) and in Province 2 (9%) (Ministry of Health and Population [Nepal] et al., 2017). It should be noted here that diarrhoea is highly seasonal and that these figures underestimate the higher incidence during the rainy season (Bhandari, Bi, Sherchand, Dhimal, & Hanson-Easey, 2020). International studies showed very modest associations between diarrhoea and stunting (Checkley et al., 2008; Richard et al., 2013) but studies from Nepal often found no relationship (Dorsey et al., 2018; Tiwari, Ausman, & Agho, 2014). Acute respiratory infection and fever are also common among children and the Nepal DHS reports that 2% and 21% respectively were affected in the two weeks prior to the survey (Ministry of Health and Population [Nepal] et al., 2017).

Underlying determinants of progress in childhood stunting

Several studies used Nepal DHS data and decomposition analysis to investigate the factors that drove the reduction in stunting (Conway et al., 2020; Cunningham et al., 2017; Headey & Hoddinott, 2015). They found that distal or underlying factors together explained much of the improvements in HAZ observed, but each factor by itself generally had modest contributions. The most important factors that they identified were improved access to and usage of health services such as antenatal care services (ANC) and child vaccination, reductions in community open defecation, better parental education (especially maternal education), wealth accumulation, and lower fertility. As an example, the two factors with the largest effects, improvements in health services and asset accumulation, accounted for 0.15 and 0.09 SD in HAZ in the study by Cunningham et al. (2017).

Qualitative interviews with mothers (Cunningham et al., 2017) and stakeholders at community and national level (Conway et al., 2020) about their perceived changes in the nutrition environment largely mirrored the study's quantitative findings. Mothers stated that ANC visits, education for both sexes, improved drinking water and toilet use were much more common now. They also stated that living conditions and socioeconomic status had changed for the better, also due to the additional income from international remittances (Cunningham et al., 2017), and that their workload had changed in the past two decades so that mothers often had more time to breastfeed and care for their children (Conway et al., 2020). Stakeholders furthermore named increased female empowerment as a driver of stunting reduction (Conway et al., 2020).

Numerous nutrition-specific and nutrition-sensitive national policies and programmes may have facilitated improvements in child stunting. Here only a selection of the most important are mentioned. Access to healthcare has improved much over the past decades. The formation of a cadre of Female Community Health Volunteers (FCHVs) in 1988 helped overcome the problem of difficult access to remote communities (Cunningham et al., 2017). FCHVs have been central to the implementation of many health and nutrition programmes. Since 2007, medical services in public institutions and essential medicines are free of charge (Conway et al., 2020). Additional to better access to general health services, further emphasis was placed on mothers and newborns with programmes such as the Safe Motherhood Program (since 1997), the Safe Delivery Incentive Program (since 2005) and the National Policy on Skilled Birth Attendants (since 2006) (Conway et al., 2020). Nutrition-specific programmes initially consisted of Vitamin A supplementation, iron and folic acid supplementation for pregnant and lactating women (Cunningham et al., 2017), the Mothers Milk Substitute Act to promote breastfeeding and control breastmilk substitutes (since 1992), and the Iodized Salt Act (since 1998) (Conway et al., 2020). Later the more comprehensive National Nutrition Policy and Strategy (since 2004) guided all nutrition-related activities and led to the Multi-Sector Nutrition Plan I (2012-17) and II (2018-22) (Conway et al., 2020). Investments in nutrition-sensitive sectors such as education, family planning, poverty reduction, and water, sanitation, and hygiene (WASH) are also key to improve child nutrition (Conway et al., 2020; Cunningham et al., 2017).

Maternal malnutrition

Maternal undernutrition has also improved considerably in the past decades. According to DHS reports, among women of reproductive age (15-49 years) the prevalence of underweight, defined as a body mass index (BMI) < 18.5, dropped from 28.3% to 17.2% between 1996 and 2016. Similarly, the prevalence of short stature, defined as height smaller than 145 cm, decreased from 14.8% to 10.6% (Ministry of Health and Population [Nepal] et al., 2017; Ministry of Health and Population [Nepal] et al., 1997). While maternal undernutrition has been and still is a major concern, the global trend towards higher numbers of overweight and obesity can also be observed in Nepal. In 2001, when the DHS first reported overweight and obesity as an indicator, defined as a BMI ≥25, the prevalence was only 6.5% (Ministry of Health [Nepal], New ERA, & ORC Macro, 2002). By 2016 it had more than tripled to 22.2% (Ministry of Health and Population [Nepal] et al., 2017). Both underweight and obesity compromise a woman's general health and wellbeing, but they also increase the risks for mother and child during and after pregnancy. Obese women are more likely to develop diabetes mellitus during pregnancy or experience complications during birth (Black et al., 2013). Underweight during pregnancy is a risk factor for intrauterine growth restriction (Black et al., 2008). Maternal short stature increases the risk of caesarean delivery due to cephalopelvic disproportion. In low resource settings where operative delivery is not always available, this can risk the life of both mother and baby (Black et al., 2008; J. C. K. Wells et al., 2021).

On a national level, undernutrition of women is highest in Province 2 where GMS is located. Here, prevalence of low stature is 13.6%, and 29.1% are underweight (Ministry of Health and Population [Nepal] et al., 2017). Additionally, 57.8% of women in Province 2 had anaemia defined as haemoglobin levels <11.0 g/dl or 12.0 g/dl for nonpregnant and pregnant women respectively. The national prevalence is comparably lower but nevertheless high at 40.8%[8] (Ministry of Health and Population [Nepal] et al., 2017). Anaemia during pregnancy is associated with low birth weight (<2500 g) (Black et al., 2008).

[8] The Nepal Micronutrient Status Survey 2016 found an overall considerably lower prevalence of anaemia (nationally 20% and 27% in non-pregnant and pregnant women, respectively), but the general pattern of considerably higher prevalence among women in the Terai (29% and 36% in non-pregnant and pregnant women, respectively) remains (Ministry of Health and Population [Nepal] et al., 2018).

3.3 Labour migration in Nepal

History, trends, and current situation

The modern history of labour migration from Nepal starts with the recruitment of Nepalis into the British army, which formally began in 1886 (Sijapati & Limbu, 2017). Around the same time, better earnings in India, particularly the Northeast, attracted Nepali labour migrants who often settled there due to the better prospects for their families. In 1950, the Treaty of Peace and Friendship between Nepal and India formalised the free movement of people between the countries.

For a long time, labour migration from Nepal was predominantly aimed at India. This changed in the 1990s and 2000s following the Nepal Foreign Employment Act in 1985 which made labour mobility beyond India possible (Sijapati & Limbu, 2017). This policy change concurred with economic growth due to high revenues from oil in Arab countries, especially the Gulf Cooperation Council (GCC)[9] in the 1970s, which lead to increasing demand for cheap labour, especially in the sectors construction, hospitality and retail (Government of Nepal, 2020). As a result, a growing number of workers from Nepal and other South Asian countries went to work in GCC countries. The volume of Nepali workers traveling to the GCC peaked in 2015/16, after which demand for foreign workers dropped due to economic and geopolitical factors, a sharp decline in oil prices, and a change in the political climate towards a preference for hiring nationals (Government of Nepal, 2020). Malaysia is the other major destination country for Nepali workers (outside of India), but the number of workers moving there similarly dropped after 2014. Figure 3.4 shows the recent trends in migration outflow to the major destination countries, but it should be noted here that these volumes of out-migrating labourers underestimate the probably much larger migrant stock residing in the hosting countries for which no data are available. There is little diversity in destination countries for Nepali workers, which makes prospective migrants and Nepal's economy as a whole vulnerable to declines in labour demand in these hosting economies. In order to secure access to safe and profitable labour markets the Government of Nepal (GoN) is trying to open up and strengthen migration corridors to new destination countries in other

[9] Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates

regions (Government of Nepal, 2020). India continues to be a major destination country for Nepali labourers, but there is a scarcity of data since migration between the two countries is undocumented (Sijapati & Limbu, 2017).

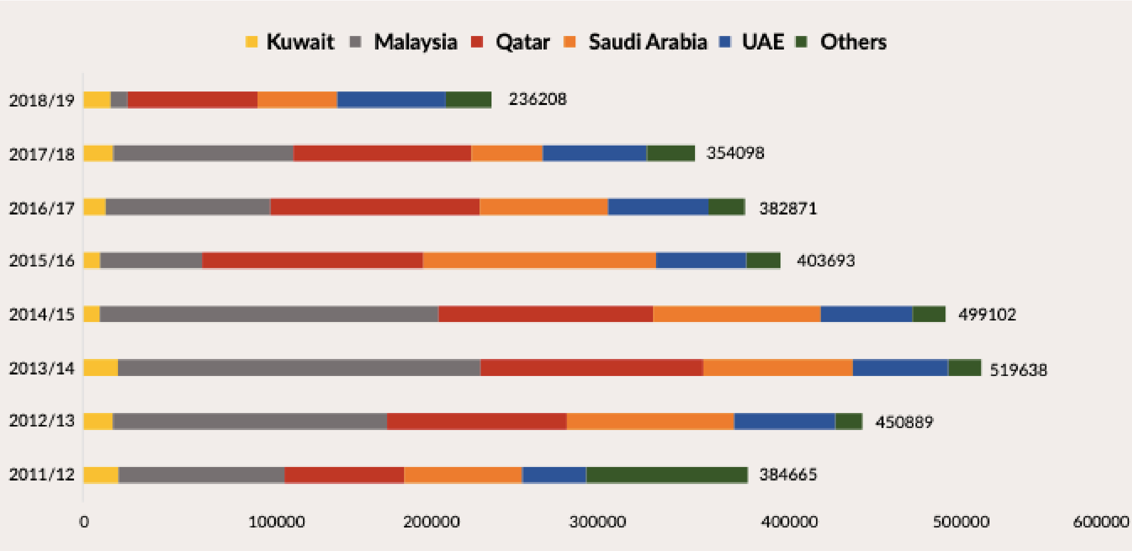


Figure 3.4: Migration flow to major destinations 2011/12 – 2018/19 (Source: Government of Nepal (2020)).

Labour migration from Nepal is predominantly male and only around five percent of (documented) international migrants are women (Government of Nepal, 2020). While international labour migration is common in all areas of Nepal, there is large variation in terms of the number of migrants and their migration destinations. Most migrants are from Provinces 1 and 2 and migrants from these areas typically seek work in Qatar. Migrants from Province 3, on the other hand, predominantly migrate to the United Arab Emirates (UAE). Dhanusha is the district with the highest number of migrants (Government of Nepal, 2020). Most migrants are between 25 and 35 years with a mean age of 29 (Government of Nepal, 2020). The majority of migrants work in low skilled jobs in the sectors construction, service and sales, or elementary occupations such as labour (unspecified) or cleaning (Government of Nepal, 2020).

The volume of remittances to Nepal has been growing relatively steadily up until 2018 when it reached 8.3 billion USD (World Bank Group, 2019c), 25% of GDP at the time (World Bank Group, 2022), despite a decrease in migrant outflow. This might be due to the large existing stock of Nepali migrants abroad, currency depreciation against the US dollar and increased monitoring of informal remittance channels (Government of Nepal, 2020). It is nevertheless assumed that the official remittance statistics underestimate the actual inflow of money as migrants often still resort to informal channels (Sijapati & Limbu, 2017). According to the 2011 Nepal Living Standards Survey, more than half (56%) of Nepal households received any remittances, and most of them (69%) were sent from abroad from countries other than India (Central Bureau of Statistics [Nepal], 2011). Recent data on annual remittances per migrant or household are limited. The average yearly remittances reported in Sijapati et al. (2017) is NPR 159,511 (GBP 1,117)[10], but there was large variability depending on migrant socio-economic status and destination country, with smallest amounts sent from India (NPR 113,837, GBP 797) and higher from South Korea (NPR 350,746, GBP 2,455). A 2014 survey among Nepali returnee migrants from Qatar found that the mean amount remitted was USD 207 per month (USD 2,484 per year) (Martin, 2016).

Labour migration governance

National instruments

The first legal document to regulate international labour migration beyond India was the Foreign Employment Act 1985. It demanded the licensing of organisations involved in foreign employment and the need to obtain government approval for the selection of workers. The act's aim was to control migration and stem the outflow of qualified workers who were deemed valuable for the economic development of the country (Sijapati & Limbu, 2017). The Foreign Employment Act 2007, which regulates labour migration from Nepal until today, marked a shift in the objectives surrounding foreign employment towards a greater focus on protections of migrants' rights and interests (Sijapati & Limbu, 2017). These are the most important features of the 2007 Act as described in Sijapati and Limbu (2017) if not stated otherwise.

- The GoN can enter bilateral agreements with other governments to send workers.
- It is the responsibility of the GoN to bring back stranded workers in the case of war, epidemic, or natural calamity.

[10] Using a 0.007 NPR to GBP exchange rate, the average exchange rate in 2013 (www.exchangerates.org.uk, n.d.-a)

- The GoN has to grant special priorities and quotas for disadvantaged groups such as women and Dalits to which recruitment agencies have to adhere.
- Gender discrimination is prohibited.
- The GoN can specify the minimum wage for workers and the maximum service fee to be collected by the recruitment agency.
- Workers have to attend a two-day orientation at a licensed institution before going abroad.
- The costs of the visa and a two-way airfare are to be borne by the employer and not to be deducted from the worker's salary ("free visa free ticket") (Provision June 2015). Previous to this provision, the costs for the visa and air ticket were typically borne by the migrants themselves. The recruitment costs paid by the worker are now reduced to a maximum of NPR 10,000.
- The recruitment agent has to procure insurance of at least NPR 500,000 for the migrant's whole contract term.
- The recruitment agent has to ensure that the migrant travels through Tribhuvan International Airport in Kathmandu. This is to make sure that the migrant passes through the labour desk where his documentation is checked, and to avoid irregular migration through India.
- The GoN can appoint a labour attaché in countries with more than 5000 Nepali workers. The attachés duties are among others to resolve disputes, provide information to the GoN, oversee repatriation of stranded workers.
- A Foreign Employment Welfare Fund is established to provide social security to migrants and their families, for example by providing repatriation of workers.

The rules and regulations to implement the Foreign Employment Act are laid out in the Foreign Employment Rules 2008. The Foreign Employment Policy 2012 addresses shortcomings of the prevailing Act and Rules and provides detailed strategies to make labour migration safer and more sustainable (Sijapati & Limbu, 2017). There are various other national laws that are applicable to labour migration, for example the Human Trafficking and Transportation (Control) Act 2007 and the Child Labour Act 2000 through which recruitment agencies sending minors or luring workers abroad using false information can be held accountable (Sijapati & Limbu, 2017).

Bilateral agreements

The national regulations as described above have no powers beyond the borders of Nepal and give the GoN no means to protect their citizens abroad. As designated in the Foreign Employment Act 2007, the GoN has therefore established bilateral agreements with five countries that directly govern matters of labour migration: Qatar (Labour Agreement, 2005), United Arab Emirates (Memorandum of Understanding (MoU), 2007), South Korea (MoU, 2007), Bahrain (MoU, 2007), and Japan (Letter of Exchange, 2009) (Sijapati & Limbu, 2017). MoUs are not legally binding and easier to negotiate and amend, whereas a labour agreement, as was established with the Qatari government, is legally binding and more formal (Sijapati et al., 2017). Such bilateral agreements enable both parties to pursue their respective goals by formalising the common terms and conditions of labour migration. The labour sending country has a means to protect its citizens' rights and welfare abroad and secures access to a labour market through which it can address unemployment at home and ensure a steady inflow of remittances. The labour-receiving country gains access to adequately qualified labour in a regulated manner.

Labour migration of women

For a long time, migration governance in Nepal was characterised by varying levels of restriction for women. Intended to protect women from exploitation and abuse, these rules constrained women's movement and made them more dependent on their male relatives (ILO, 2015). The Foreign Employment Act 1985 demanded that women may only leave for foreign employment after obtaining permission from their guardian (Sijapati & Limbu, 2017). In 1998, following the death of a domestic worker in Kuwait, a complete ban on the migration of women to work in Gulf countries was imposed (ILO, 2015). This ban was partially lifted in 2003 and the Foreign Employment Act 2007 prohibits any form of gender discrimination and even mandates quotas to be reserved for women (Sijapati & Limbu, 2017). Nevertheless, Government directives in the years to follow imposed several restrictions for women on the basis of age, working sector or destination (ILO, 2015). A study by the International Labour Organization (ILO) concluded that these measures fell short of protecting women but instead made them more vulnerable to abuse as they resorted to informal migration channels (ILO, 2015). Female labour migration via licensed recruitment agents accounts for only about five percent of migrants from Nepal, but it is believed that migration via irregular channels through India or Bangladesh is much higher. Estimates by Amnesty International, for example, are as high as 30% (Amnesty International, 2011). In 2015, the Directive for Sending Domestic Workers on Foreign Employment reopened regular migration channels for women aged 24 or older who intend to work in the domestic sector in countries with which Nepal has established bilateral agreements (Sijapati, Mak, Zimmerman, & Kiss, 2019). This Directive also includes a range of additional procedures and requirements that are intended to make migration safer for domestic workers, but which also make the administrative hurdles for women and recruitment agencies much higher and thus disincentivise orderly migration (Sijapati & Limbu, 2017).

The process of international labour migration: A cascade of brokerage

Labour migration in Nepal is typically organised through recruitment agencies (also called manpower companies or recruitment agencies) who are registered with the Department of Foreign Employment (DoFE). These agencies are based in Kathmandu and either have regional branches or work with unregistered regional agents who may again work with unregistered subagents, also called brokers or *dalal*, at the village level (Verité, 2012). Brokers are often the first point of contact with prospective migrants and their familiarity elicits trust with locals. Especially in Dhanusha district, where the highest number of migrants come from, there is a general mistrust towards recruitment agencies and people prefer to deal with locals from the same caste (Verité, 2012). Brokers recruit clients through word of mouth and regular visits to the villages in their area, and provide information about available jobs, destinations, and wages. They are often important facilitators in the migration process by for example helping with the paperwork and updating the migrant on the application process (Amnesty International, 2011). Brokers usually work with several agents and are paid by commission based on the numbers of migrants that they recruit, which creates an incentive to deceive potential migrants. In Dhanusha district in 2011 a broker got about NPR 5,000 per migrant from the regional agent, who got NPR 10,000-15,000 from the recruitment agency, who got NPR 15,000-20,000 for each migrant sent abroad (Verité, 2012). In contrary to common perception that a local and seemingly trustworthy because familiar broker makes migration safer, the opposite is often true. Also, the additional link in the chain of brokerage increases the costs for the migrant (Amnesty International, 2011). Once the DoFE has approved the application for foreign employment the prospective migrant is invited to Kathmandu for the actual job interview. This can mean that the migrant learns the actual details of the contract only days before the departure date, if at all. Before leaving the migrant must undergo a two-day orientation training and pass medical checks, as per GoN regulations.

Before the 2015 "free visa free ticket" provision, the GoN set maximum allowable service charges to migrants depending on the destination country. The maximum service charge that recruitment agencies were allowed to collect from migrants to Gulf countries, for example, was NPR 70,000 (Verité, 2012). But unofficial market rates were often considerably higher, a practice that continues even after the introduction of the new policy (Amnesty International, 2017; A. Gurung, 2019). The worker's recruitment fees are either paid to the local broker or the recruitment agency (Verité, 2012), sometimes both (Amnesty International, 2017). The mode through which the recruitment agencies are in contact with employers in destination countries is very variable and somewhat obscure (Verité, 2012). Many Nepali recruitment agencies have no direct link with employers or recruitment agencies in destination countries and rely on foreign agents from India, Bangladesh, China, Pakistan or Sri Lanka as middlemen (Verité, 2012). The high recruitment costs that Nepali migrants had to pay, and still do, are a result of the multiple middle men through which the migration process is organised and to whom commissions have to be paid (Verité, 2012).

Instances of exploitation in foreign labour migration

There are numerous occasions in the migration process where Nepali workers become victims of exploitation and fraud. As mentioned above, recruitment costs are very high and usually higher than what migrants from other countries pay. At the same time, their salaries are often considerably lower than that of other nationals (Kern & Muller-Boker, 2015; Martin, 2016; Sijapati & Limbu, 2017). To pay these high fees, workers typically take up loans and severely indebt themselves. According to Nepali law, financial institutions may only charge rates as prescribed by the national bank of Nepal (Rastra Bank) (Amnesty International, 2011) which ranges between eight and fourteen percent per annum, and private individuals may only charge interest rates up to ten percent (Muluki Ain, 1963; Chapter 17, no 6). However, no individual has ever been prosecuted for violating this law (Amnesty International, 2011). Most prospective migrants are not in a position to borrow money from banks because they cannot offer any kind of collateral, therefore they are forced to take loans from private individuals who often charge illegal annual interest rates of up to 60% (Amnesty International, 2011).

The recruitment agencies are required to provide migrant workers with accurate documentation, including receipts of all fees paid. However, prospective migrants rarely receive receipts for their fees and if they do, these state smaller amounts than were actually paid. That way, recruitment agencies can conceal their overcharging and appear to be compliant with government regulations (Amnesty International, 2017). Prospective migrants often also have to pay fees to multiple instances (subagents, regional agents, recruitment agency in Kathmandu), but do not know what it is that they pay for and where they are being overcharged (Amnesty International, 2017). The recruitment agents often do not offer the orientation training required as per government regulations, or it is of very poor quality and does not prepare the migrant at all for his stay overseas (Amnesty International, 2011). Migrants frequently do not receive a copy of their working contract, only see the contract hours before departure and are then forced to sign it with worse terms than they had previously been promised and salary below the minimum wage set by the GoN. Often, they cannot understand the contract because they are illiterate or because it is written in a foreign language, or are made to sign multiple contracts with different terms and conditions (Amnesty International, 2011, 2017; Verité, 2012). Essential facts about their migration are frequently withheld from migrants or they are intentionally given wrong information. Many workers did not know or were given wrong details about their destination country, employer, accommodation, work, salary, working times and rest days, overtime work and payment. Upon arrival in their destination country, they are additionally faced with wage theft through withholding of salaries and lack of compensation for excessive overtime work (Amnesty International, 2011, 2017; Verité, 2012).

The *kafala*, or sponsorship system, is a significant feature of labour migration to GCC countries and a root cause of exploitative working conditions reported in these countries. As per this system, the migrant worker's visa and legal status is tied to the sponsor who has complete control over the worker's mobility (Bajracharya & Sijapati, 2012). A migrant worker cannot change employer or leave the country without the sponsor's consent. But even in destination countries that do not have the kafala system such as Malaysia, workers' passports are commonly confiscated by employers to prevent the workers from changing company (Verité, 2012).

The recruitment and working conditions of Nepali migrant workers frequently fulfil the two components of ILO's definition of forced labour: work that is performed involuntarily and under the menace of any penalty (ILO, 2016). The condition of involuntariness is fulfilled where workers enter a working relationship under false promises, for example regarding the nature of work and the salary. Menace of penalty can be physical violence, reporting to authorities or non-payment of wages, but also more subtle threats such as indebtedness (Amnesty International, 2011; Verité, 2012).

Social and economic impact of migration at the local level

The migration of large numbers of men and the additional income from remittances have brought about significant social and economic change in Nepal. Labour migration provides an opportunity for men and women who otherwise have limited prospects for income generation due to a lack of capital for business ventures, limited employment opportunities in rural areas, and lack of education. In Nepal a history of caste discrimination and bonded labour resulted in many marginalised and landless groups who depended on the higher-class groups for access to land. On the one hand, labour migration posed an alternative livelihood for landless groups and, in cases where migration was successful and accumulative, an opportunity to buy land. The greater independence of marginalised groups from local elites has in many instances challenged traditional hierarchies. On the other hand, the net benefits of labour migration are distributed unevenly across the caste/ethnicity divide, with low-status groups on average paying loans with higher interest rates and accessing jobs with lower salaries than their middle-class counterparts. In that way labour migration is perpetuating existing inequalities (Sijapati et al., 2017).

The absence of men due to migration is likely to have a societal impact. According to Nepal DHS, the number of female-headed households almost doubled between 2001 and 2016 from 16% to 31%, probably as a result of migration (Ministry of Health and Population [Nepal] et al., 2017). The impact of male migration on left-behind women's decision-making and participation in the public sphere is mixed, as found in a qualitative study by Sijapati et al. (2017). Left-behind women have a larger say in household decision-making after their husband migrated, especially in nuclear families. However, they are nevertheless still subjected to a paternalistic environment that narrowly observes their behaviour. There were many accounts of how wives gained greater participation and visibility in the public sphere, which increased their confidence and allowed them to learn new skills. The extent to which this can happen seems to largely depend on the husband's support, with some encouraging their wives to engage more with the community and social groups, and other forbidding such behaviour. Another effect of the absence of men is a decrease in fertility. An analysis of Nepal DHS data concluded that male migration is likely to account for much of the decline in fertility observed in recent years (Khanal, Shrestha, Pant, & Mehata, 2013).

3.4 The study site: Dhanusha district

Dhanusha district is part of Province 2 and located in the Central *Terai* region of Nepal, bordering the Indian state of Bihar. The 2011 census counted 750,000 inhabitants of which eight percent were absentees (Central Bureau of Statistics [Nepal], 2012), probably largely due to migration.

The district capital is Janakpur which, according to Brahmanical literature, was also the capital of the ancient kingdom of Mithila (Burghart, 1978). Today, Janakpur and surrounding sites are important pilgrimage destinations for Hindus. The most commonly spoken language in Dhanusha is Maithili. As they share the Mithila culture and the same language, the ties with communities in the Indian state Bihar are tight and cross-border marriages are common.

The people living in the *Terai* region have traditionally been marginalised by the Kathmandu-based government, which failed to grant them equal rights and opportunities (Bennett et al., 2008). For example, in the absence of birth certificates, Nepali citizenship was for a long time granted on the basis of fluency in spoken and written Nepali, which many in the *Terai* did not have as their mother tongue was Hindi, Maithili or another language. Lack of citizenship precluded them from land ownership, government positions, political posts, and other important aspects of citizen rights and participation (Crisis Group, 2007). Sentiments of persistent disadvantage led to the *Madheshi* uprisings in 2007, 2008 and the border blockage of 2015/16.

Although the land in Province 2, as in other *Terai* areas, is very fertile, the level of household food insecurity is similar to other regions of Nepal (Ministry of Health and Population [Nepal] et al., 2017). This may be partly attributed to inequality in landholding also due to a history of bonded labour (*haruwa/charuwa*) in the district. Although legally prohibited, a 2013 study found that bonded labour is still practiced in Dhanusha, as in other *Terai* districts, and that mostly Dalits are affected (B. K. KC, Subedi, & Suwal, 2013). In many aspects of development, Province 2 fares worse than other provinces. Levels of stunting (34%), wasting (14%) and underweight (28%) in children under five years are higher than the national average (32% stunting, 12% wasting, 24% underweight) (National Planning Commission [Nepal], 2020a). Province 2 has the lowest levels of education in Nepal, with 30.6% of males and 52.9% females aged six and older having no formal education. One third of men and two thirds of women cannot read or read only part of a sentence (Ministry of Health and Population [Nepal] et al., 2017). On many indicators of female empowerment, Province 2 also does worse than the national average. Only 53% of women have a say in decision-making regarding their own health and 45% regarding major household purchases, compared to the national average of 58% and 53%, respectively. Women's median age at first marriage and age at first birth are lower than in any other province at 16.5 years and 19.2 years respectively (Ministry of Health and Population [Nepal] et al., 2017). Especially in rural areas of Province 2, women, and to a larger degree men, have very high levels of acceptance towards domestic violence against women. More than half of the men consider it justified to beat their wife (National Planning Commission [Nepal], 2020a).

Rice paddies and ponds are characteristic of the landscape in Dhanusha. Figure 3.5 shows some scenes in villages across the district. During the rainy season (June to September) heavy rainfalls flood the roads and make transport difficult, but also result in less sanitary living conditions (Figure 3.6). Summers are very hot with temperatures passing 40°C.

Figure 3.5: Village scenes in Dhanusha district (photographs taken by me between April 2018 and January 2019)

Figure 3.6: Flooded roads during the rainy season in Dhanusha district (photos taken by me in August and September 2018)

4 General methods

Summary

In this chapter I start by providing a brief outline of the methods of the original Growth Monitoring Study (GMS, 2012-2014) on which my study builds upon. Following that, I describe in detail the methods used in my follow-up of the GMS cohort conducted in 2018. First, I describe the anthropometric measurement techniques used and how anthropometric measurement error was controlled and assessed. Secondly, I explain the structure of the survey questionnaire and how it was administered. The third part lists the various approvals needed for the study, and ethical or security aspects that had to be considered. A fourth part describes the methods of the isotope calibration sub-study which aimed to develop a prediction equation to calculate total body water from bio-electric impedance analysis measurements. Lastly, I explain some analytical challenges encountered in the analysis of longitudinal data and in studies that aim to determine the effects of labour migration. I then provide an overview of the analytical methods employed by other authors studying the impact of labour migration on families left-behind, and reflect to what extent these are appropriate for my own study.

4.1 The Growth Monitoring Study 2012-2014

The Growth Monitoring Study was designed by Vikas Paudel, Dr Naomi Saville, Professor Anthony Costello, and colleagues at Mother and Infant Research Activities (MIRA). The study protocol was formalised as part of the ethics application to the Nepal Health Research Council but had not been published elsewhere. I had no role in the design or data collection of this study. Vikas Paudel, who was an early career researcher with MIRA, tragically passed away before the work could be written up.

Aim: This Growth Monitoring Study was a prospective cohort study designed to assess the growth trajectory and causes of growth faltering in children under two years in Dhanusha district, located in the plains (*Terai*) of Nepal.

Power and sample size estimation: Investigators aimed for a sample size of n=600. Using the function `pwr.norm.test` from library `pwr` in R (Champely, 2020) I calculated that with this sample size a comparison of two groups of equal size (i.e. 300 per group), under the assumption of normal distributions and equal variances, yields the power to a detect difference equal to or more than 0.162 height-for-age z-scores (HAZ) with power 80% and a 5% significance level. Similarly, a group size of n=200 has a power of 80% at 5% significance level to detect a difference of less or equal to 0.2 HAZ (Table 4.1). Attrition and clustering were not accounted for in the sample size estimation.

Table 4.1: Power calculation for the Growth Monitoring Study using the function `pwr.norm.test` from the R library `pwr` (Champely, 2020). Assuming normal distributions and equal variances between groups.

Sample (per group)	Standard deviation	Significance level	Power	Effect size
175	1	0.05	0.80	0.212
200	1	0.05	0.80	0.200
225	1	0.05	0.80	0.187
250	1	0.05	0.80	0.177
300	1	0.05	0.80	0.162

Recruitment of participants and inclusion criteria: At the time of the study, Dhanusha district had an overall 101 geopolitical units known as Village Development Committees (VDCs), of which 60 VDCs were randomly selected during the MIRA Dhanusha cluster randomised controlled trial that ran from 2005 to 2011 and included prospective identification of all births. Incentivised local women in these randomly selected VDCs informed MIRA data collectors about births in their community. Data collectors would visit the home to measure length and weight of the new-born, and to fill in an enrolment questionnaire containing details about the demographics and socioeconomic situation of the household, antenatal care, mother's health during pregnancy, and new-born health. A baby was recruited into the study if all inclusion criteria were fulfilled: (I) the mother planned to live in one of the 60 study VDCs for the next 12 months, (II) the child was a singleton baby, and (III) the baby was measured within 72 hours of birth. Birth measurements of 697 babies were taken, of which 602 fulfilled all inclusion criteria and were enrolled into the study.

Timeline and measurements: The babies recruited into the study were born between June 3rd and August 26th 2012. The infants' length and weight were measured in 28 day-intervals, and from follow-up three onwards immunisation, deworming and Vitamin A supplementation were assessed. On every third visit data on infant and young child feeding practices, child morbidity, hygiene and care practices, child morbidity and care during illness were collected (Figure 4.1). The data collection was terminated once the child was 24 months of age, so that each child has up to 27 measurements.

Infant weight was measured using the Tanita BD-590 Pediatric Scale (Tanita Corp, Japan) accurate to 10g. The observer placed the scale on a level surface and tared it to zero. The child was placed on the scale without clothes. Measurements were recorded to the nearest 0.01 kg.

Infant length was measured with a ShorrBoard® stadiometer (Maryland, USA) accurate to 1mm. The measuring board was placed on a hard flat surface and the child was carefully placed on the board, while their head was being supported. The assistant, who was usually the ward enumerator who identified births, cupped their hands over the child's ears and placed the child's head against the base of the board so that the child was looking straight up. The child's line of sight was perpendicular to the ground. The observer placed their left hand on the child's shins (above the ankles) or on the knees and pressed them firmly against the board. With their right hand, they placed the foot piece firmly against the child's heels and read the measurement to the nearest 0.1 cm. Both weight and length were measured in duplicate.

All interviews and measurement were conducted in the participants' homes.

Follow Up	Mean age in months	Mean age in days	Length and weight	Household socioeconomic status	Household food insecurity	Details about pregnancy, birth, delivery	General hygiene practices	Sources of household food	Vaccination, deworming, vitamin A	Breastfeeding practices	Complementary feeding practices	Hygiene around feeding practices	Maternal absence	Child morbidity and care during illness
0	0.1	1.6	X	X	X	X				X				
1	1.0	30	X											
2	1.9	58	X				X	X						
3	2.9	87	X							X	X		X	X
4	3.8	115	X						X					
5	4.7	144	X						X					
6	5.7	172	X						X	X	X	X	X	X
7	6.6	200	X						X					
8	7.5	229	X						X					
9	8.4	257	X						X	X	X	X	X	X
10	9.4	285	X						X					
11	10.3	313	X						X					
12	11.2	341	X						X	X	X	X	X	X
13	12.1	369	X						X					
14	13.0	397	X						X					
15	14.0	425	X						X	X	X	X	X	X
16	14.9	453	X						X					
17	15.8	481	X						X					
18	16.7	508	X						X	X	X	X	X	X
19	17.6	536	X						X					
20	18.5	564	X						X					
21	19.4	592	X						X	X	X	X	X	X
22	20.4	619	X						X					
23	21.3	647	X						X					
24	22.2	675	X					X	X	X	X	X	X	X
25	23.0	701	X						X					
26	24.0	730	X						X					

Figure 4.1: Measurements and their timing in the Growth Monitoring Study 2012-2014

Supervision: Fifteen data collectors were supervised by four experienced field coordinators who observed interviews and replicated measurement at regular intervals. On the first three visits, 20% of measurements were replicated and differences between observers were very small. The inter-observer technical error of measurement (TEM), a measure of imprecision between measurements by different observers, was only 0.09 cm or 0.17% (the technical details of TEM are explained below in Chapter 4.2, Reliability: Standardisation of measurements). On subsequent visits, between five and ten percent of measurements were replicated.

Ethical approval: Ethical approval was granted by the Nepal Health Research Council (Reg. no. 95/2013) (see Appendix A. 2).

4.2 The Growth Monitoring Study Follow-up 2018

Design of the follow-up

Using a one-time follow-up design, four trained data collectors searched for all children enrolled in the GMS cohort. Between June 7th and Dec 21st, 2018, they measured all children and mothers in the cohort that could be located and took interviews in their households.

All data collectors had many years of working experience in previous MIRA studies in this area. They were residents of Dhanusha district or adjacent Mahottari district and were fluent in both Nepali and Maithili.

Power calculation

In the original study (2012-2014), between 540 and 460 children were measured at each follow-up, and assuming an attrition of around 15%, I hoped to find between 400 and 450 children at the follow-up in 2018. Using the R function `pwr.norm.test` from library `pwr` (Champely, 2020) and assuming groups of equal size, I calculated that this sample size would provide a power to detect a difference between 0.187 and 0.20 HAZ between children of migrants and children whose parents did not migrate (Table 4.1). Clustering was not accounted for.

Physical measurements

I took measurements of the height and weight of both children and their mothers. The following measurements were only taken of the children: Body circumferences (head, mid-upper arm (MUAC), waist, hip, thigh, calf), skinfold thickness (biceps, triceps, subscapular, supra-iliac), tibia length, bioelectrical impedance analysis (BIA), grip strength.

Measurements techniques

The standard operation procedures (SOPs) for anthropometric measurements, including illustrations, are provided in Appendix A. 3. Below I present an abbreviated description of techniques and equipment. We generally applied the UCL Great Ormond Street Institute of Child Health Standard Operating Procedures (SOPs) based on the techniques described by Lohman, Roche, and Martorell (1988); in case of divergence from the SOPs this has been annotated.

Height: The height of children and mothers was measured with a ShorrBoard® (Maryland, USA) stadiometer. Measurements were taken in duplicate. The participant was asked to take off shoes and hair ornaments. S/he stood straight with feet flat on the floor. Back, shoulder, head, buttocks, and heels touched the backboard of the stadiometer. The head was positioned in horizontal Frankfurt plane. The participant took a breath in and on expiration the headboard was moved down onto the head. The observer read at the height of the headboard to avoid parallax. The measurement was recorded to the last completed 1mm.

Weight: Children <20 kg were weighed using the Tanita BD-590 Pediatric Scale; Mothers and children ≥ 20 kg were measured using the Tanita HS-302 Solar Scale (Tanita Corp, Japan). Measurements were taken in duplicate. Children were asked to change into the panties that we provided as part of our gift set. The observer placed the scale on a level surface and tared it to zero. The participant was asked to stand on the centre of the scale, keep still with hands at the sides, facing forward. Measurements were recorded to the nearest 0.1 kg on the Tanita HS-302 Solar Scale, and to the nearest 0.01 kg on the Tanita BD-590 Paediatric Scale.

Body circumferences: Body circumferences were measured in duplicate and recorded to the nearest 0.1 cm. The Seca 212 head circumference tape was used to measure head, mid-upper-arm, mid-thigh, and calf circumference. For waist and hip circumference an insertion tape was used.

Head circumference: Hair ornaments were removed so that hair could be compressed close to the skull. The participant stood straight with head in Frankfurt plane. The operator placed the insertion tape horizontally around the widest point of the occipital bones and forehead, perpendicular to the long axis of the face.

Mid-upper arm circumference (MUAC): The participant stood straight with left arm at the side and the elbow bent at a 90° angle. The operator identified the depression at the end of the acromion process and located the lateral tip of the acromion process. The operator measured the distance between the acromion process and olecranon process (elbow) and marked the halfway point between these two points. The participant then let the harm hang loosely at the side and the tape was positioned at this point, perpendicular to the long axis of the arm. The tape was pulled tight so that it was in contact with the skin without compression.

Waist circumference: The participant stood straight with abdomen relaxed and arms hanging at the sides and feet together. The operator marked the point 4 cm above the umbilicus[11] (Rudolf et al., 2007). At the end of normal expiration, the operator measured and recorded the waist circumference at this point with the tape horizontal and in contact with the skin without compressing the waist.

Hip circumference: The participant stood straight with arms at the sides and feet together. The operator found the widest girth of the hips, usually at the maximum protruding point of the buttocks around the greater trochanters of the femur. The tape was passed around this point and the operator checks this is horizontal and in close contact with the skin but without compression.

Mid-thigh circumference: The participant stood straight with legs slightly apart and weight evenly distributed over both legs. The measurement was taken on the participant's left side. The operator found the anterior superior iliac spine (ASIS), the bony prominence on the front of the hip bone just below the iliac crest, and the knee joint space, by bending the knee if necessary. The operator measured the distance between ASIS and knee joint space and marked the point halfway between the two anatomical landmarks. At this point, the mid-thigh circumference was measured, with the tape horizontal and in contact with the skin without compressing the thigh.

Calf circumference: The participant stood straight with legs slightly apart and weight evenly distributed over both legs. The measurement was taken on the participant's left side. The tape was positioned around the calf at the point with the widest girth, with

[11] This measuring technique is a divergence from the GOS ICH protocol, which describes the WHO/Lohman method of placing the tape around the narrowest girth as seen from the front. In the trainings it became apparent that it was difficult to reliably locate this point as many children in this population do not have a discernible waist. It was found that the method endorsed in Rudolf, Walker, and Cole (2007) resulted in a better technical error of measurement and was comfortable for participants.

the tape perpendicular to the long axis of the calf and tight enough to be in contact with the skin but not compressing the calf.

Skinfold thickness

Skinfold thickness was always measured in triplicate and on the participant's left side. Before taking measurements, the operator checked that the dial of the calipers (Holtain Limited, UK) started at zero and adjusted if necessary. Once the correct measurement location had been located and marked, the thumb and forefinger of the left hand were used to elevate a fold of skin and subcutaneous fat about 1cm away from the measurement point. The thumb and finger were positioned far enough away from the point of measurement so that the fingers were not compressing the point of measurement and the skinfold was pulled away from the musculature in order to form a fold with almost parallel skin surfaces. The right hand was used to open the calipers and place them over the skinfold perpendicular to the long axis of the fold approximately halfway between the crest of the fold and the body surface.

The location of each skinfold was the following:

Biceps and triceps skinfold: A horizontal line was drawn at the point of the MUAC reading (see above). A perpendicular line was drawn over the humerus on the anterior (biceps) and posterior (triceps) aspect of the arm, making a cross.

Subscapular skinfold: The inferior angle of the lower margin of the scapula was located and a line at 45° to the spine was drawn approximately 1cm below that point. A second line was drawn at a 90° angle from the first one, towards the inferior angle of the scapula, marking the point where the skinfold was grasped infero-laterally.

Supra-iliac: The operator located the top of the iliac crest and marked a cross aligned with the mid-axillar. An oblique skinfold following the natural cleavage line of the skin was grasped just above the cross.

Bioelectrical impedance analysis (BIA): Bioelectrical impedance analysis (BIA) was measured using the Bodystat 500 Touch (Bodystat Ltd, UK). It measures impedance, resistance, reactance and phase angle at 50kHz (single frequency).

Following the manufacturer's instruction, the participant was asked to pass urine and to wash hands and feet, if necessary. To ensure that the fluid levels had stabilized in the body before a measurement is performed, the participant was asked to lay down in the supine position for 3-4 minutes before taking the measurements. The measurements were taken on the child's left hand and foot. Electrodes were placed sideways on the participant so that the non-stick electrode connector point was facing the observer. Electrodes were placed (1) behind the second toe next to the big toe, (2) on the ankle at the level of and between the medial and lateral malleoli (the large protruding bones on the sides of the ankle) (3) behind the knuckle of the middle finger, and (4) on the wrist next to the ulna head. Usually this device uses long electrodes, but since the children's hands and feet were too small, the manufacturer recommended the use of short electrodes. The alligator clips were attached to the non-stick ends of the electrodes, the red clip to the electrode nearest to the finger or toe. Legs and arms were spread out so as to not touch other parts of the body, and it was assured that surrounding spectators did not touch the child. Measurements were taken in triplicate.

Tibia length: The measurement was taken on the participant's left side using a conventional 300mm engineering Vernier caliper. The participant was sitting and asked to bend the left leg and lay the left foot on the right knee. The observer palpated the end of the tibia at the knee joints and ankle joints (below the protruding bones) and marked these points. The caliper was placed at these points and the distance measured in duplicate. We did not use the calipers' digital displays as these broke and showed faulty measurements during the training sessions.

Grip strength: Grip strength was measured using the Takei 540 which measures hand grip strength from 5kg and above. The observer checked that the grip size was appropriate for the child and adjusted it if necessary. The participant was standing up holding the device in the dominant hand and had to squeeze it as hard as possible. The measurement was taken two times and recorded to 0.1 kg.

Anthropometric measurement error

Validity: Measurement techniques and calibration of equipment

Nutritional assessment across a large sample with several anthropometrists requires careful control of measurement error. Measurement error consists of two components: Validity and reliability. Validity, or accuracy, refers to the extent to which measurements depart from the true value. In order to ensure validity, measurement techniques followed the pre-defined standard operating procedures outlined above and detailed in Appendix A. 3. From their previous involvement in similar research studies, the team of data collectors had ample experience in taking height and weight measurements, and to a lesser extent in measuring MUAC. I conducted three days of training in which I taught them the new techniques and we recapped the already familiar ones within the group (Figure 4.2.).

Figure 4.2: First training session in anthropometric measurement techniques in the Janakpur office (03.05.2018).

Another source of inaccuracy is instrument bias, which we aimed to control by using the equipment according to the manufacturers' instructions and through regular equipment checks:

- Stadiometers: The stadiometers were checked using a 1m calibration rod.

- Scales: Scales were checked at regular intervals using standardised weights purchased from a government-approved weight shop in Kathmandu.
- BIA machine: The machines and leads were checked every day following the manufacturer's instruction: The leads are attached to a calibrator and a test is performed. The impedance reading should be between 496 Ω and 503 Ω. If the readings were outside of that range the leads were exchanged with a new pair and the test was repeated.
- Skinfold calipers: Calipers were zeroed before each use. Callipers were checked in regular interval using combinations of six to 12 one Rupee coins.

Reliability: Standardisation of measurements

Reliability, or precision, refers to the extent to which repeated measurements produce the same result. The most commonly used measure of imprecision is the technical error of measurement (TEM), which represents the standard deviation between repeated measurements.

In order to obtain the TEM, a series of repeated measurements on the same individuals is conducted. We can differentiate between intra-observer TEM (degree of imprecision within repeated measurements done by *one* observer) and inter-observer TEM (imprecision between measurements across *several* observers). The equations for inter- and intra-observer TEM are generally the same (Equation 4.1):

$$TEM = \sqrt{\frac{\sum_{i=1}^{N}[(\sum_{k=1}^{K} M_{ik}^2) - ((\sum_{k=1}^{K} M_{ik})^2/K)]}{N(K-1)}}$$

Equation 4.1: Technical error of measurement (inter- OR intra-observer)

Where N is the number of subjects (indexed by i), M_{ik} is the measurement, and K (indexed by k) is either the number of observers (for calculation of inter-observer TEM) or the number of repetitions (for calculation of intra-observer TEM). The unit of TEM is the same as the unit of the anthropometric measurement and the size of the TEM may be positively associated with the size of the measurement in that large mean values of measurement are associated with large TEM and vice versa (Ulijaszek & Kerr, 1999). These characteristics limit the usefulness of TEM for comparisons across measures (e.g., weight vs. height) and populations (e.g., children vs. adults). Such comparisons can be made using the relative TEM (%TEM), calculated as shown in Equation 4.2

$$\% \, TEM = \frac{TEM \times 100}{\mu}$$

Equation 4.2: Relative technical error of measurement (%TEM)

where μ is the mean of measurements. The %TEM is a coefficient of variation, has no units and is expressed as a percentage (Ulijaszek & Kerr, 1999). In order to quantify the overall TEM in a study involving several observers, the inter- and intra- TEMs can be summarised using the total TEM as demonstrated in Equation 4.3.

$$total \, TEM = \sqrt{\frac{\sum_{k=1}^{K} intraTEM_k^2}{K} + interTEM^2}$$

Equation 4.3: Total technical error or measurement (inter- AND intra-observer)

Where K is the number of observers (Ulijaszek & Kerr, 1999). The relative total TEM (% total TEM), calculated as shown in Equation 4.4, can then be used to compare measurement error across studies.

$$\% \, total \, TEM = \frac{total \, TEM \times 100}{\mu}$$

Equation 4.4: Relative total technical error of measurement (% total TEM)

Another widely used measure of precision in anthropometric studies is the coefficient of reliability (R), calculated as shown in Equation 4.5

$$R = 1 - \left(\frac{total \, TEM^2}{\delta^2}\right)$$

Equation 4.5: Coefficient of reliability

where is δ^2 the total variance in the sample (assuming one unique measurement per subject and observer). R ranges from 0 to 1 and quantifies the proportion of between-subject variance in a sample that is free from measurement error (WHO Multicentre Growth Reference Study Group, 2006). A coefficient of reliability R =0.9 means that 90% of the total variability is true variation, while the remaining 10% are due to measurement error.

Using the above equations, an `R` function (Appendix A. 4) was programmed by my supervisor Professor Mario Cortina Borja; I assisted him and checked the correctness of formulas. I used this function to compute the level of precision achieved in our standardisation sessions.

Standardisation sessions were conducted between 24th May and 1st June 2018. Each session involved ten children and every one of them was measured by each of the four data collectors. We had to split each session into two days of five participants because we observed that after some time the children got tired from standing. Halfway through the sessions we furthermore took breaks in which we provided snacks. Children received small gifts (soap, toothbrush and –paste, nail clipper, pencils, sharpener, eraser, notebooks) to thank them for their participation.

Measurements were taken in duplicate except for skinfold thickness which was taken in triplicate. Measurements were repeated right after one another. I aimed to achieve R ≥0.95 for each measurement (Ulijaszek & Kerr, 1999). If the value was lower, further training and subsequently another standardisation session were run. A total of three standardisation sessions were conducted. All measurements except skinfold thickness achieved the desired threshold (Table 4.2). The total TEM for skinfold measurements was very low (0.27-0.46 mm) and far below the reference values suggested by Ulijaszek and Kerr (1999) and those achieved in other studies, as reported in the same publication. The relatively low value of R despite low error levels in terms of TEM is explained by the low variance and low mean values in our population. The children in our sample were all very slim, so that measurement error, even if small, made up a relatively large proportion of the total observed variance in the sample. Final careful examination of each observer's measurement techniques further confirmed my impression that the trainings could be concluded.

Table 4.2: Technical error of measurement (TEM), relative TEM (%TEM) and coefficient of reliability (R) across three standardisation sessions.

	Standardisation 1			Standardisation 2			Standardisation 3		
	TEM	**%TEM**	R	**TEM**	**%TEM**	R	**TEM**	**%TEM**	R
Height	0.44	0.38	1.00	-	-	-	-	-	-
Weight	0.20	1.06	1.00	-	-	-	-	-	-
Tibia	4.09	1.66	0.98	-	-	-	-	-	-
Circumferences									
Head	0.37	0.75	0.91	0.34	0.71	0.85	0.27	0.57	0.97
MUAC	0.23	1.45	0.93	0.22	1.33	0.99	-	-	-
Waist	0.68	1.32	0.93	0.85	1.64	0.97	-	-	-
Hip	0.69	1.22	0.97	-	-	-	-	-	-
Mid-thigh	0.57	1.84	0.93	0.53	1.66	0.98	-	-	-
Calf	0.19	0.88	0.99	-	-	-	-	-	-
Skinfold thickness									
Biceps	1.34	26.50	0.30	0.64	12.72	0.74	0.41	8.43	0.80
Triceps	0.68	11.28	0.87	0.61	10.01	0.82	0.30	5.28	0.92
Subscapular	0.67	13.82	0.71	0.37	7.92	0.56	0.27	5.38	0.80
Suprailiac	0.87	14.95	0.67	0.63	11.04	0.77	0.46	8.62	0.74

Survey questionnaire

Measurement of migration and remittance flows

For the purpose of this study, I defined an international labour migrant as the following: A person who (I) has been living in another country (II) for six months or more, (III) for the purpose of work. I decided to define a minimum duration of migration because growth faltering is a longer-term process and I had to allow for enough time in order to be able to plausibly ascribe potential differences to the exposure to migration. The cut-off of six months was selected in order to be comparable with previous studies (Fellmeth and Rose-Clarke et al. 2018; Gao et al., 2010; Tao et al., 2016; Wickramage, Siriwardhana, Vidanapathirana, et al., 2015). I set the recall period for seven years (i.e. one year before childbirth) because I was only interested in migration which could have plausibly impacted the child.

In order to get a complete account of the history of migration in the household it was important to structure the questionnaire in a systematic way that would aid the respondent's memory. I therefore decided to start the interview with an account of the household composition, asking for the number of people living in the household and how many of them had ever worked overseas in the past seven years (since Baisakh 2068, corresponding to mid-April 2011 in the Gregorian calendar). I additionally asked whether there were any people who would usually be part of this household but who were currently absent because they were working in another country. For the non-migrant family members, I only asked about the general demographic composition, such as the number of men and women, and the age distribution and level of education in each gender-group. For each past and current migrant, I asked about their gender, age, relationship to the study child (father, uncle, etc.), level of education, occupation before going abroad, the problems they encountered overseas, and the number of migration cycles they had had within our recall period. For each cycle of migration, I asked about the year and month of their migration (in the Nepali calendar), the destination, and working sector. Getting a complete account of the financial aspects of migration was particularly important. I asked about the total costs of migration (covering things like broker, visa, medical checks, flight) and how these had been covered. If that cycle of migration had been financed through a loan, I asked about the source of the loan, its duration, interest rates, and whether it had been repaid. I then asked whether the migrant had ever remitted and if yes, which amount in which intervals. If the migrant had not remitted in a regular pattern, I asked the respondent to indicate the lump sum of remittances received. Finally, I asked the respondent what the remittances had been used for.

I included several plausibility checks throughout the questionnaire to assess whether the combination of answers was possible, and the values entered within a credible range. For example, I first asked how many months the migrant had stayed abroad and then the exact month and year when he had left and returned. The questionnaire then calculated whether the duration indicated by the dates matched with the initially indicated migration duration. If the values differed more than two months a notification would pop up and ask the interviewer to check the entered values.

The flow of questions through this part of the questionnaire is visualised in Figure 4.3.

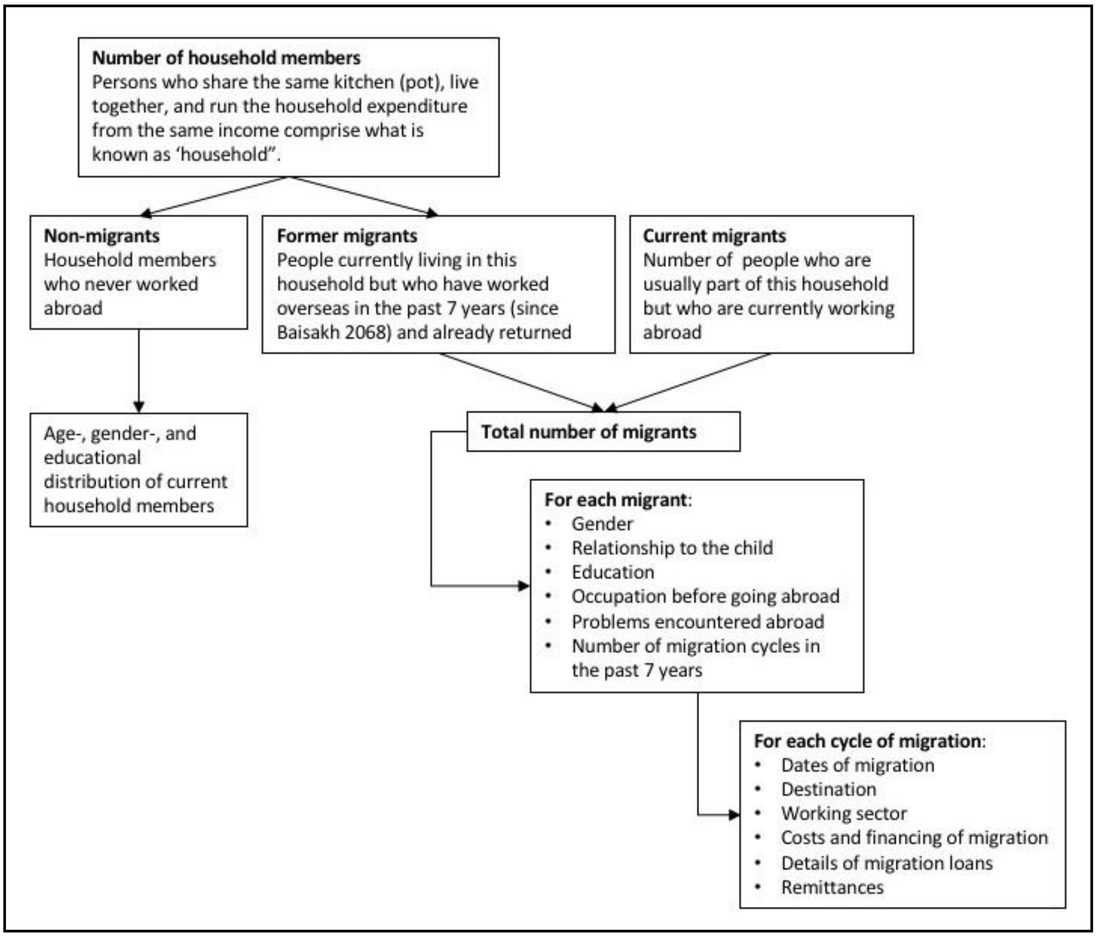


Figure 4.3: Flow of questions for recall of household's migration history

Measurement of mediating and confounding factors

In the conceptual framework in Chapter 1.4, I outlined through which pathways the father's labour migration could have an impact on the nutrition and growth of the child that he leaves behind. Using the three mentioned pathways, financial, father's absence, and social remittances, I list the respective possible mediating factors and how they were operationalised in the questionnaire (Table 4.3).

Table 4.3: Potential mediating factors in the association between father's migration and the left-behind child's nutrition and their implementation in the survey questionnaire.

Mediating factors	Implementation in the survey questionnaire
Financial pathways	
Receipt of remittances	For each cycle of migration, we ask whether the migrant remitted at all, whether that was at regular intervals, what amount they usually sent and whether they sent additional money for special occasions such as festivals
	Receipt of in-kind remittances
Use of remittances	Main use of remittances
	Major expenses over the past 12 months
	Possession of household assets and whether they were purchased through remittances
Indebtedness	Way of funding migration
	Loans taken and interest rates
Agricultural production	Source of staple foods (bought or home produced)
	Practice of subsistence agriculture
	Household food insecurity in access (Coates, Swindale, & Bilinsky, 2007)
	Child 24-hour dietary recall[12]
Absence of migrant	
Maternal mental health	General Health Questionnaire (GHQ12) (Clarke, Saville, Shrestha, et al., 2014)
Maternal and child workload	Estimation of hours spent in the day doing predefined activities
Child morbidity	Fever, cough, diarrhoea
Social remittances	
Knowledge and practices	Hygiene practices
	Childcare during illness

[12] Data on dietary diversity were collected using the open recall method. Data collectors asked interviewees (generally the child's mother) to recall what the child had eaten on the previous day, starting with the first meal. Data collectors then matched the interviewee's accounts with a predefined list of 18 food groups.

Many of the factors that might influence the likelihood of father's migration could also be associated with the growth of his child and introduce bias. In Chapter 1.4 I presented a conceptual framework and explained my assumptions. Table 4.4 lists the identified potential confounders and how they have been operationalised in the questionnaire.

Table 4.4: Potential confounding factors in the association between father's migration and child growth and their implementation in the survey questionnaire.

Potential confounding factor	Implementation in the survey questionnaire
Household food insecurity	Household food insecurity in access (Coates et al., 2007)
Migration of other household members	Included in the household migration history described above
Household socioeconomic status	Ownership of assets for calculation of asset score using principal component analysis[13]
Parental education	Last completed class (available from original study in 2012)

Questionnaire administration

The questionnaire was administered using smartphones (Nokia 2) and the open source data collection software Open Data Kit (ODK) Collect (Hartung et al., 2010) (see Appendix A. 1). User could choose between the languages English, Nepali and Maithili (Figure 4.4). I knew that long questionnaires with complex programming had caused technical difficulties in the field in other studies, especially if phones had limited processing capacity. For this reason, I decided to separate the questionnaire into three parts: In Part I, I collected information about the household composition, migration history, recall of the household's 12 months consumption, ownership of assets and land,

[13] To construct asset scores, I followed the advice provided by UCL colleagues and further guidance by Vyas and Kumaranayake (2006). Briefly, in a first step I pre-selected asset variables that were positively correlated, had few missings, and where the distribution varied across households. Second, I used factor analysis to determine which of the potential assets worked best to form a scale to measure the same concept. Third, I performed principal component analysis to extract the first principal component and predicted an asset score from this.

sources of staple food. The main respondents for Part I were generally the children's mothers (75%) but this section could have also been answered by other household members if the mother was absent or did not know the answers. Often, the main respondent was the mother, but she was assisted by other household members who were more involved in the economic aspects of the household such as remittances and land ownership. In Part II, I asked the mother about the physical home environment and how that had changed since childbirth, household food insecurity, household decision-making, and generally questions concerning the mother (hygiene behaviours, mental health) and child (24-hour recall of food groups consumed, child's school enrolment, morbidity in the two weeks preceding the interview). This part should be answered by the child's mother alone. A third questionnaire was for entering the anthropometric measurements of child and mother.

Separating the questionnaire also allowed me to swap between interviewees or avoid unwanted spectators in Part II which covered sensitive questions, for example about the mother's mental health. Part I covered economic details which mothers were often unable to answer entirely themselves because they were less involved in the household's economic decision-making. This part of the interview was often conducted with the husband (13%) or the mother's parents in-law if the husband was absent (9%). Even if the mother was the main respondent in Part I, the interview was often initially closely observed by other household members – out of interest, but also to oversee the daughter-in-law's responses. Depending on the number of migrants and migration cycles in the household, this part of the interview could take quite long and require the interviewees to remember many details, such as dates and remittances. For this reason, spectators often got bored at this point and left the interview. If the first part of the interview was mainly answered by another household member (husband, parents-in-law), they were often quite happy to leave the second part of the interview to the mother. This meant that we could interview her in relative privacy and also ask her about sensitive issues such as her mental health and her role in household decision-making processes.

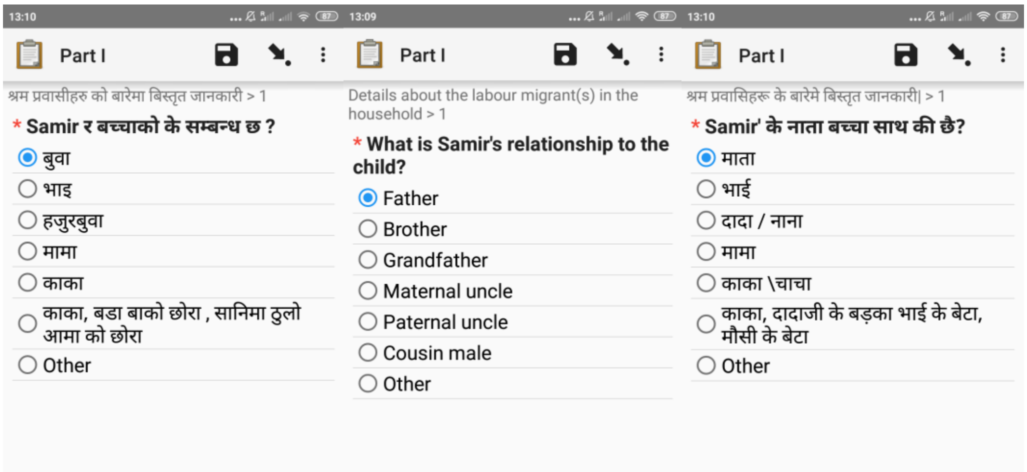


Figure 4.4: Example survey questionnaire in Nepali, English and Maithili, using Open Data Kit software.

Translations, pre-testing and adaptations of the questionnaire

Users could choose between three languages, Nepali, Maithili and English. Many of the questionnaire items had been used in previous studies conducted in this population by UCL Institute for Global Health, so that translations were already available. New items, most importantly the questions concerning migration, were translated to Nepali and Maithili by a translator who had worked in previous MIRA/UCL projects and was recommended.

The team were introduced to an early version of the questionnaire at our first meeting in Janakpur in February 2018. After receiving an introduction to the overall aim of the study and the general structure of the questionnaire, the field team considered each item in detail and received an explanation to why it was asked. We resolved questions and suggestions for improvement by discussion.

The questionnaire was first pre-tested by the field team alone on the 17th to 23rd of April. Difficulties and suggestions for improvement were later shared within the team and solutions identified by discussion. After incorporating the changes into the questionnaire, a second round of tests was conducted on the 3rd and 4th of May, this time under my supervision (Figure 4.5). In both rounds of pre-tests, sampling criteria for pre-testing households were (I) having a child between 4 and 8 years, (II) migration of a household member in the past 7 years, and (III) not being a member of the study cohort.

The team purposively sampled representatives of the general population as well as members of special interest groups such as Dalits, Muslims, and *Pahadis* (originating from the hill regions of Nepal).

Figure 4.5: Team members Shyam Sundar Yadav and Dev Lal Biswakarma discussing the questionnaire during a pre-testing session in Lohana VDC (04.05.2018).

Limitations of the questionnaire

Despite extensive piloting and several rounds of adaptations to the questionnaire, we still observed some limitations during the main data collection. I found three scenarios in which my instrument did not fully capture the migration pattern.

Migration prior to recall period: The recall period was set to seven years so that we did not capture the migration of those who returned before our cut-off date (Baisakh 2068). It is likely that long-term migration prior to the child's birth would have improved the household's economic situation, which in turn would have benefitted the child. This, however, would have been captured in our assessment of the household's wealth at enrolment into the study.

Failed migration: Some of the very unfortunate migrants returned home after less than six months of working abroad, usually because they did not get the expected job or the salary that they had been promised. Since they did not meet the criterion of having been abroad for six months or more, they were not categorized as migrants and we did not collect their migration information, including the loan that they had taken to go abroad and which they then struggled to pay back. I am only aware of one case where this scenario occurred.

Changes in the household composition: The questionnaire asks about the migration history of the members of the current household, but in some households the composition had changed during the child's lifetime. This was usually the case when the father's brother split from the household and moved his family into a home of their own, so that our instrument failed to collect the migration history of the brother who left the joint household. Since we believe this to have been a relatively rare phenomenon and because this research focusses on the impact of paternal migration, we do not believe that this shortcoming could have influenced our results.

Identifying children

A sample list was obtained from the study records. It contained the information with the household's approximate location (Village Development Committee, tole and ward number), the names of the head of the household and the child's mother, the sex of the child and his/her date of birth. The local women who had identified the births in the previous studies were contacted and they helped locate the correct children. Their support was rewarded with NPR 100 for every child they found, and NPR 50 for every household they correctly located, even if the child or mother were temporarily absent or had moved away. Whenever the child and mother had moved to a different home, the remaining household members or neighbours were interviewed about the new location and a 'Transfer Form' was filled in, detailing the new address and a contact number if available. These children were looked for at the end of the data collection period in December 2018.

Study approvals and ethical aspects

Ethical approval

I obtained ethical approval from the UCL Research Ethics Committee (Ethics Application 11345/001) and the Nepal Health Research Council (Reg. no. 13/2018) (see Appendix A. 2).

Approvals from national and regional authorities

From 08th to 18th of April we sought and obtained approval from all 18 newly established municipalities in Dhanusha district (see example in Appendix A. 2). Approval from the Nepal Social Welfare Council was received on June 6th, and we started the data collection on the same day.

Consent from participating households

Consent for study participation was obtained from a parent or, in their absence, another guardian such as a grandparent. An information sheet in either Nepali or Maithili language was handed to the guardian and the project and study procedures were explained orally in their preferred language (Information Sheet and Consent Form in Appendix A. 6). As this was a follow-up of a previous study, guardians were familiar with the procedures and did not have any major concerns. If the guardian could not write, we took written consent by thumbprint.

Data protection and anonymity

Data were saved on password-protected mobile phones, servers, and a data stick. Only anthropometric measurements were recorded on paper forms and these documents were handed over to MIRA in Kathmandu for secure storage.

All names and the location of households were removed from the dataset, and I only used non-identifiable data in my analyses.

Risks for participants

I did not identify any critical risks for participants from taking the children's anthropometric measurements or discussing the household's migration history. There was a possibility that children would get distressed from taking these unfamiliar measurements, especially BIA, but most children were extraordinarily calm and cooperative. In cases where children got scared and for example did not want to lie down and have the BIA cables attached to their hands and feet, one of the children observing the data collection would happily volunteer to demonstrate the procedure and that it is not hurtful or even uncomfortable. This would usually resolve the problem.

Risks for the data collection team and myself

Following UCL regulations, I completed a risk assessment before travelling to Nepal. Identified risks for myself included illness (infections, dehydration), lone working, earthquakes and political unrests. I took precautions to minimise these risks. I only drank bottled or sterilised water, was vaccinated according to recommendations by UCL occupational health services, used insect repellent, avoided the sun as much as possible, took oral rehydration salts, did not stay out alone in Janakpur after dusk, and had an earthquake kit in my home in Kathmandu. There was no political unrest during my stay in Janakpur.

For the data collection team we identified hostility from participants or the community as a potential risk. Since this was a follow-up study and the community was generally aware and supportive of the MIRA/UCL activities, the team was generally greeted welcomingly. In the very remote areas close to the border to India the team was at one point accused of “stealing children to sell them to India”. We resolved this issue by making sure that the team always carried documents that identified them as MIRA staff.

Data management and cleaning

Finalised questionnaires were uploaded from the ODK Collect smartphone application to ODK Aggregate, a password-protected open-source Java application that stores the survey data collected with ODK Collect. I downloaded the collected data at regular intervals and stored them on a password-protected data stick (Datashur®).

The data were downloaded from ODK Aggregate as .csv files and imported into Stata SE 15 for processing. As mentioned above, the questionnaire was separated into three parts: Part I covering the household migration history, Part II about the home environment and questions relating to the study child, and the part containing anthropometric data. In order to record the migration history in Part I, I used question “loops” that repeated themselves for every migrant and for every migration cycle per migrant. As a result, questionnaire Part I produced three datasets containing information about each (A) household, (B) each migrant in the household, (C) each migration cycle per migrant. Table 4.5 gives an overview of the datasets resulting from each questionnaire.

Table 4.5: Datasets resulting from the ODK questionnaire

Questionnaire	Dataset	Applicable households	Information	Format
Part I	Part I A - General household information	All households	Household composition Number of migrants Recall of the household's 12 months consumption Ownership of assets and land Sources of staple food	One row per household
Part I	Part I B - Migrants	Migrant households only	Gender Relationship to the child Education Occupation before going abroad Problems encountered abroad Number of migration cycles in the past 7 years	One row per migrant
Part I	Part I C - Migration cycles	Migrant households only	Dates of migration Destination Working sector Costs and financing of migration Details of migration loans Remittances	One row per migration cycle
Part II	Part II	All households	Physical home environment Household food insecurity Household decision-making	One row per household

Questionnaire	Dataset	Applicable households	Information	Format
			Questions concerning the mother and child	
Anthropometry	Anthropometry	All households	Anthropometric measurements of mother and child	One row per household

In order to bring the separate datasets into a usable format I proceeded with the following steps:

1. Reshape migration cycle dataset (Part I C) wide to have one row per migrant.
2. Merge the resulting wide migration cycle dataset with Migrants dataset (Part I B).
3. Summarise migration cycles for each migrant and drop redundant variables.
4. Reshape Migrants dataset wide to have one row per household.
5. Summarise migration history in each household and drop redundant variables.
6. Merge the resulting wide household migration dataset with general household dataset (Part I A).
7. Merge resulting Part I dataset with Part II and Anthropometry datasets.

At each step I checked the plausibility of entries throughout the data collection and again after completion of the fieldwork. For continuous variables I checked for outliers using histograms. I made notes regarding extreme values and asked the team at the next meeting whether these were correct and if not, what they should be. In the case of anthropometric measurements, we could also resort to the paper sheets and compare whether a mistake had been made when the values were entered into the phone. Anthropometric measurements were taken in duplicate or triplicate and I compared whether the recorded values were consistent by calculating their standard deviation. I made all corrections in a Stata `.do` -file.

Isotope calibration sub-study

Background and aims

Almost all countries, including Nepal (Ministry of Health and Population [Nepal] et al., 2017), have simultaneously experienced an increase in the prevalence of overweight and obesity, which is a risk factor for many non-communicable diseases such as type 2 diabetes and cardiovascular disease (Swinburn et al., 2011). A double burden of overweight and stunting in children has been observed in many Low and Middle Income Countries (LMICs) (Fernald & Neufeld, 2007; Keino, Plasqui, Ettyang, & Van Den Borne, 2014; Popkin, Richards, & Montiero, 1996) and overweight children tend to grow into overweight adults (A. S. Singh, Mulder, Twisk, Van Mechelen, & Chinapaw, 2008). Most research studying the risks factors and consequences of overweight and obesity uses body mass index (BMI, body weight/height^2) as the indicator of body fatness, as both constituents are relatively easy to measure. Since BMI correlates not only with fat mass but also lean mass, and a given BMI can comprise a wide range of body fat (J. C. K. Wells, 2000), it is a poor indicator of fatness.

The most frequently used model of body composition is the two-component model which divides the body into fat mass (FM) and lean mass (LM). Body water makes up the largest proportion of LM, but the level of hydration depends on the individual's age (J. C. K. Wells et al., 2010). With estimates of total body water (TBW) and hydration, LM can be calculated. FM is the difference between total body weight and LM.

Deuterium dilution is the gold-standard for estimating total body water, but it is time consuming, expensive, requires very specialised equipment and is therefore less suitable for population-based studies and research in low-resource settings. Bioelectrical impedance analysis (BIA) constitutes a portable, simple to use and non-invasive method of measuring body composition. The prediction of TBW from BIA measurements, however, requires specific prediction equations for the respective population due to differences in body geometry, specifically variability in limb segment girths, and differences in the ratios of segments to trunk. Most prediction equations built into BIA machines are derived from white European populations with poor validity in other ethnic populations (Haroun et al., 2010). The main aim of this sub-study was to calibrate the Bodystat 500 Touch by estimating total body water using deuterium oxide in a sub-sample of children in the GMS cohort. The full protocol for data collection in the isotope sub-study can be found in Appendix A. 5.

Selection of participants

The isotope calibration study was conducted over one month after the main data collection had been completed. We aimed to sample 60 children (30 girls), equally distributed over the range of weights observed in our population (10.9 - 26.0kg). Children were purposively selected from the main study cohort and were all six years old.

Preparation of doses

Deuterium doses and other equipment were prepared in the office in Janakpur. I used 0.07g of stock deuterium oxide (~ 99.9%) per kg of the child's body weight, which was obtained from the records of the main data collection. For example: 1.19g deuterium oxide for a child weighing 17 kg. Fifty grams (50g) of water was added to the deuterium. The dosing bottle and a straw were put into a resealable plastic bag and weighed using a Sartorius TE212 (Sartorius AG, Germany) accurate to 0.01g. The cotton buds in the salivettes were cut in half because the children found it difficult to handle the relatively large piece of cotton as a whole. The dosing bottle and salivettes were pre-labelled with the child's ID number.

Figure 4.6: Preparation of deuterium doses.

Collection of samples

The selected children were visited in their homes. The data collector (SSY) explained the procedures to the mother or guardian and took her/his consent. We asked the family when the child last ate or drank anything. If it had been less than half an hour, he waited before taking the first sample. To collect the saliva sample, the child was advised to first collect saliva in his/her mouth and then take half a cotton bud, roll it around in the mouth for one to two minutes until it was fully soaked in saliva (Figure 4.7, right picture). The soaked bud was then put back in the salivette and the procedure was repeated with the second half of the cotton bud.

The child was then asked to drink the deuterium dose through the straw while the bottle was kept in the bag to catch possible spillage (Figure 4.7, left picture). When the child was finished the straw was put into the bottle, the bottle closed, and the bag sealed. Back in the office the weight of the empty bag was recorded.

Figure 4.7: Administration of deuterium dose (left) and collection of saliva sample (right).

A pre-weighed one litre drinking bottle with water was handed to the family and they were instructed to only let the child drink from this bottle until our return four hours later. We also provided a small carton (200ml) of fruit juice as an incentive for the child and recorded whether s/he drank it.

The data collector returned to the household four hours later. Upon arrival he would ask the family when the child last ate or drank anything and would wait for up to half an hour before collecting the second saliva sample or taking the BIA measurements. He asked the family to return the drinking bottle and weighed it using the Tanita BD-590 Pediatric Scale accurate to 0.01kg to determine the amount of water that the child had drunk during the four-hour waiting period. To thank the child for his/her participation, we gifted a pair of sweatpants and a long-sleeved shirt of known weights and asked the child to change into these clothes. This allowed us to control possible inaccuracies arising from differences in the children’s clothes. The data collector then took measurements of the child’s weight, height and BIA. Lastly, a second saliva sample was taken following the same procedure as for the first one. A detailed protocol is provided in Appendix A. 5.

Sample analysis

Samples were stored in a fridge in the project office in Janakpur until completion of the data collection. In Kathmandu, before bringing them to London, the salivettes were spun in a centrifuge rented at a local laboratory and the resulting saliva samples stored in a freezer.

The samples were analysed at the UCL Great Ormond Street Institute of Child Health. Isotopic enrichment of the samples was estimated using continuous flow isotope ratio mass spectrometry (IRMS), using Delta XP instrumentation (Thermo Fisher Scientific). Each sample was pipetted into Exetainer tubes and an aluminium rod with 5% platinum was added. The tubes were sealed, filled with hydrogen and left to equilibrate. All samples were analysed in duplicate and measured against five reference standards.

My own contribution in the analysis was the following: I diluted the deuterium doses and prepared all samples for analysis. The analysis itself was done by Dr Simon Eaton at the UCL Great Ormond Street Institute of Child Health.

Total body water (TBW) and lean mass (LM) estimation

Using the results from IRMS analysis I calculated total body water (TBW) as shown in Equation 4.6.

$$TBW\ (kg) = \frac{\frac{A * T}{a} \times \frac{(Ed - Et)}{(Es - Ep)}}{1000 \times 1.044} - W$$

Equation 4.6: Total body water (TBW)

Where A is the mass of the isotope drink (dose) given to the child, a is the amount of isotope drink diluted for analysis in the IRMS, T is the amount of diluent water used to dilute a. Average Isotope enrichment E is expressed in delta (δ) units. Ed is the average dose enrichment, Et is the average diluent water enrichment, Es is the average post-dose enrichment, Ep is the average pre-dose enrichment. The correction factor 1.044 accounts for hydrogen ion exchange and 1000 transforms from g to kg. W is the amount of water (in kg) that the child drank in the four-hour equilibration period.

Lean mass (LM) consists mostly of water, but the exact hydration levels vary by sex, age and nutritional status. Since the BMI-specific hydration factors established by Gutiérrez-Marín et al. (2019) mostly differentiate BMI-levels at the higher end of the range and the children in my sample are mostly (very) thin or normal weight, I decided to use the hydration factors which only differentiate by age and sex as established by Wells et al. (2010) for children between 6 and 8 years. The hydration factors used were 0.761 for boys and 0.753 for girls. Equation 4.7 shows the equation used to calculate LM.

$$LM = \frac{TBW}{hydration\ factor}$$

Equation 4.7: Lean mass (LM)

Data cleaning

I excluded children with a phase angle > 6.5 or TBW< 5 litres as these are likely implausible and due to measurement error. I additionally used boxplots and scatterplots to detect outlying values.

Description of analytical sample

Sixty-three children were enrolled in the study. One child had a learning disability and was unable to provide a sample or drink the deuterium dose, so we could not complete the data collection. Two children had a phase angle > 6.5 and three children had TBW< 5 litres. I additionally excluded three children with very unlikely body composition results (e.g., extremely low FM relative to body weight) that were likely due to contaminations in the isotope sample collection. Table 4.6 shows characteristics of the 54 children included in the analysis.

Table 4.6: Description of sample in the isotope sub-study

	Boys *n*=27	Girls *n*=27
Age (months) (median, IQR)	78.8 (78.0-79.3)	79.0 (77.9-79.8)
Height (cm) (mean, SD)	109.8 (6.5)	107.5 (7.2)
Weight (kg) (median, IQR)	15.9 (14.9-18.9)	16.5 (14.3-17.3)
Height-for-age *z*-score (mean, SD)	-1.8 (1.3)	-2.0 (1.3)
Stunting (*n*, %)	14 (52%)	15 (56%)
Body mass-index (kg/m^2) (median, IQR)	13.8 (12.9-14.9)	13.9 (13.1-14.7)
Total body water (l) (mean, SD)	10.8 (1.9)	10.0 (1.5)
Lean mass (kg) (mean, SD)	14.2 (2.5)	13.3 (2.1)
Lean mass index (kg/m^2) (mean, SD)	11.7 (1.3)	11.5 (1.0)
Fat mass (kg) (median, IQR)	2.6 (2.1-3.6)	3.1 (2.2-4.0)
Fat mass index (kg/m^2) (mean, SD)	2.4 (1.0)	2.5 (0.9)

Prediction equations for lean mass and total body water

Prediction of total body water from BIA relies on the assumption that the body is a cylinder-shaped conductor and the conduction material is water. The volume can be calculated using Equation 4.8 (Kushner, 1992)

$$V = \rho \times \frac{l^2}{Z}$$

Equation 4.8: Prediction of body volume from impedance

where V is the volume (cm^3), ρ = specific resistivity (ohm-cm), Z = impedance (ohm), l is the length of the conductor.

The prediction equations for LM and TBW were generated by performing a linear regression with LM or TBW as the dependent variable and impedance index (height^2/impedance) as the independent variable.

The resulting prediction equations were:

LM = 2.730 + 0.788 m^2/Z

Coefficient of determination (R^2) = 0.80, root-mean-square error ($RMSE$) = 1.04

TBW = 2.014 + 0.600 m^2/Z

R^2 = 0.80, $RMSE$ = 0.80

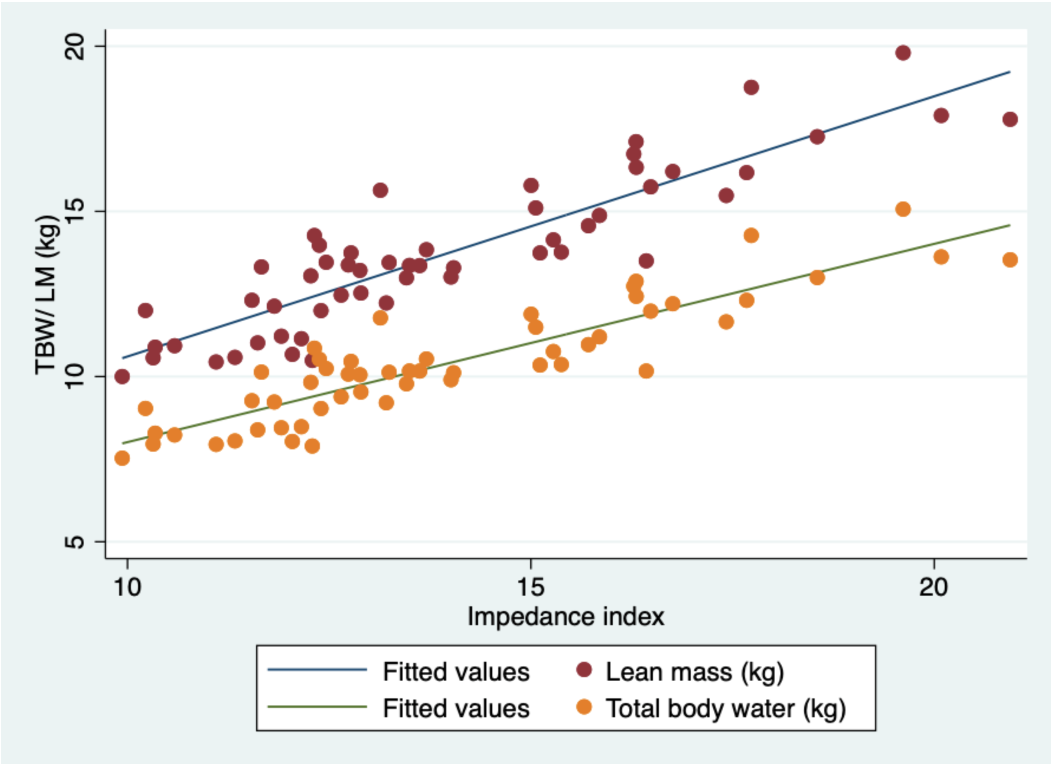


Figure 4.8: Scatter plot with regression line for lean mass and total body water from impedance index (height squared/impedance)

Comparison with selected prediction equations from other validation studies in Asian children

Table 4.7 lists prediction equations for TBW and LM from two other studies in Asian populations (Devakumar et al., 2015; Haroun et al., 2010). The sample sizes in these studies were considerably larger than in my own, but the goodness of fit of my prediction equation (R^2 = 0.80) is nevertheless satisfactory and comparable to these larger studies. The study by Haroun et al. (2010) was done in adolescent children who are much older than those in my population and therefore the resulting prediction equation could not have been used. The study by Devakumar et al. (2015) was done in the same geographical area of Nepal, but in slightly older children and using a different BIA machine (Tanita BC-418) that takes measurements in a standing position rather than lying down, which is why I deemed it unsuitable for my study.

Other validation studies in Asian children are not listed here because they reported prediction equations with additional predictors, most commonly weight and sex, because they improve the model's goodness of fit (see for example Liu et al., 2011; Wickramasinghe, Lamabadusuriya, Cleghorn, & Davies, 2008). In my study, child sex did not improve the model. Child weight would have improved the model fit but I decided not to include it in the end for two reasons: Firstly, weight correlates with the impedance index and would have caused multicollinearity. Secondly, I did not want to include in a prediction of LM a factor that also correlates with fat mass.

Table 4.7: Prediction equations from other validation studies in Asian populations

Study	Outcome	Ethnicity	Gender	Age (years) Mean (SD)	*n*	Equation	Goodness of fit
Haroun et al. (2010)	TBW	South Asian	Boys	13.3 (1.2)	79	0.522 + 0.640 ht^2/Z	R^2=0.94
	TBW	South Asian	Girls	13.4 (1.3)	91	1.475 + 0.640 ht^2/Z	R^2=0.82
Devakumar et al. (2015)	TBW	South Asian (Nepal)	Boys and girls	Boys: 8.7 (0.6) Girls: 8.6 (0.6)	Boys: 50 Girls: 52	0.7146 + 1.5959 ht^2/Z	RMSE = 0.781, R^2 = 0.92
	LM	South Asian (Nepal)	Boys and girls	Boys: 8.7 (0.6) Girls: 8.6 (0.6)	Boys: 50 Girls: 52	2.2022 + 0.9406 ht^2/Z	RMSE = 1.053, R^2 = 0.91

4.3 Analytical considerations

Dealing with longitudinal data

The GMS is a longitudinal study meaning that the same measurements are repeated on the same subjects over time. Longitudinal designs are necessary to study the within-subject change in a response variable in relation to one or more influencing factors, but the analysis of longitudinal data poses several challenges. Firstly, longitudinal data are clustered within individuals and clustered observations typically present with positive correlation which must be accounted for in the analysis (Fitzmaurice, Laird, & Ware, 2011). Secondly, longitudinal data have a temporal order which also has implications for the analysis. Thirdly, although measurements are scheduled for the same time points across all participants, it is in practice inevitable that some fraction of the participants delays the measurement or misses it altogether. When measurements are not taken at a common set of time points, the resulting data is called "unbalanced" and if there is some missingness the data is referred to as being "incomplete" (Fitzmaurice et al., 2011, p. 23f.).

Mixed-effects models are suitable in dealing with the above characteristics of longitudinal data. This class of models accounts for the natural heterogeneity in the population by letting certain parameters in the regression vary randomly between individuals. This allows individuals in the cohort to have their own trajectory. The distinctive characteristic of mixed-effects models is that they model the mean population effects that are shared across the cohort (the *fixed* effects) and subject-specific-effects that are unique to individuals (the *random* effects). Of primary interest are the population specific fixed effects.

The simplest version of a mixed-effects model is a random intercept model where the intercept is allowed to vary randomly by individual. This yields the following equation

$$\Upsilon_{ij} = \beta_1 \mathrm{X}_{ij1} + \beta_2 \mathrm{X}_{ij2} + \cdots + \beta_p \mathrm{X}_{ijp} + b_i + e_{ij}$$

Equation 4.9: Linear mixed-effects model with random intercept (Fitzmaurice et al., 2011, p. 191)

Where the response Υ for the i^{th} subject at j^{th}occasion is assumed to differ from the population mean β_1 by an individual random effect b_i, and with within-subject error e_{ij}.

This error term is assumed to be normally distributed with mean 0 and variance σ_e^2. X denotes a covariate. The random effects terms b are assumed to be normally distributed with mean 0 and variance σ_u^2. Where appropriate, additional covariates can be allowed to vary randomly leading to more complex models.

Estimating the causal effect of migration on families

As with all observational research that attempts to determine causal effects, the study of the effects of migration is complicated by the fact that migration is not random. Households and individuals carefully self-select into labour migration and the factors that lead to the decision to migrate are likely associated with the outcome. This makes it difficult to determine whether migration itself causes the outcome of interest or whether it is an unobserved variable that is associated with both migration and the outcome (Antman, 2013). For example, very poor or very rich households may not choose to send one of their members overseas for work because in the case of the former, they may not be able to afford it, or in the case of the latter, they do not need to take the risk of sending one of their members away to an unknown future that may involve living and working under degrading circumstances. Socio-economic status, in turn, has been shown to be associated with risk of child stunting (Devakumar et al., 2017; MAL-ED Network Investigators, 2017). In epidemiology, this constellation is known as confounding (Hernán & Robins, 2020). In the econometrics literature, which dominates much of the migration research, this is described as omitted variable problem which leads to endogeneity. Endogeneity is a situation when the independent variable is associated with the error term (Azzarri & Zezza, 2011), a violation of the assumptions of linear regression (Casson & Farmer, 2014).

Different analytical strategies have been used to deal with this problem. Many researchers from the field of econometrics apply instrumental variable estimators to study the effects of migration and children and families left behind. An instrument has to be associated with the independent variables but must not be associated with the dependent variable (Azzarri & Zezza, 2011). Finding an instrument that only affects the dependent variable through its effect on the independent variable is a difficult task and the validity of the instrument ultimately cannot be tested (Antman, 2011). Instruments that have been used in past studies are migration networks or proxies thereof (Alcaraz, Chiquiar, & Salcedo, 2012; Chezum et al., 2018; Davis & Brazil, 2016; Kan, 2020; Maharjan et al., 2013), economic conditions in remittance-sending countries such as earnings, unemployment rate and real interest rate (Amuedo-Dorantes, Georges, & Pozo, 2008; Azizi, 2018), conditions in the home region such as distance from the household to the capital city and mortality rate (Kakhkharov, Ahunov, Parpiev, & Wolfson, 2020).

Another set of strategies is based on the assumption that there is a set of observed variables that sufficiently adjusts for confounding, for example propensity score matching (see for example Romano & Traverso, 2019; Sun & Liang, 2021) or adjusting in regression analysis (Ban et al., 2017; Gao et al., 2010). The problem of such strategies is that they cannot control for potential unobserved confounders. Econometricians commonly use so-called fixed-effects models, sometimes also referred to as "unobserved effects models" (Imlach Gunasekara, Richardson, Carter, & Blakely, 2014) to overcome this problem in scenarios where observations are clustered within families (Antman, 2012) or individuals with repeated measurements (i.e. longitudinal data) (de Brauw & Mu, 2011; Mu & de Brauw, 2015; C. V. Nguyen, 2016). Fixed-effects models in the econometric sense are not to be confused with fixed effects as used in mixed-effects models where they denote mean population effects (see section above). Fixed-effects models are very similar to the mixed-effects models described above but assume that there are time-invariant characteristics within clusters that are otherwise not accounted for by the inclusion of the time-invariant covariates in the model (Fitzmaurice et al., 2011, p. 243). Their ability to control for unobserved time-invariant confounders make fixed-effects models a popular choice. However, there are three limitations of fixed effects models that may make mixed-effects models the preferred option in certain cases: Firstly, fixed-effects models can only estimate the effect of time-varying covariates, but not constant covariates. Mixed-effect models can provide estimates of both time-varying and constant covariates. Secondly, unlike mixed-effects models that combine variation within and between individuals, fixed-effects models only use within-individual variation (Imlach Gunasekara et al., 2014). The benefit of reduced bias in fixed-effects models comes at the price of efficiency and estimates will generally yield larger standard errors compared to mixed-effects models (Fitzmaurice et al., 2011, p.

246). Thirdly, fixed-effects models are only helpful in scenarios where time-variant confounders are deemed unlikely. If for example a natural disaster ruined the harvest, this could both incentivise the family to send one of their members abroad, and at the same time increase the child's risk of undernutrition. In such circumstances, fixed-effects models cannot account for these confounders, but will also produce biased estimates.

For the present study I could not identify a valid instrument and therefore did not pursue this analytical approach. The fixed-effects model (or unobserved effects model) with its ability to control for unobserved time-invariant confounders is an interesting option, but I decided not to use it for two reasons. Firstly, its reliance on only within-individual variation results in less precise estimates compared to mixed-effects models which additionally use between-individual variation. Secondly, I am not familiar with such models from the field of econometrics and do not know anyone who has experience with them. I therefore decided to use mixed-effects models which I am more familiar with. I rely on directed acyclic graphs (DAGs) to identify both time-variant and constant potential confounders and adjust for them in my regressions analyses.

5 Results

Summary

In this chapter I present the results of the original Growth Monitoring Study (GMS, 2012-2014) and my follow-up conducted in 2018 as follows:

1. Description of the follow-up rates at each survey and the reasons for loss to follow-up at my data collection in 2018.
2. Description of family characteristics and changes in the home environment between 2012 and 2018.
3. Characterisation of the children's growth in the GMS from birth to two years using *z*-scores and description of the children's nutritional status in 2018.
4. Description of children's body composition and other growth outcomes in 2018.
5. Assessment of the extent to which families adhered to recommended infant feeding practices in the first two years of life, and description of dietary composition in 2018.
6. Description of the burden of morbidity in the GMS and how children were taken care of in case of sickness.
7. Characterisation of the mothers' absence from home due to work and care arrangements for the baby during her absence from birth to two years.
8. Portrayal of the families' migration history in the seven-year recall period.

5.1 Flow of participants

Six hundred and two children were enrolled into the Growth Monitoring Study (GMS) between June 5th and August 26th, 2012. Girls made up 48% (*n*=288) of the sample. The sample size at birth (follow-up 0) is 601 because the anthropometric measurements for one baby are missing. Follow-up rates ranged between 90% and 81% for most of the study but fell to 50% at follow-up 25 at 23 months of age. Table 5.1 lists the follow-up rates and ages at measurement in the GMS cohort 2012-2014 and 2018. Five children died within the first two years of life. At the 2018 follow-up, 529 children (89% of the 597 that were still alive at the end of the original study) were found and included in the survey. Sixty-eight children were lost to follow-up, mostly because their families had moved away (Table 5.2). I compared households' baseline information by follow-up status and found that mothers from households that were lost to follow-up had higher education, but found no differences by caste, religion, ethnic group, asset score, father's education, food insecurity, maternal age, or parity.

Table 5.1: Follow-up rates and ages at measurement in the Growth Monitoring Study cohort 2012- 2018

Follow-up	*n*	Follow-up rate	Median child age	Range child age (months)
0	601	99.8%	0.1	0.0 - 0.1
1	544	90.4%	1.0	0.9 - 1.2
2	517	85.9%	1.9	1.7 - 2.2
3	496	82.4%	2.8	2.7 - 3.1
4	511	84.9%	3.8	3.4 - 4.0
5	499	82.9%	4.7	4.1 - 5.4
6	533	88.5%	5.6	5.3 - 5.9
7	532	88.4%	6.6	6.0 - 6.9
8	512	85.0%	7.5	6.9 - 7.8
9	509	84.6%	8.4	7.8 - 8.7
10	521	86.5%	9.4	8.7 - 9.6
11	523	86.9%	10.3	9.7 - 10.5
12	506	84.1%	11.2	10.6 - 11.6
13	510	84.7%	12.1	11.5 - 12.4
14	516	85.7%	13.1	12.4 - 13.4
15	506	84.1%	14.0	13.3 - 14.2
16	510	84.7%	14.9	14.3 - 15.2
17	517	85.9%	15.8	15.2 - 16.2
18	511	84.9%	16.8	16.1 - 17.0
19	512	85.0%	17.7	17.0 - 18.1
20	517	85.9%	18.6	17.9 - 18.9
21	515	85.5%	19.5	18.9 - 20.0
22	488	81.1%	20.4	19.7 - 20.7
23	465	77.2%	21.3	20.7 - 21.7
24	493	81.9%	22.3	21.6 - 22.6
25	304	50.5%	23.1	22.5 - 23.7
26	387	64.3%	24.0	23.5 - 24.3
2018	529	88.6%	73.5	78.2 - 79.8

Table 5.2: Reason for loss to follow-up in the 2018 survey

Reason for loss to follow-up	*n*
Moved within the district	24
Moved outside of district	14
Moved to India	9
Child died within the first two years (2012-2014)	5
Child died between 2014 and 2018	5
Family withdrew consent	2
Unknown reason/child or household not found	7
Child temporarily absent	7
Total	**73**

In this area of Nepal, season has been shown to be associated with maternal and newborn anthropometry, dietary diversity and eating behaviours in pregnancy (Saville et al., 2021). Seasonality is therefore an important factor to consider in the context of child undernutrition. Figure 5.1 shows the season of measurement in the GMS 2012 to 2014. The follow-up in 2018 was conducted between June 7th and Dec 21st, 2018. Most children were measured during Monsoon (52%) and Autumn (41%), and to much lesser extent in Spring (5%) and Winter (2%).

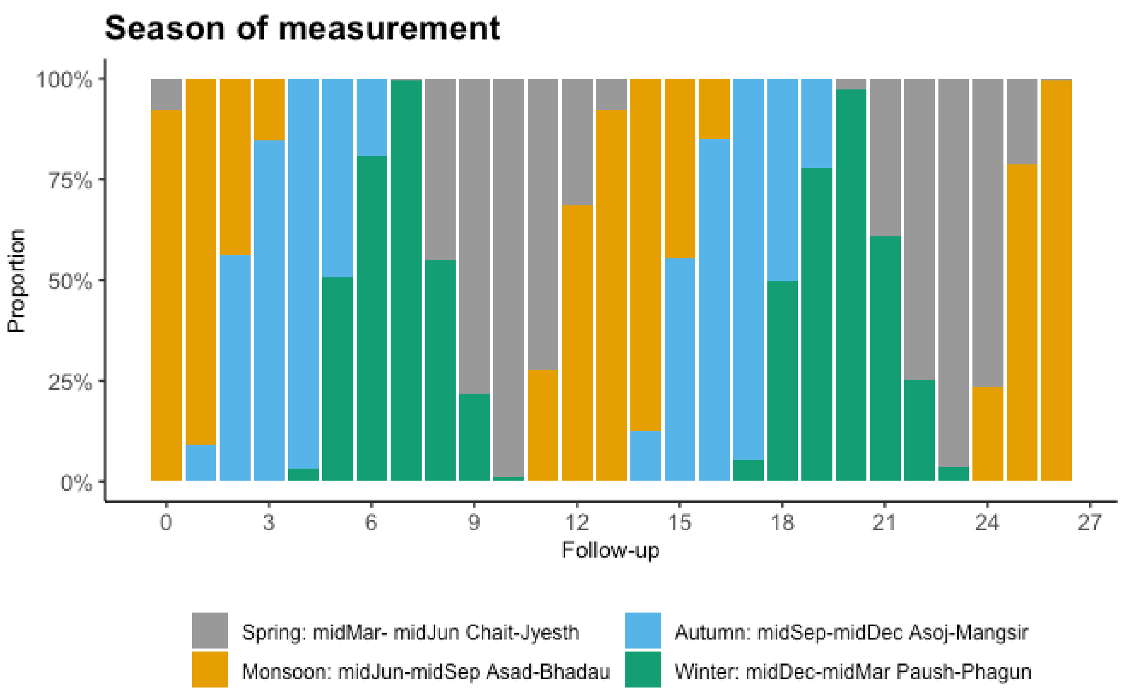


Figure 5.1: Season of measurement in the Growth Monitoring Study 2012-2014.

5.2 Family and home environment

Table 5.3 gives information on participants' family background at baseline. One in five children were from a Dalit household. The vast majority of households were Hindu (86%, *n*=518) and belonged to the *Madheshi* ethnic group (97%, *n*=583). Most of the mothers had no formal education (70%, *n*=422) and one in five had some level of secondary education. Levels of education among fathers were better, but nevertheless 43% (*n*=257) had no formal education.

Table 5.3: Family factors in the Growth Monitoring Study Cohort (*n*=602)

Indicator	% (*n*)
Caste	
Dalit	20% (123)
Muslim	13% (77)
Janajati	6% (34)
Other Terai (plains) castes	31% (185)
Sah/Sudi/Teli	10% (58)
Yadav	19% (112)
Brahmin/Chettri	2% (13)
Religion	
Hindu	86% (518)
Muslim	13% (77)
Buddhist	1% (7)
Ethnic group	
Pahadi	3% (19)
Madheshi	97% (583)
Mother's education	
None	70% (422)
Primary (1-5 years of schooling)	8% (46)
Secondary (6-12 years of schooling)	22% (131)
College (≥13 years of schooling)	0% (1)
Father's education	
None	43% (257)
Primary (1-5 years of schooling)	15% (93)
Secondary (6-12 years of schooling)	39% (237)
College (≥13 years of schooling)	2% (14)
Number of older siblings, median (IQR)	1 (0-3)

Mothers' characteristics are presented in Table 5.4. Most mothers (64%, *n*=388) were aged 20 to 29 years at the time of the study child's birth. One in five mothers were still an adolescent aged less than 20 years and the youngest mother was only 13 years old. One quarter of mothers were primiparous and 12% (*n*=70) had less than 12 months between their previous child's birth and getting pregnant again with the study child. Maternal weight and height were only measured at the 2018 follow-up. At that time, 21% (*n*=106) of mothers were underweight with a body-mass-index (BMI) of <18.5, whereas 13% (*n*=64) were overweight or obese with a BMI ≥25.0. Maternal short stature with a height <145cm was more prevalent in the GMS (14%, *n*=76) than at national level (11%) (Ministry of Health and Population [Nepal] et al., 2017).

Table 5.4: Maternal factors in the Growth Monitoring Study (*n*=602)

Maternal factors	***% (n)***
Mother's age at time of child's birth	
≤19 years	20% (123)
20-29 years	64% (388)
30-39 years	14% (84)
≥40 years	1% (7)
Number of live or stillborn children	
1 child	28% (171)
2 children	26% (155)
3 children	20% (118)
4 children	13% (79)
≥ 5 children	13% (79)
Birth-to-pregnancy-interval before study child	
primigravida	26% (159)
<12 months	12% (70)
12-23 months	18% (111)
24-35 months	12% (73)
≥ 36 months	17% (105)
Previous child's date of birth unknown	14% (84)
Maternal BMI (non-pregnant mothers) in 2018 (*n*=499), median (IQR)	21 (19-23)
Maternal BMI categories (non-pregnant mothers) in 2018 (*n*=499)	
Underweight	21% (106)
Normal weight	66% (329)
Overweight/ obese	13% (64)
Maternal height in 2018 (*n*=525), mean (SD) (cm)	151 (5)
Maternal short stature (<145cm) in 2018 (*n*=525)	14% (76)

The physical home environment changed between study inception in 2012 and the 2018 follow-up (Figure 5.2). The proportion of houses with cement and brick walls increased from 25% to 47%. In 2018, 31% of homes had a cement floor compared to only 9% in 2012. Solid fuel use also decreased from 98% to 82%.

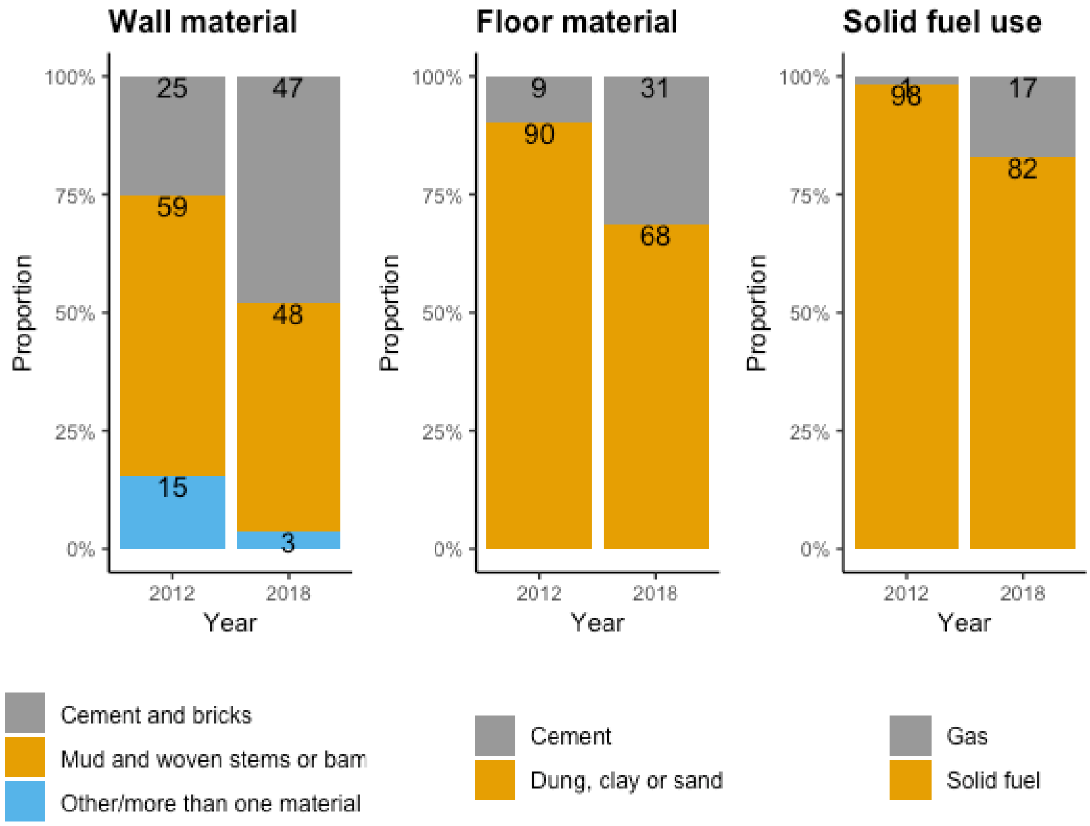


Figure 5.2: Physical home environment in the Growth Monitoring Study 2012 and 2018

A dramatic change can be observed in the prevalence of open defecation. In 2012, 75% of households reported that they resorted to open defecation but this proportion more than halved to 32% in 2018. The use of soap for handwashing increased dramatically from 47% to 86% (Figure 5.3). Household food insecurity was assessed using the household food insecurity in access category (Coates et al., 2007). Levels of food insecurity did not change between 2012 and 2018 (Figure 5.4).

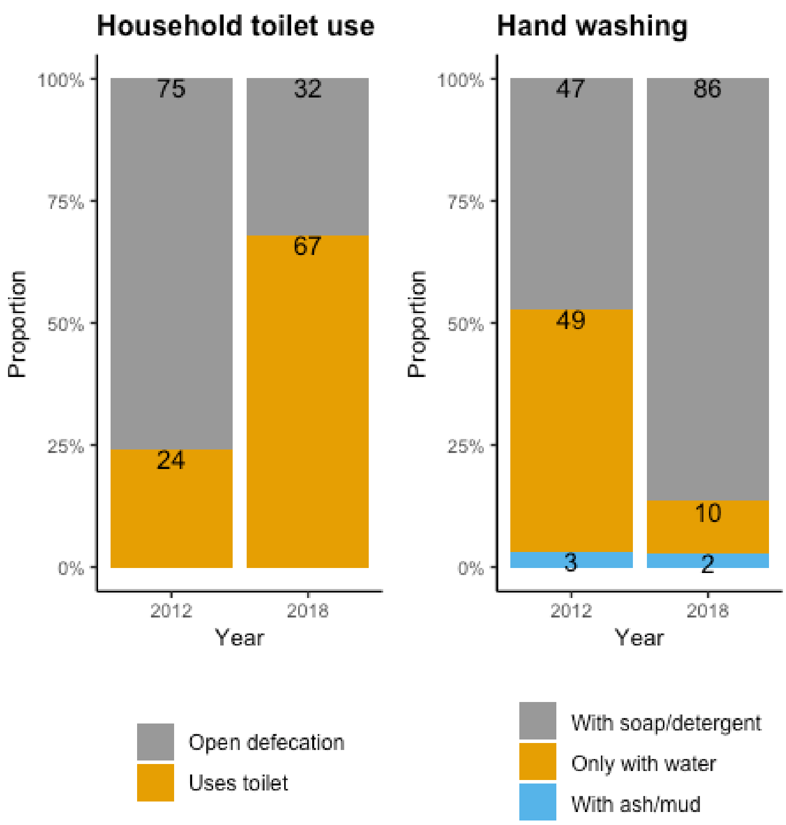


Figure 5.3: Toilet use and handwashing in the Growth Monitoring Study 2012 and 2018

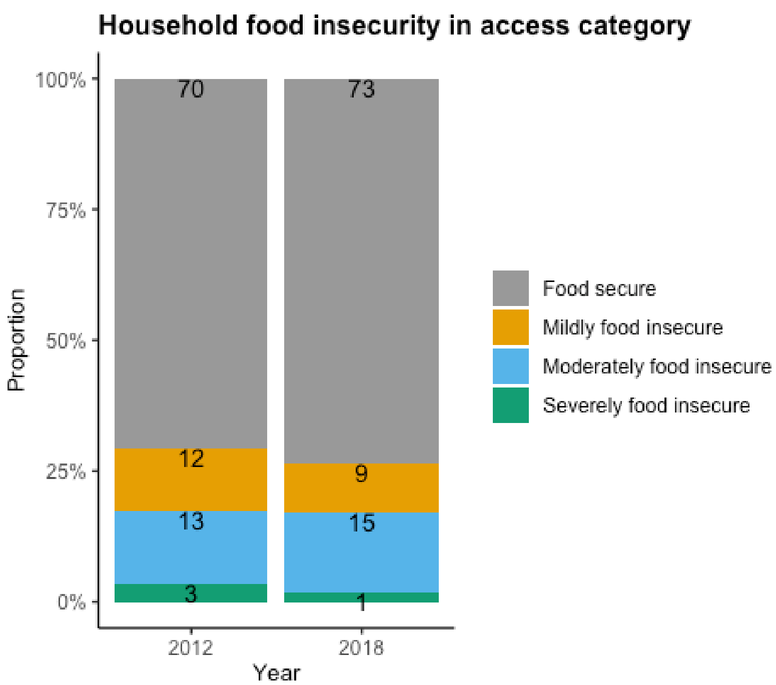


Figure 5.4: Household food insecurity in access category in the Growth Monitoring Study 2012 and 2018

5.3 Growth and nutritional status

2012-2014

The growth of the children from birth to two years in terms of *z*-scores (WHO Multicentre Growth Reference Group, 2006) is described in Table 5.5 and Figure 5.5. At birth, mean length-for-age *z*-score (LAZ) was -1.0 and 16% of the children were stunted with a LAZ of less than -2. The top panel in Figure 5.5 shows LAZ curves smoothed with general additive models (GAM) with standard error bounds. The models' degrees of freedom were obtained by cross validation. Mean LAZ declined almost linearly until the children reached 17 months when mean LAZ levelled at -2.0/-2.1, and prevalence of stunting at around 50%, until the end of the original study when children were two years of age. At birth the mean weight-for-length *z*-score (WLZ) was -1.1 and improved to -0.5 at follow-up six. Prevalence of wasting (WLZ < -2) peaked at follow-up 15 with 29%. Mean weight-for-age *z*-score (WAZ) at birth was -1.4 and remained relatively stable until follow-up seven when it started to fall to -1.9 at follow-up 12. Almost one third of the children (31%) had low birthweight with ≤2500g.

Table 5.5: Length-for-age *z*-score, weight-for-length *z*-score and weight-for-age *z*-score in the Growth Monitoring Study Cohort 2012-2014

Follow-up	Length-for-age *z*-score mean (SD)	*n*	Weight-for-length *z*-score mean (SD)	*n*	Weight-for-age *z*-score mean (SD)	*n*
0	-1.0 (1.1)	601	-1.1 (1.1)	557	-1.4 (1.0)	596
1	-0.7 (1.1)	540	-1.0 (1.0)	533	-1.2 (1.0)	539
2	-0.8 (1.1)	514	-0.8 (1.1)	510	-1.3 (1.0)	513
3	-0.9 (1.1)	494	-0.9 (1.1)	491	-1.4 (1.1)	493
4	-1.1 (1.0)	511	-0.8 (1.1)	509	-1.4 (1.1)	509
5	-1.2 (1.0)	494	-0.6 (1.1)	490	-1.3 (1.1)	495
6	-1.3 (0.9)	530	-0.5 (1.1)	529	-1.3 (1.1)	532
7	-1.4 (1.0)	532	-0.6 (1.1)	530	-1.4 (1.1)	530
8	-1.4 (1.0)	508	-0.8 (1.1)	505	-1.5 (1.1)	509
9	-1.4 (0.9)	505	-1.0 (1.0)	502	-1.6 (1.0)	506
10	-1.6 (1.0)	519	-1.2 (1.1)	518	-1.8 (1.1)	520
11	-1.6 (1.0)	521	-1.3 (1.0)	512	-1.8 (1.0)	514
12	-1.6 (1.0)	503	-1.4 (1.0)	493	-1.9 (1.0)	496
13	-1.7 (1.0)	507	-1.4 (1.0)	493	-1.9 (1.0)	496
14	-1.8 (1.0)	514	-1.4 (1.0)	500	-1.9 (1.0)	502
15	-1.9 (1.0)	501	-1.4 (1.0)	494	-2.0 (1.0)	499
16	-1.9 (1.0)	503	-1.4 (1.0)	494	-1.9 (1.0)	501
17	-2.0 (1.0)	514	-1.3 (1.0)	508	-1.9 (1.0)	511
18	-2.0 (1.0)	506	-1.1 (1.1)	501	-1.8 (1.0)	506
19	-2.1 (1.0)	510	-1.0 (1.0)	505	-1.7 (1.0)	507
20	-2.1 (1.0)	516	-0.9 (1.0)	509	-1.7 (1.0)	510
21	-2.1 (1.0)	514	-1.0 (1.0)	509	-1.7 (1.0)	510
22	-2.1 (1.0)	486	-1.0 (1.0)	483	-1.8 (1.0)	485
23	-2.0 (0.9)	465	-1.2 (1.0)	459	-1.9 (1.0)	459
24	-2.0 (0.9)	489	-1.2 (1.0)	484	-1.9 (1.0)	488
25	-2.1 (1.0)	300	-1.2 (1.0)	292	-1.9 (1.0)	296
26	-2.0 (0.9)	382	-1.0 (1.0)	380	-1.8 (0.9)	386

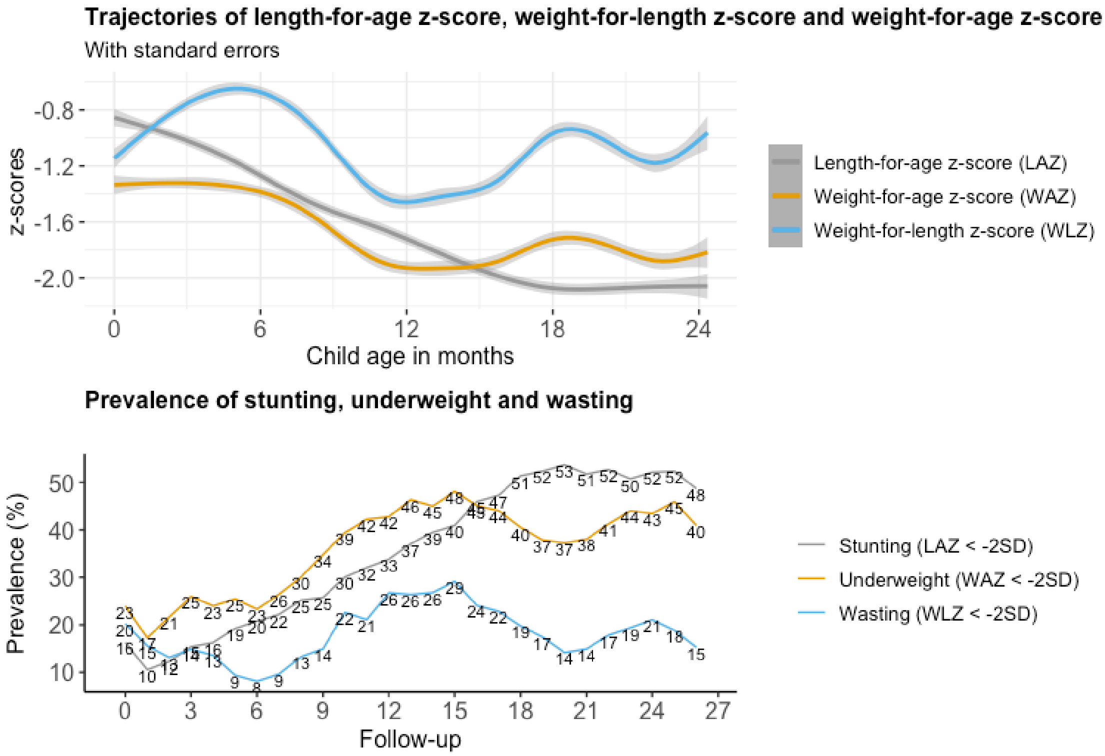


Figure 5.5: *Z*-score trajectories and prevalence of undernutrition in the Growth Monitoring Study cohort 2012-2014.

Mean *z*-scores and prevalence cannot tell us about the trajectories of individual children and how they change in terms of stunting status over time. For this reason, I created a horizontal line plot (Tueller, 2017) in Figure 5.6 which summarises the individual stunting trajectories of all children in the cohort from 2012 to 2014. Each horizontal line represents one child and the colour shows their stunting status at the given time point as indicated on the y-axis. The children are first sorted by their stunting status at birth and then by stunting status at subsequent follow-ups. Missing observations are indicated by white cells which can be seen at the lighter shading at follow-up 25 when the proportion of missings was highest. This graph demonstrates the cumulative nature of stunting in that children rarely recover from stunting but gradually progress to a more severe level of stunting.

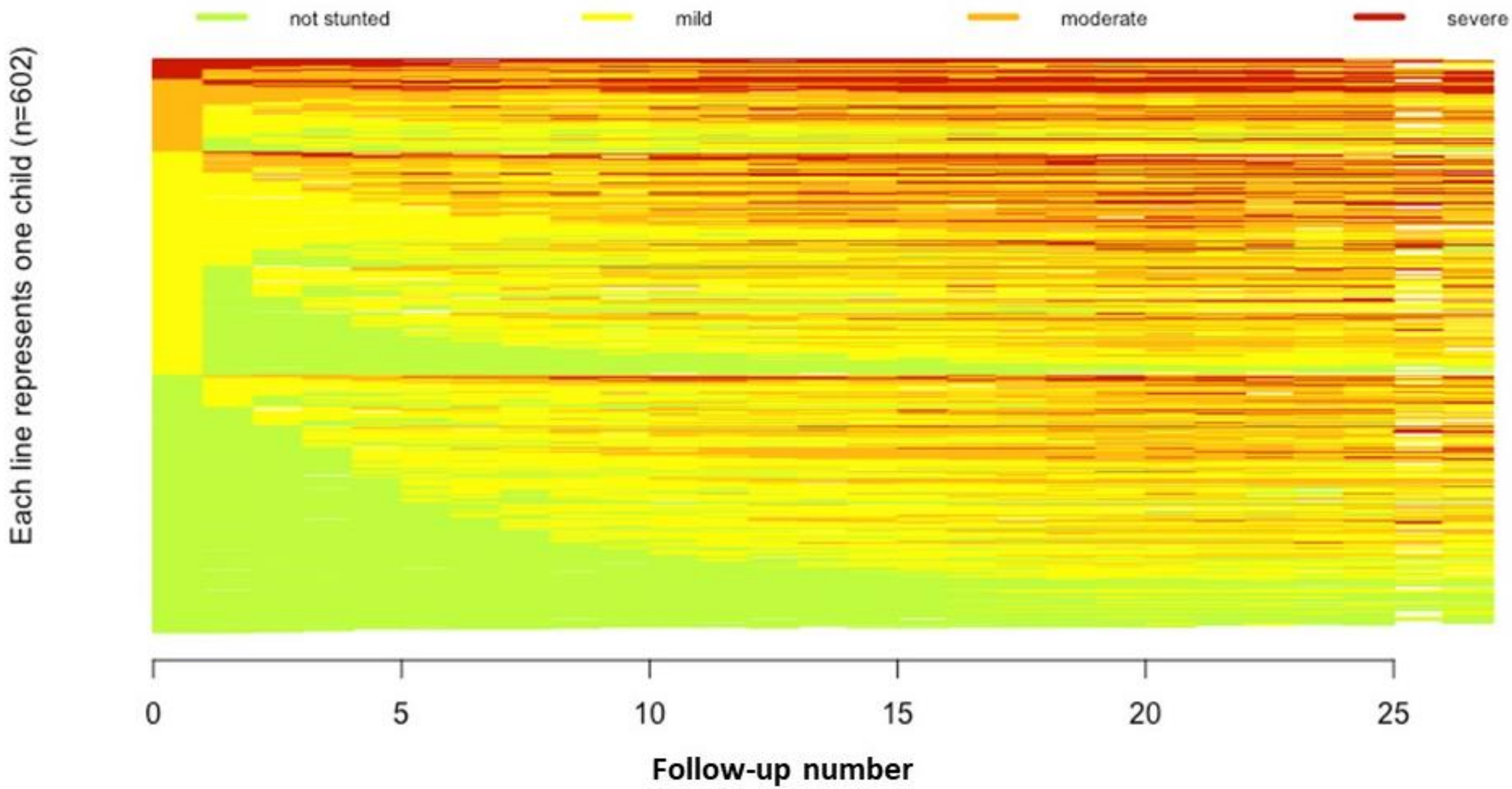


Figure 5.6: Stunting trajectories in the Growth Monitoring Study cohort 2012-2014. Not stunted: LAZ ≥-1 SD, mildly stunted: LAZ <-1 SD and LAZ ≥ -2 SD, moderate stunting: LAZ<-2 SD and LAZ ≥ -3 SD, severe stunting: LAZ < -3 SD.

2018

Linear growth in children under two years is determined by measuring their length in supine position (lying horizontally with face up), after two years height is measured while standing up. The same procedures were followed during the data collection of the WHO reference population (WHO Multicentre Growth Reference Group, 2006). Length-for-age and height-for-age *z*-scores (HAZ) are comparable and both define stunting at <-2. At the follow-up in 2018 when children were around six years old, the prevalence of stunting was 31.6% and mean HAZ was -1.6 (Table 5.6). Mean WAZ was -2.0 and almost half the children were underweight. For children aged five years and older, weight-for-height/length *z*-score is replaced by a *z*-score of body mass index (BMI) for age (BMIZ). Mean BMIZ was -1.3 and 20.8% of the children were categorised as "thin" with a BMIZ <-2.

Table 5.6: Nutritional status in the Growth Monitoring Study 2018

Nutritional status	Mean (SD)	*n*
Height-for-age z-score (HAZ)	-1.6 (0.9)	528
BMI-for-age z-score (BMIZ)	-1.3 (0.9)	528
Weight-for-age z-score (WAZ)	-2.0 (1.0)	529
Stunting (HAZ <-2 SD), % (*n*)	31.6% (167)	528
Thinness (BMIZ <-2 SD), % (*n*)	20.8% (110)	528
Underweight (WAZ <-2 SD), % (*n*)	47.3% (250)	529

Compared to the end of the original GMS study in 2014, prevalence of stunting had fallen by almost 20 percentage points and mean HAZ increased by 0.4. It should, however, be noted that the considerably better indicators in 2018 do not necessarily imply "catch-up growth" in a sense that study children experienced accelerated growth between 2014 and 2018 which narrowed the gap between their height and that of the children in the WHO reference population. A *z*-score is calculated by subtracting the median value in the reference population from the observed value (x) and divide it by the standard deviation (δ) in the reference population (Equation 5.1). The standard deviation in the reference population increases with age, for example for girls at 24 months it is 3.2 and for girls at 72 months it is 5.1 (for boys 3.1 and 4.9, respectively) (de Onis et al., 2007; WHO, n.d.; WHO Multicentre Growth Reference Group, 2006). By rearranging Equation 5.1 we can calculate the height-for-age difference (HAD) in cm. Using 3.1 and 5.0 as the reference population SDs, and -2.0 and -1.6 as the *z*-scores at 24 and 72 months, respectively, I can calculate the mean HADs as -6.2 cm in 2014 and -8 cm in 2018. This shows that the children in the GMS cohort have further fallen behind the reference population in absolute terms, but that this difference is smaller considering the greater variability in height at this age.

$$\boldsymbol{z = \frac{\mathrm{x} - median}{\delta}}$$

Equation 5.1: *z*-score

$$Height - for - age\ difference\ (cm) = x - median = z \times \delta$$

Equation 5.2: Height-for-age difference

5.4 Body composition and other growth outcomes 2018

The body composition, body circumferences, skinfold thickness, tibia length and grip strength of the children at the age of six is presented in Table 5.7. Lean mass was calculated using height-adjusted impedance (Z) from bioelectrical impedance analysis (BIA) measurements, and the prediction equation generated in the isotope calibration sub-study described in Chapter 4.2. Impedance values were available for 468 of the 529 children followed up. Missing BIA measurements were due to faulty BIA cables (*n*=45) or the inability to take measurements because the child was disabled or very thin (*n*=3). I further dropped observations with a phase angle > 6.5 (*n*=13). For those children included in the isotope calibration study (*n*=54) I used the body composition data directly generated from isotopes, not from the prediction equation. I calculated lean mass (LM) for 431 children using the prediction equation. Fat mass (FM) was calculated as the difference between total body weight and LM, as described in Chapter 4.2. Lean mass index (LMI) and fat mass index (FMI) are height-adjusted outcomes (kg/m^2). I further calculated LM and FM *z*-scores (LMZ and FMZ) using UK reference data (J. C. K. Wells et al., 2012). I excluded children with FM < 0 (*n*=7) and FMZ < -7 (*n*=2) so that the final analytical sample includes 476 children.

Table 5.7: Body composition in the Growth Monitoring Study follow-up 2018

Body composition	Median (IQR)	*n*
Lean mass (kg) (mean, SD)	14.0 (1.7)	476
Lean mass index (kg/m^2) (mean, SD)	11.8 (0.9)	476
Lean mass *z*-score (mean, SD)	-1.9 (0.9)	476
Fat mass (kg)	2.2 (1.5, 2.8)	476
Fat mass index (kg/m^2)	1.8 (1.3, 2.4)	476
Fat mass *z*-score	-1.6 (-2.4, -0.9)	476
Body circumferences (cm)		
Head (mean, SD)	48.2 (1.3)	528
Mid-upper arm (MUAC)	15.1 (14.4, 16.1)	529
Waist	49.2 (47.5, 51.0)	529
Hip	52.5 (50.5, 54.2)	529
Calf (mean, SD)	20.3 (1.4)	529
Skinfold thickness (mm)		
Biceps	4.1 (3.7, 4.8)	528
Triceps	6.0 (5.1, 7.1)	527
Subscapular	4.6 (4.1, 5.1)	525
Suprailiac	5.2 (4.4, 6.2)	528
Tibia length (cm)	235.5 (226.5, 245.5)	519
Grip strength category (% (n))		528
<5kg	6.4% (34)	
5 - <6.5kg	41.1% (217)	
6.5 - <8kg	35.2% (186)	
≥8kg	17.2% (91)	

5.5 Child feeding practices and diet

I calculated seven of the eight core WHO infant and young child feeding (IYCF) indicators (WHO, 2010) to describe feeding practices in the GMS[14]. One indicator, consumption of iron-rich or iron-fortified foods, could not be calculated due to a lack of data.

Table 5.8: WHO 2010 infant and young child feeding indicators 1-4 in the Growth Monitoring Study cohort 2012-2014.

Indicator	Definition	%	*n/N*
1. Early initiation of breastfeeding	Proportion of children born in the last 24 months who were put to the breast within one hour of birth	27	163/602
2. Exclusive breastfeeding under six months	Proportion of infants 0–5 months of age who are fed exclusively with breast milk	54	296/552
3. Continued breastfeeding at one year	Proportion of children 12–15 months of age who are fed breast milk	98	552/565
4. Introduction of solid, semi-solid or soft foods	Proportion of infants 6–8 months of age who receive solid, semi-solid or soft foods	84	434/516

[14] The 2008/2010 WHO/UNICEF IYCF indicators presented here were replaced in April 2021, during the writing of this thesis, by a revised set of indicators (WHO & UNICEF, 2021). A key difference between the new and the old indicator is that dietary diversity was extended from seven to eight food groups and now includes breastmilk. In the updated indicator, minimum dietary diversity is now defined as having consumed at least five out of eight food groups, compared to only four out of seven in the old indicator. Using the new indicator would have marginally reduced the prevalence of minimum dietary diversity in my sample. The largest difference between the new and the old indicator would have been at older ages when the prevalence of breastfeeding started to decrease. At follow-up 24, the prevalence of minimum dietary diversity would have been 31% using the updated indicator instead of 34% using the old indicator. In contrast, there would have been no difference at follow-up 9 (both 3%).

Breastfeeding was initiated within the first hour by only 27% of mothers (IYCF Indicator 1) (Table 5.8). This proportion is only half of that reported in the 2016 Nepal DHS report (Ministry of Health and Population [Nepal] et al., 2017). Most (55%) initiated breastfeeding within the first 24 hours, but later than one hour after giving birth.

Children who had been fed liquids other than breastmilk in the 24 hours preceding the interview were categorised as non-exclusively breastfed. At the third follow-up visit (child age between 2.7 and 3.1 months), 76% of children were exclusively breastfed, at follow-up six (5.3 - 5.9 months), that fraction had gone down to 54% (IYCF Indicator 2). These proportions are comparable with those at national level as reported in the 2016 Nepal DHS report (Ministry of Health and Population [Nepal] et al., 2017). Figure 5.7 shows which other foods had been fed to breastfed children who were not exclusively breastfed at follow-up three and six. Almost all children (98%) were still breastfed at follow-up number 15 (13.3- 14.2 months) (IYCF Indicator 3).

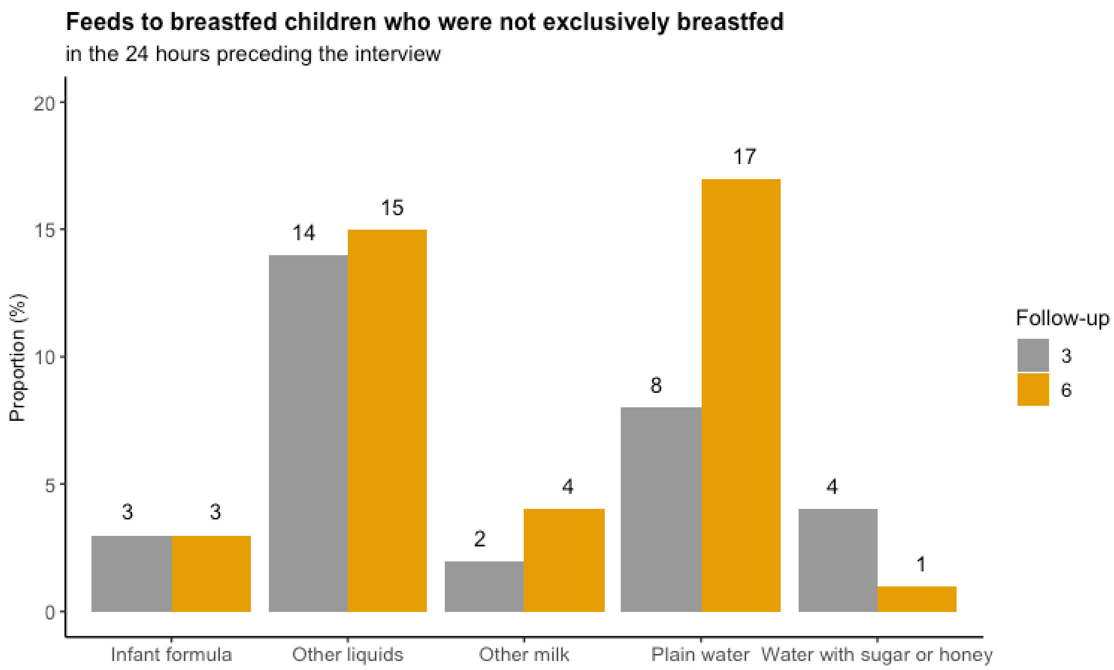


Figure 5.7: Feeds to breastfed children who were not exclusively breastfed (fed anything other than breastmilk in the 24 hours preceding the survey) in the Growth Monitoring Study cohort at follow-up 3 (2.7 - 3.1 months, *n*=138) and 6 (5.3 - 5.9 months *n*=256).

IYCF Indicator 4, introduction of solid, semi-solid or soft foods by age six to eight months, was determined by asking mothers at follow-up nine (7.8 - 8.7 months) about the timing of introduction of complementary foods. If mothers answered that they had introduced complementary foods before or after six months, their children were categorised as having been introduced to complementary foods. It should be noted that even though these children had already been introduced to complementary foods, their main source of nourishment was usually still breastmilk. Of those 434 (84%) children who had been introduced to complementary foods at follow-up nine 393 (91%) still received breast milk as their main food and 205 (47%) had not eaten any foods other than breast milk in the 24 hours preceding the survey.

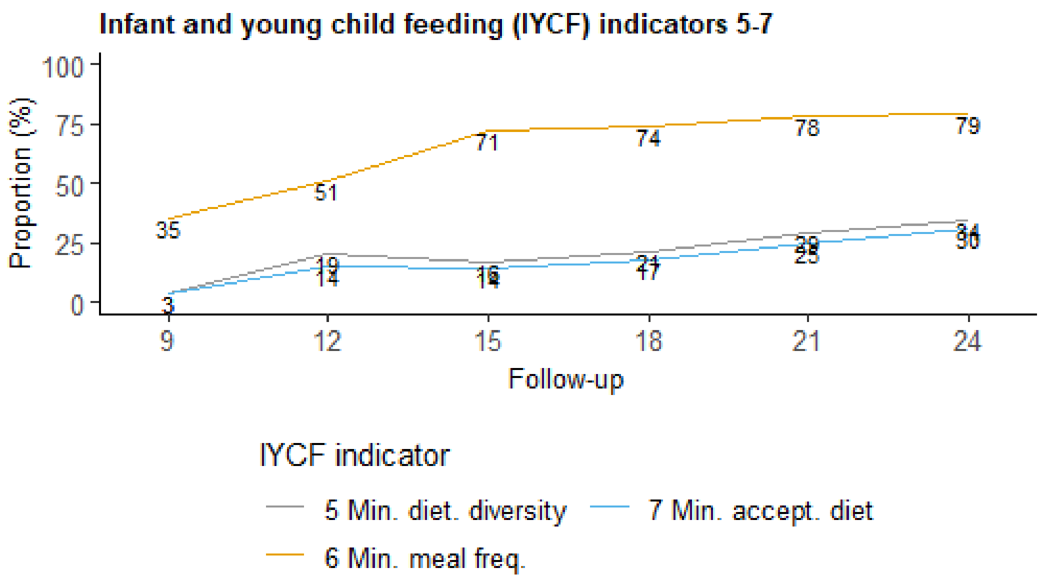


Figure 5.8: Infant and young child feeding indicators 5-7 in the Growth Monitoring Study cohort 2012-2014.

At follow-up nine, only 3% of the children ate from at least four food groups in the 24 hours preceding the survey. The proportion increased during the rest of the study period but remained low at 34% when the children turned two years (Figure 5.8). At a national level, one can observe the same pattern of initially low minimum dietary diversity that increases with age (see Chapter 3.2), but the proportions are considerably lower in the GMS. The proportion of children fed the minimum meal frequency also increased with age and reached 79% at follow-up 24, the same level reported for two year-old children at national level (80%, Ministry of Health and Population [Nepal] et al., 2017). Minimum acceptable diet is a composite indicator of minimum dietary diversity and minimum meal frequency and hence tracks or remains below the lower of the two indicators, in this case minimum dietary diversity. The proportion of children fed the minimum acceptable diet increased with age but only reached 30% at the last follow-up. This proportion is considerably higher at national level with 49% at age 18-24 months (Ministry of Health and Population [Nepal] et al., 2017).

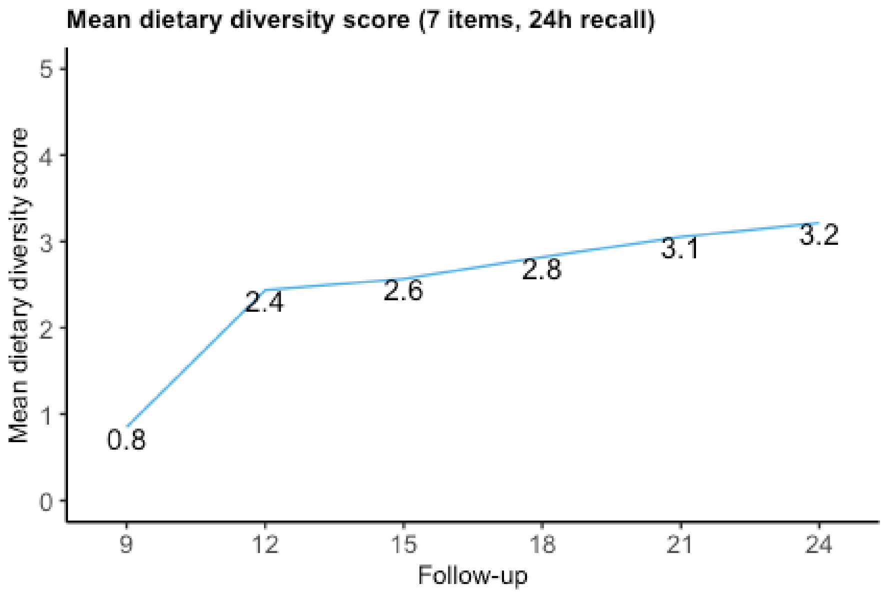


Figure 5.9: Mean dietary diversity score in the Growth Monitoring Study 2012-2014.

Mean dietary diversity score increased linearly from 2.4 to 3.2 food groups between follow-up 12 and 24 (Figure 5.9). Figure 5.10 shows the consumption of the individual food groups included in the seven-item dietary diversity score. Starches and pulses, and to a lesser extent vitamin A-rich fruits and vegetable, were staples in the children's diet. Other food groups were eaten only rarely.

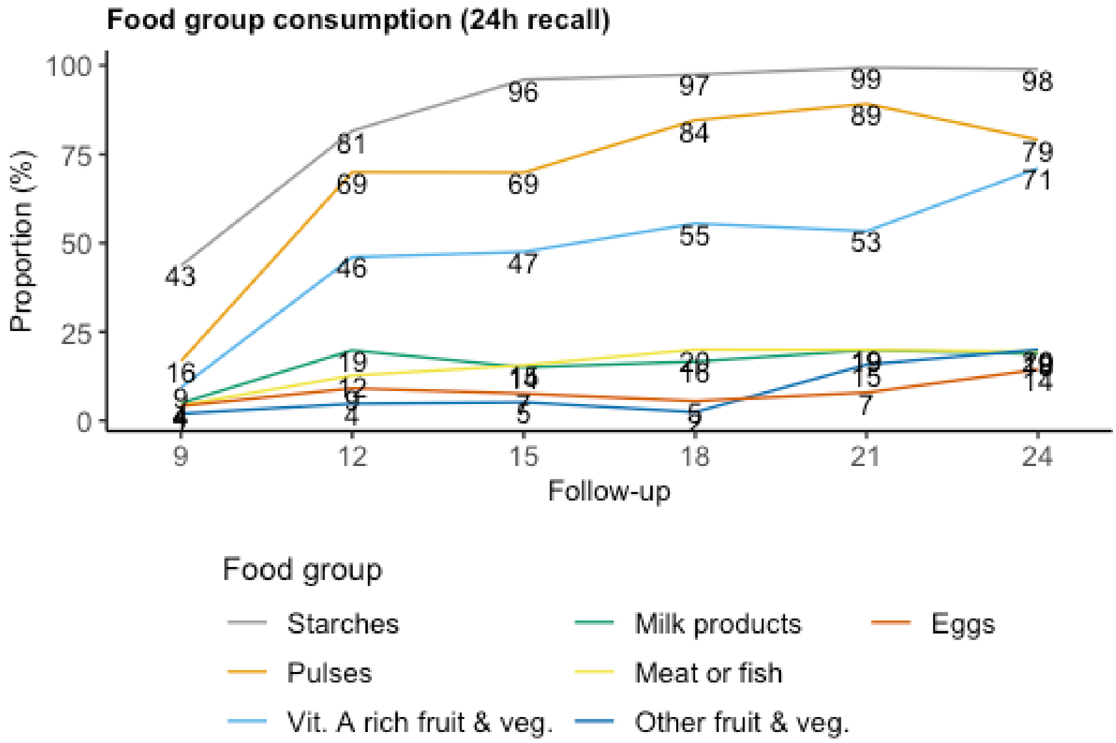


Figure 5.10: Food group consumption in the Growth Monitoring Study cohort 2012-2014.

In 2018, the mean dietary diversity score was 3.8, slightly higher than in 2014 (Table 5.9). Comparing the dietary pattern between the 2012-2014 study and the 2018 follow-up shows that starches and pulses were still the most common components of children's diets, and that eggs and meat or fish were only rarely eaten. In contrast to 2012-2014, the food group 'other fruits and vegetables' were eaten by most of the children whereas vitamin A-rich fruit and vegetable were less common (Table 5.9). Consumption of milk products was also much more common in 2018, which could be partly attributed to the fact that children now often drink milk tea. In autumn and winter almost half of the children (46% and 47%, respectively) had had tea (data not shown). Although the seasons winter and spring have only few observations, one can detect a pattern of seasonally varying food group consumption. Vitamin A-rich fruit or vegetables were most commonly eaten in spring and consisted mostly of yellow fruit, most likely mango (data not shown). In autumn, Vitamin A-rich fruit and vegetables consisted almost exclusively of green leafy vegetables (data not shown).

Table 5.9: Child dietary recall (24h) in the Growth Monitoring Study 2018 follow-up.

24h dietary recall	Total % (*n/N*)	Winter[1] % (*n/N*)	Spring[1] % (*n/N*)	Monsoon[1] % (*n/N*)	Autumn[1] % (*n/N*)
Dietary diversity score (7 items), mean (SD)	3.8 (0.9)	4.2 (1.3)	3.8 (1.0)	3.8 (0.9)	3.9 (0.9)
Food groups consumed					
Starches (cereals or starchy roots)	100% (523/524)	100% (13/13)	96% (24/25)	100% (270/270)	100% (216/216)
Pulses or nuts	82% (431/524)	77% (10/13)	68% (17/25)	83% (224/270)	83% (180/216)
Milk products	53% (279/524)	62% (8/13)	60% (15/25)	49% (131/270)	58% (125/216)
Meat or fish	20% (107/524)	31% (4/13)	12.0% (3)	17% (47/270)	25% (53/216)
Eggs	2% (11/524)	15% (2/13)	12% (3/25)	1% (3/270)	3% (6/216)
Vit A-rich fruit or vegetables	44% (231/524)	31% (4/13)	0% (0/25)	51% (138/270)	32% (70/216)
Other fruit or vegetables	82% (432/524)	100% (13/13)	76% (19/25)	77% (209/270)	89% (193/216)
Total *n*	524	13	25	270	216

[1] Spring: mid-March to mid-June, Monsoon: mid-June to mid-September, Autumn: mid-September to mid-December, Winter: mid-December to mid-March

5.6 Infection and care during illness

During the main GMS 2012-2014, levels of infection were determined by asking mothers on every third visit whether their child had had any of the following symptoms in the two weeks preceding the interview: Cough, cough together with fast breathing, fever, or diarrhoea, defined as loose stools more than three times a day. The prevalence of these symptoms from 2012 to 2014 is depicted in Figure 5.11. Cough and cough together with fast breathing were most frequent at the third and sixth follow-up when the predominant seasons were autumn and winter. At follow up three, almost three quarters of the babies suffered from cough according to their mothers. Levels of diarrhoea peaked at follow-up nine, when the predominant season was spring, when half of the children had loose stools more than three times a day. The high burden of diarrhoea might be attributable to the babies' increasing mobility at that age, which results in greater exposure to the pathogens in their environment. The relatively higher prevalence of diarrhoea in children of this age is consistent with the findings in the 2016 Nepal DHS survey where prevalence was 15% at 9-11 months and 6-10% at other ages under two years, but the absolute levels reported in the GMS are considerably higher. Similarly, prevalence of fever in the 2016 Nepal DHS survey was lower at 16%-30% compared to 29%-44% reported in the GMS.

Mothers of children who had cough with fast breathing were asked whether they sought any treatment for their child and if so, where they went to. I differentiated sources of treatment as qualified and unqualified, with hospitals, primary health care centres, health posts, sub health posts and nursing homes as qualified sources of treatment, and other medical providers such as medical shops, or village practitioners as unqualified sources of treatment. Across all time points, between 84% and 97% of mothers sought treatment for their child with a cough together with fast breathing. Of these, only between 21% and 35% sought treatment from a qualified source.

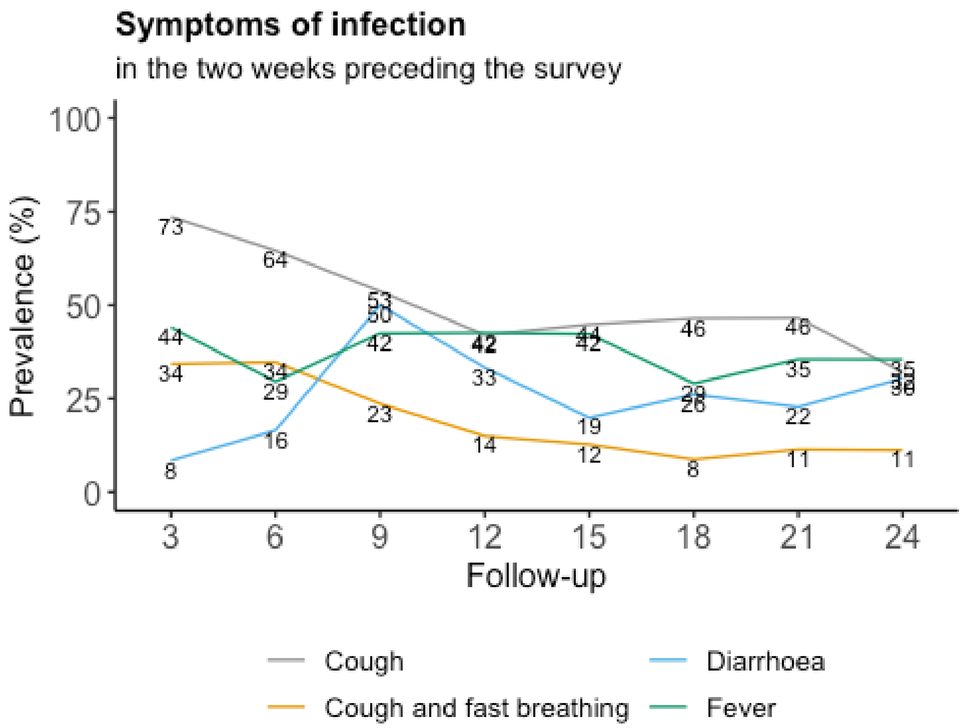


Figure 5.11: Trajectories of symptoms of infection in the Growth Monitoring Study cohort 2012-2014.

If the child’s mother had reported that the child suffered from diarrhoea, the mother was asked how she fed the child during this episode of diarrhoea (Figure 5.12). Most mothers continued to breastfeed their children if the child was still breastfed. Plain water was rarely given to children under six months (9%) but was commonly given to children once they were at an age when they ate complementary foods (ranges between 67% and 76% from follow-up 9 to 24). Feeding of sugar water was generally common and increased with age (58%-80%), potentially intended as a variant of home fluids, a home-made substitute for the recommended oral rehydration salts (ORS). However, sugar water alone is an unsuitable fluid during diarrhoea (WHO, 2005b). ORS were rarely given to children under six months (0%-8%) but their use increased as the children grew older (31%-61%). Gruel made from rice or other grains was overall rarely given and increased only slowly with age (0%-15%). I summarised feeding practices during diarrhoea as appropriate according to the following criteria. Children under six months who continued to be breastfed more or children who were breastfed the same as before and additionally received ORS, children older than six months who continued to be breastfed more or children who were breastfed the same as before and additionally received either ORS or gruel. Appropriate feeding plummeted at follow-up six (8%) because many children were breastfed less compared to before they were ill. The proportion of appropriately fed children with diarrhoea increased slowly to 34% at follow-up 24.

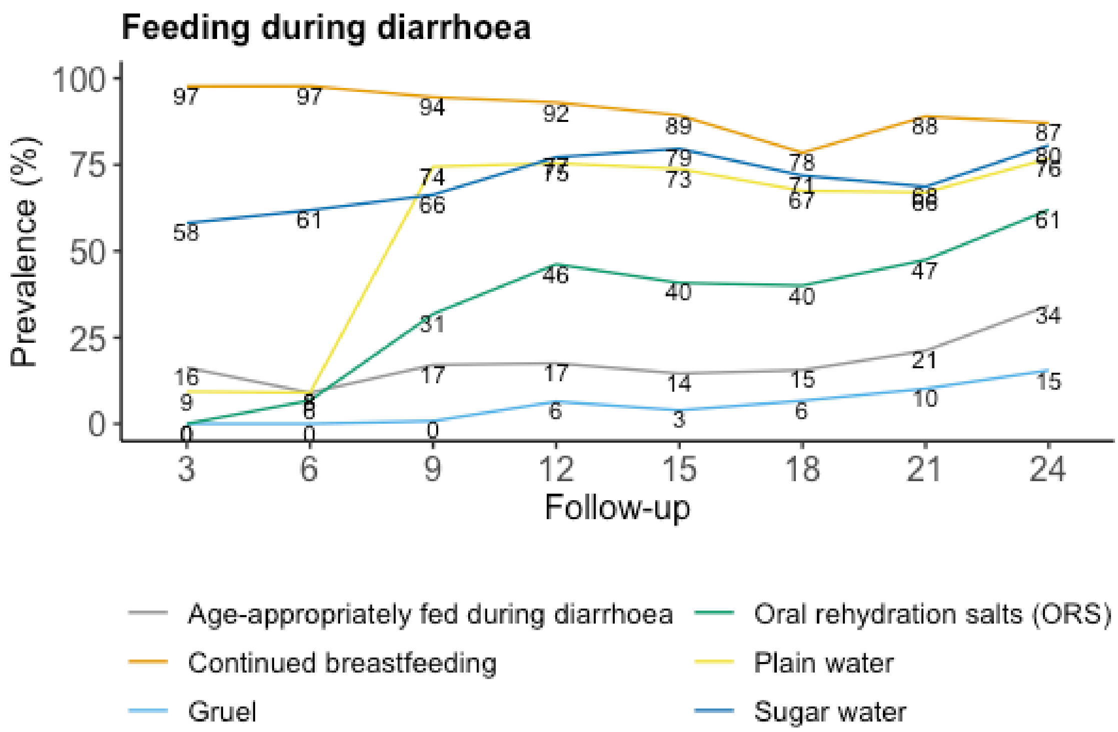


Figure 5.12: Feeding practices during diarrhoea in the Growth Monitoring Study cohort 2012-2014

At the 2018 follow-up I asked each mother whether her child had suffered from fever, diarrhoea or cough in the two weeks preceding the survey. I further asked whether she had sought any treatment for the sick child and if so where she had gone to. I categorised sources of treatment as qualified and unqualified as described above in the 2012-2014 survey. One in four children suffered from fever and/or cough in the two weeks preceding the survey (Table 5.10). Diarrhoea was much less prevalent than in the first two years of life with only 9%. When the child was ill, most carers sought some kind of treatment for their sick child, but only every fifth child was taken to a qualified source of treatment. About half of the children with diarrhoea were given ORS (55%) and plain water (49%), sugar water was much less common (4%) than in the first two years of life (58%-80%, Figure 5.12).

Table 5.10: Child morbidity and care during illness in the Growth Monitoring Study 2018 follow-up.

Illness and care during illness in the two weeks preceding the survey	***% (n/N)***
Fever	28% (147/529)
Diarrhoea	9% (47/528)
Cough	25% (133/529)
Cough with fever	13% (68/529)
Sought any treatment during episode of fever	90% (132/147)
Sought any treatment during episode of diarrhoea	72% (34/47)
Sought any treatment during episode of cough	80% (106/133)
Sought any treatment during episode of cough with fever	93% (63/68)
Qualified treatment during episode of fever[1]	29% (38/132)
Qualified treatment during episode of diarrhoea[1]	26% (9/34)
Qualified treatment during episode of cough[1]	26% (28/106)
Qualified treatment during episode of cough with fever	22% (14/63)
Care during diarrhoea	
Amount of liquids given during episode of diarrhoea	
Much less than usual	11% (5/47)
Somewhat less than usual	19% (9/47)
About the same as usual	40% (19/47)
More than usual	30% (14/47)
Amount of food given during episode of diarrhoea	
Much less than usual	17% (8/47)
Somewhat less than usual	40% (19/47)
About the same as usual	34% (16/47)
Stopped food	9% (4/47)
Given during diarrhoea	
Plain water	49% (23/47)
Sugar water	4% (2/47)
Oral rehydration salts (ORS)	55% (26/47)
Gruel	9% (4/47)
Total *N*	529 (100%)

[1] Hospitals, primary health care centres, health posts, sub health posts and nursing homes are considered qualified sources of treatment, other medical providers such as

ayurvedic hospitals, medical shops or village practitioners are considered unqualified sources of treatment.

5.7 Mothers’ work outside the house and infant feeding arrangements

During the 2012-2014 data collection, mothers were asked on every third visit whether they had been working away from home in the past three months and how the child was taken care of in the meantime. The proportion of mothers who worked outside the house increased steadily over the 24 months period (Figure 5.13). Some mothers took their baby with them or took breaks to feed the baby. From follow-up nine, once the baby had been introduced complementary foods, they were increasingly left in the care of other women such as relatives or neighbours. Mothers were also asked how many hours per day they typically worked outside. Interestingly, the median number of hours didn’t increase much over time and ranged between two and three hours per day. (Figure 5.14). A very worrying observation is that some, albeit few, mothers had no feeding arrangement despite being absent for many hours. At follow-up six, mothers were absent up to eight hours with no feeding arrangement for their baby.

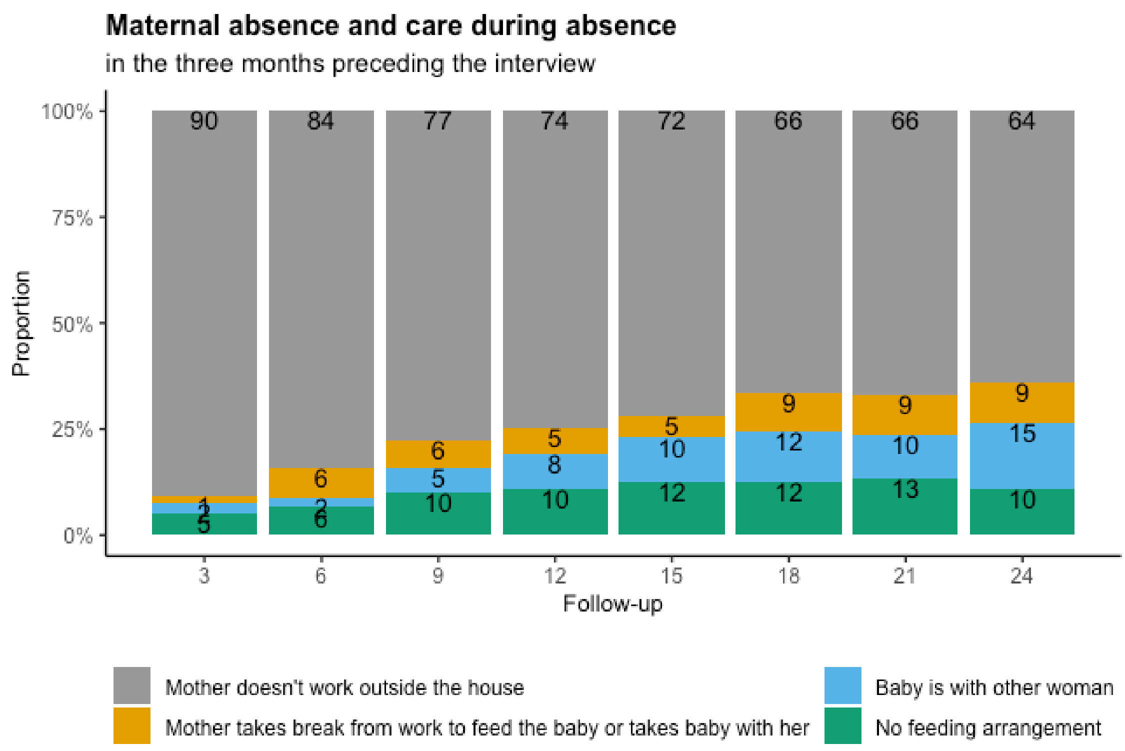


Figure 5.13: Maternal absence for work and feeding arrangements during her absence.

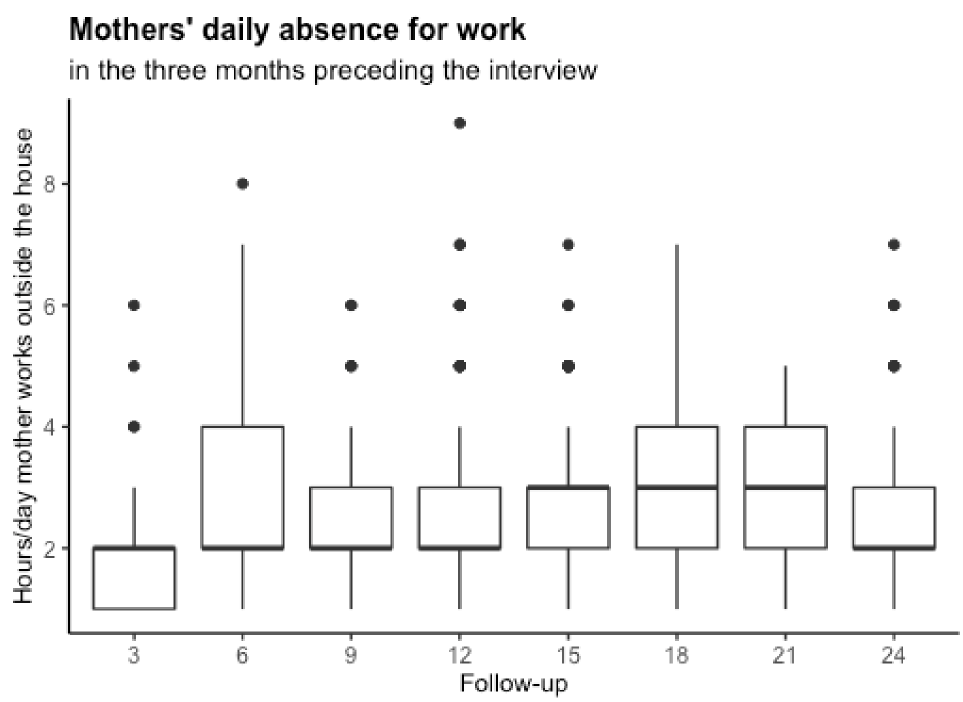


Figure 5.14: Duration of mothers' absence for work (hours/day).

5.8 Migration profile

Across the 529 households that were followed up, we collected data on 388 (73%) migrant households with a total of 510 migrants and 715 cycles of migration. In most households only one person had gone abroad for work over the seven-year recall period (55%, *n*=290), and few had two (15%, *n*=78) or three (3%, *n*=17) migrants, however two households had four and five each.

Who are the migrants?

Information on 510 migrants was collected, all of whom were male. They were aged between 14 and 61 years, with a median age of 30 years (IQR 27-34). Most migrants were the father (70%, *n*=356) or paternal uncle (22%, *n*=113) of the study child. Almost one third of the migrants had no schooling (31%, *n*=160). Before going abroad, most of the migrants worked in unskilled or low-skilled jobs such as agriculture (26%, *n*=134) or daily paid labour (39%, *n*=198). Only a few of the migrants had a regular job (4%, *n*=25) or business at a small (e.g., tea shop, small market stall) or medium scale (e.g., small grocery) (4%, *n*=21).

Table 5.11: Migrant profile.

Migrants	**% (*n*)**
Migrant's age (at the time of the interview), median (IQR)	30 (27-34)
Migrant's relationship to the study child	
Father	70% (356)
Brother	3% (16)
Grandfather	3% (13)
Maternal uncle	2% (11)
Paternal uncle	22% (113)
Cousin	0% (1)
Migrant's education	
None	31% (160)
Primary (1-5 years of schooling)	22% (112)
Secondary (6-12 years of schooling)	46% (237)
College (≥13 years of schooling)	0% (1)
Migrant's main activity before going abroad	
Daily paid labour (servant, labour exchange, daily waged labour, factory labour, band party player, tube well digger)	39% (198)
Regular Job (driver, teacher, factory, gov job, NGO job, etc.)	5% (25)
Small scale business (tela, small market stall, very small shop, tea shop)	3% (15)
Medium Scale business (small grocery, medicine shop/practitioner, small rice mill, operating a wedding band)	1% (6)
Agricultural work	26% (134)
Keeping/looking after livestock	2% (8)
Making things for sale, e.g. bamboo baskets, fans, tailoring, etc.	2% (9)
Selling things gathered from the wild (e.g., fish, firewood, sag)	1% (7)
Doing unpaid work outside the household	0% (2)
In school/education	8% (39)
Unemployed	3% (16)
Other	10% (51)
Total	510

Financing of migration

Of the 715 cycles of migration, 89% (*n*=637) were financed through loans while only 11% (*n*=78) were financed through other sources such as gifts from family, mortgage, or the migrants' own savings. Almost all loans (95%, *n*=606) were taken from a local informal sector moneylender ("sau"), the median interest rate was 36% (IQR 36-36) and ranged between 18% and 60%. According to the respondents, the median costs of migration were NPR 125,000 (IQR 100,000-150,000) and comprised things like the broker, medical checks, passport and flight. Migrants paid a median of NPR 45,000 (IQR 36,000-54,000) in interest, so that the costs of migration (including interests for those with loans) increased to a median NPR 163,200 (IQR 136,000-204,000). At the time of the interview, most migrants had already repaid their loan (74%, *n*=473) or were in the process of paying it back (16%, *n*=101) (Table 5.12).

Table 5.12: Financing of each migration cycle (*n*=715) reported in the Growth Monitoring Study follow-up 2018.

Financing of migration	Median (IQR)	*n*
Costs of migration (NPR, excl. interests)	125,000 (100,000-150,000)	715
Costs of migration (GBP, excl. interests)*	875 (700-1,050)	715
Financing of migration, % (n)		715
Loan	89% (637)	
Other source (gift, savings, mortgage)	11% (78)	
Source of loan, % (n)		637
Local moneylender	95% (606)	
Other source (bank, pawnbroker, relative)	5% (31)	
Loan taken to finance migration (NPR)	127,690 (48,812)	637
Loan taken to finance migration (GBP) *	894 (342)	637
Amount from sources other than loan to finance migration (NPR)	50,000 (8,000-100,000)	85
Amount from sources other than loan to finance migration (GBP) *	350 (56-700)	85
Annual interest rate on the loan (%)	36 (36-36)	637
Total amount of interest paid (NPR)	45,000 (36,000-54,000)	612
Total amount of interest paid (GBP) *	315 (252-378)	612
Total costs of migration (NPR)	163,200 (136,000-204,000)	690
Total costs of migration (GBP) *	1,142 (952-1,428)	690
Pledged collateral for loan		637
No collateral	97% (619)	
House a/o land	3% (17)	
Personal items	0% (1)	
Mean duration of loans from this cycle of migration (months)	12 (12-12)	612
Have the migration loans been repaid?		637
All loans repaid	74% (473)	
Outstanding and currently being repaid	16% (101)	
Outstanding and currently not repaid	10% (63)	

*Using an NPR to GBP exchange rate of 0.007

Nature of migration

Of the 715 migration cycles, 556 (78%) were to Arab Countries, 127 (18%) to Malaysia and 32 (5%) to India (Table 5.13). The median intended duration of migration was 24 months (IQR 24-24) and very similar to the actual median duration of those migrants that had already returned (25.0, IQR 18.1-36.0). However, if I look at the individual difference between the intended and the actual duration of migration, I find that 17% (*n*=65) returned home more than 12 months earlier than planned, which suggests that they encountered problems abroad and that they will have consequently faced a considerable debt with limited means to repay. On the other hand, I find that 26% (*n*=101) of returned migrants ended up staying more than 12 months longer than intended. This might indicate that they found their working situation sufficiently rewarding. Migrants mostly worked in construction (30%, *n*=211), manufacturing (14%, *n*=101), or other type of labour (24%, *n*=169).

Table 5.13: Nature of each migration cycle (*n*=715) reported in the Growth Monitoring Study follow-up 2018.

Nature of migration	Median (IQR)	*n*
Destination of migration, % (n)		715
India	4% (32)	
Arab Countries	78% (556)	
Malaysia	18% (127)	
Intended duration of migration (months)	24 (24-24)	696
Actual duration of migration (months) - both returned and current migrants	26 (16-48)	715
Actual duration of migration (months), only returned	25 (18-36)	393
Difference between intended and actual duration of migration, % (n)		386
Returned home more than 12 months earlier	17% (65)	
Returned home between >3 and 12 months earlier	10% (39)	
Returned as planned +/- 3 months	35% (135)	
Stayed between >3 and 12 months longer	12% (46)	
Stayed more than 12 months longer	26% (101)	
Working sector abroad, % (n)		
Construction	30% (211)	715
Manufacturing	14% (101)	715
Agriculture/farming	2% (12)	715
Health sector (nurse, caregiver, paramedic)	0% (1)	715
Security	2% (13)	715
Driver	7% (52)	715
Tourism, restaurants, other service jobs – contact with customers	4% (30)	715
Tourism and restaurants, other service jobs – no contact with customers	4% (32)	715
Wholesale, retail	2% (11)	715
Domestic work private household	0% (1)	715
Office job	2% (15)	715
Education	0% (2)	715
Electrician (assistant)	4% (31)	715
Painter	2% (12)	715
Plumber	3% (18)	715
Other type of labour job	24% (169)	715
Other job	0% (2)	715
Respondent doesn't know/can't remember	4% (26)	715

Table 5.14: Migrants' migration history (*n*=510).

Migration experience	% (*n*)
Benefits of migration outweigh the costs, according to the respondent	80% (410)
Migrant reported problems while being abroad	37% (187)
Problems reported:	
Physical/sexual/psychological abuse	8% (43)
Work-related illness or injury	9% (44)
Withholding or delay of payment, lower salary	16% (81)
Poor housing and lodging	4% (20)
Overtime work without compensation	2% (11)
Language barrier	2% (8)
Lack of info regarding workers' rights	1% (4)
Isolation from other workers /difficulty staying in contact with family	1% (5)
Company break-down/ project phase-out	3% (13)
Migrant's number of migration cycles in the 7-year recall period	
1	65% (331)
2	30% (154)
3	5% (24)
4	0% (1)
Total	510

During our recall period of seven years, most migrants had gone abroad once (65%, *n*=331) and almost one third had gone twice (30%, *n*=154) (Table 5.14). We asked the respondents whether they thought this household member's migration was overall successful, in the sense that the benefits outweighed the costs and difficulties that he experienced. Most respondents (80%, *n*=410) considered this to be the case. Nevertheless, more than one third of the migrants (37%, *n*=187) reported problems. The most commonly reported problems were related to payment of salaries (16%, *n*=81), abuse (8%, *n*=43) and work-related injuries and illness (9%, *n*=44).

Remittances

Households received remittances from most migration cycles (93%, *n*=667), but in only a few of them (12%, *n*=80) at regular intervals (Table 5.15). The median sum of remittances per migration cycle was NPR 400,000 (IQR 190,000-800,000) for all migrants, including those who were still abroad and likely to further increase their income. The median sum of remittances for migrants who had already returned from this cycle of migration was similar (NPR 400,000 IQR 200,000-700,000). The migrants' median return on investment[15] was 176% (IQR 37%-385%) for those migrants that had already returned home. Most households used remittances for everyday consumption of food (54%, *n*=362) and other things (68%, *n*=451), medical expenses (63%, *n*=417), paying off the migration loans (62%, *n*=413), paying off other loans (45%, *n*=300), utilities bills (32%, *n*=216), and building or rebuilding their house (33%, *n*=218). Only a few invested the money in agricultural inputs (1%, *n*=6), business investments (2%, *n*=13) or savings (8%, *n*=52).

[15] The return on investment (ROI) is calculated as the benefit of an investment (here, the difference between the total amount of remittances and the costs of migration) divided by the cost of the investment (here, the costs of migration). An ROI of 100% means that for every NPR 100 invested, you get NPR 100 back after the costs are covered (Phillips & Phillips, 2005).

Table 5.15: Remittances from each migration cycle (*n*=715) reported in the Growth Monitoring Study follow-up 2018.

Remittances	% (*n)*	*n*
Migrant sent any remittances	93% (667)	715
Number of months after departure migrant sent first remittances, median (IQR)	4 (3-5)	596
Migrant remits at regular intervals	12% (80)	667
Remittance interval (months), median (IQR)	2 (1-3)	79
Total amount of remittances from this cycle of migration (NPR), median (IQR)	400,000 (190,000-800,000)	564
Total amount of remittances from this cycle of migration (GBP) *, median (IQR)	2,800 (1,330-5,600)	564
Total amount of remittances from this cycle of migration (NPR) - only returned migrants, median (IQR)	400,000 (200,000-700,000)	314
Total amount of remittances from this cycle of migration (GBP) * - only returned migrants, median (IQR)	2,800 (1,400-4,900)	314
Return on investment (profit/total costs) in% - only returned migrants, median (IQR)	176% (37%-385%)	303
Remittances used for the following purpose:		
Purchase food	54% (362)	667
Everyday consumption other than food	68% (451)	667
Health and medical expenses	63% (417)	667
Pay off migration-finance loans	62% (413)	667
Pay off other (non-migration) loans	45% (300)	667
Pay utilities bills (phone, electricity, rent, etc.)	32% (216)	667
Build or rebuild house	33% (218)	667
Special occasions (wedding, funeral)	26% (173)	667
Education of household members	26% (172)	667
Build toilet	15% (100)	667
Purchase agricultural land	18% (117)	667
Purchase homestead land	14% (91)	667
Purchase electronic devices (tv, mobiles, laptop)	8% (53)	667
Savings	8% (52)	667
Purchase household goods	6% (42)	667
Buy jewellery	8% (53)	667
Install water pump	4% (28)	667
Business investment	2% (13)	667
Buy agricultural inputs (ox, fertiliser, tractor)	1% (6)	667
Finance migration of other family member	1% (4)	667
Hire labour	0% (1)	667

*Using an NPR to GBP exchange rate of 0.007

The impact of migration on the left-behind mothers

We asked the mothers whose husband had gone abroad in the past seven years (*n*=356) how labour migration had affected them (Table 5.16). Most women said their life was easier (53%, *n*=173) or even much easier (20%, *n*=66). Only very few said life was harder (5%, *n*=15) or much harder (1%, *n*=4). If mothers had stated that life had become easier to some extent, I asked in what way things had improved for them. The most often mentioned positive aspects of migration were enhanced social status (56%, *n*=136), increased mobility (56%, *n*=136), better education (51%, *n*=124), and improved decision-making capacity (47%, *n*=114). I asked all mothers in what ways they had been affected negatively by their husband's migration. The most frequently mentioned negative aspect was the increased work burden (72%, *n*=236), having to raise the child(ren) alone (69%, *n*=225), the lack of security due to the absence of a male household member (66%, *n*=217), and the financial burden caused by the migration loan (39%, *n*=128).

Table 5.16: Impact of husband's migration on the mothers.

Impact on mothers	% (n/N)
How would you describe your daily life now compared to before your household member went abroad?	
Much easier	20% (66/328)
Easier	53% (173/328)
The same/neither easier nor harder	20% (64/328)
Harder	5% (15/328)
Much harder	1% (4/328)
Some things have become harder, some things have become easier	2% (6/328)
What are the positive aspects of migration for you?	
Reduced work burden	25% (62/245)
Enhanced purchasing power	36% (89/245)
Increased employment opportunities	30% (74/245)
Increased mobility	56% (136/245)
Better education	51% (124/245)
Social status enhanced	56% (136/245)
Improved decision-making capacity	47% (114/245)
How have you been negatively affected by migration?	
Increased work burden	72% (236/328)
Financial burden through debt	39% (128/328)
Reduction in mobility	3% (9/328)
Social status diminished	3% (11/328)
Lack of security due to absence of male family member	66% (217/328)
Disruption of family life	2% (6/328)
Social tensions in household over remittances	7% (22/328)
Having to raise the child/children alone	69% (225/328)
Exposed to the gossip in the community	2% (6/328)
n missing	28

Migrant households vs. non-migrant households

As mentioned earlier in this thesis (Chapters 1.4 and 4.3), migration does not happen at random. Instead, the household carefully considers whether it is desirable for them to send one of their members abroad and whether they can bear the costs (fees, loss of labour at home, etc). In the following section I therefore compare households with any migration in the seven-year recall period (*n*=388) with those households that did not report any migration (*n*=141).

In Table 5.17 I compare migrant and non-migrant households by their caste, religion, and ethnic group, but find no differences.

Table 5.17: Caste, religion and ethnic group of migrant and non-migrant households.

Family characteristics	Total	Non-migrant household	Migrant household	*p*-value
	% (*n*) *n*=529	% (*n*) *n* =141	% (*n*) *n* =388	
Caste				0.53*
Dalit	21.6% (114)	19.1% (27)	22.4% (87)	
Muslim	13.4% (71)	11.3% (16)	14.2% (55)	
Janajati	5.7% (30)	6.4% (9)	5.4% (21)	
Other *Terai* (plains) castes	29.1% (154)	29.1% (41)	29.1% (113)	
Sah/Sudi/Teli	9.8% (52)	14.2% (20)	8.2% (32)	
Yadav	18.5% (98)	17.7% (25)	18.8% (73)	
Brahmin/Chettri	1.9% (10)	2.1% (3)	1.8% (7)	
Religion				0.18*
Hindu	85.6% (453)	86.5% (122)	85.3% (331)	
Muslim	13.4% (71)	11.3% (16)	14.2% (55)	
Buddhist	0.9% (5)	2.1% (3)	0.5% (2)	
Ethnic group				0.24*
Pahadi	2.8% (15)	4.3% (6)	2.3% (9)	
Madheshi	97.2% (514)	95.7% (135)	97.7% (379)	

* Pearson's chi-squared

Comparing the household composition (as measured in 2018) between migrant and non-migrant households I find that it differs in many aspects. Migrant households are larger, have a higher male to female ratio (i.e., more men than women), and a higher number of females and males of “productive” age (15 to 54 years) (Table 5.18). The family is furthermore more likely to live with the father’s parents. The number of “unproductive” household members, i.e., children under 15 years and adults over 64 years, is the same between migrant and non-migrant households.

Table 5.18: Household composition of migrant and non-migrant households at the Growth Monitoring Study follow-up 2018

Household composition	**Total** Median (IQR) *n*=529	**Non-migrant household** Median (IQR) *n* =141	**Migrant household** Median (IQR) *n* =388	***p*-value**
Total number of household members (incl. migrants)	6.0 (5.0-8.0)	6.0 (5.0-7.0)	7.0 (5.0-9.0)	0.001‡
Household sex-ratio (male to female, 15-64 years, incl. migrants), mean (SD)	1.0 (0.4)	0.9 (0.4)	1.1 (0.4)	0.001⁺
Number of females aged 15-64 years in the household	2.0 (1.0-2.0)	1.0 (1.0-2.0)	2.0 (1.0-3.0)	0.006‡
Number of males aged 15-64 years in the household, incl. migrants	1.0 (1.0-2.0)	1.0 (1.0-2.0)	2.0 (1.0-3.0)	<0.001‡
Number of males aged 15-64 years in the household, excl. migrants	1.0 (0.0-1.0)	1.0 (1.0-2.0)	0.0 (0.0-1.0)	<0.001‡
Number of 'productive' household members (15-64 years, incl. migrants)	3.0 (2.0-5.0)	2.0 (2.0-4.0)	3.0 (2.0-5.0)	<0.001‡
Number of 'unproductive' household members (under 15 or over 64 years)	3.0 (3.0-5.0)	3.0 (3.0-4.0)	3.0 (3.0-5.0)	0.25‡
Ratio productive to non-productive household members	1.0 (0.7-1.3)	0.8 (0.6-1.0)	1.0 (0.7-1.4)	0.017‡
Living with husband's parents				<0.001*
Live with mother-in-law a/o father-in-law	54.4% (288)	43.3% (61)	58.5% (227)	
Don't live with mother-in-law or father-in-law	28.9% (153)	31.2% (44)	28.1% (109)	
Both mother-in-law and father-in-law are dead	16.6% (88)	25.5% (36)	13.4% (52)	

‡ Wilcoxon rank-sum, ⁺ Two sample t test, * Pearson's chi-squared

Migrant and non-migrant households also differ slightly in their levels of education (Table 5.19). Comparing the highest level of education attained by male and female household members aged 15 to 64 years, I find that women in migrant households are more likely to have no education and less likely to have more than secondary education. Migrant households are less likely to only have men without education, more likely to have at least one male member with primary or secondary education, and less likely to have a male member with secondary completed or above education. The lower proportions of higher education in migrant households could point to the fact that the better-off households do not need to send any of their members overseas.

Table 5.19: Levels of education in migrant and non-migrant households in the Growth Monitoring Study follow-up 2018

Level of education	Total % (*n*) *n*=529	Non-migrant household % (*n*) *n* =141	Migrant household % (*n*) *n* =388	p-value
Highest level of education among female household members aged 15-64 years				<0.001*
No education	53.3% (282)	48.9% (69)	54.9% (213)	
Only non-formal education	3.8% (20)	2.8% (4)	4.1% (16)	
Some primary	11.2% (59)	7.8% (11)	12.4% (48)	
Primary completed	1.9% (10)	1.4% (2)	2.1% (8)	
Some secondary	18.0% (95)	17.7% (25)	18.0% (70)	
Secondary completed	5.5% (29)	6.4% (9)	5.2% (20)	
More than secondary	6.4% (34)	14.9% (21)	3.4% (13)	
Highest level of education among male household members aged 15-64 years, incl. migrants				<0.001*
No education	27.6% (145)	32.8% (45)	25.8% (100)	
Only non-formal education	0.6% (3)	2.2% (3)	0.0% (0)	
Some primary	12.8% (67)	12.4% (17)	12.9% (50)	
Primary completed	6.9% (36)	1.5% (2)	8.8% (34)	
Some secondary	28.0% (147)	24.1% (33)	29.4% (114)	
Secondary completed	14.3% (75)	11.7% (16)	15.2% (59)	
More than secondary	9.9% (52)	15.3% (21)	8.0% (31)	

* Pearson's chi-squared

In Table 5.20 I compare migrant and non-migrant households by the study child's dietary diversity, household food insecurity and main sources of staple food in 2018 but find no differences. Considering the nutritional status of mothers and children in 2018 (Table 5.21), there seems to be pattern in that those from migrant households had lower weight for their age or height. Children in migrant households were more likely to be thin or underweight and had a lower WAZ and BMIZ than children in non-migrant households. Mothers in migrant households had a lower BMI. There was no difference between groups in terms of stunting or HAZ. This finding is a first step towards addressing the main research question of this thesis but should be interpreted with caution for various reasons. Firstly, it should be noted that the group 'migrant household' not only includes households with migrant fathers but also households where only male household member other than the father migrated (*n*=32). Secondly, this unadjusted, cross-sectional comparison does not consider the potential confounding, mediating and moderating factors in the association between parental migration and child stunting. As mentioned earlier in this thesis (see Chapter 1.4), factors such as child age (moderator) and volume of remittances (mediator) are likely to influence the strength and even direction of an effect of parental migration. Household characteristics such as education and socio-economic status likely affect both the likelihood of paternal migration and child nutritional status and can therefore confound this association. In Chapter 7 I use the opportunity of the wealth of information and longitudinal data in the GMS to investigate in detail how and under what circumstances the fathers' migration affects the left-behind children's growth.

Table 5.20: Nutrition factors in migrant and non-migrant households in the Growth Monitoring Study follow-up 2018

Nutrition factors	Total Mean (SD) *n*=529	Non-migrant household Mean (SD) *n*=141	Migrant household Mean (SD) *n*=388	*p*-value	*n* missing
Household Food Insecurity Access category				0.21*	0
Food Secure	73.7% (390)	68.8% (97)	75.5% (293)		
Mildly Food Insecure	9.3% (49)	8.5% (12)	9.5% (37)		
Moderately Food Insecure	15.1% (80)	19.9% (28)	13.4% (52)		
Severely Food Insecure	1.9% (10)	2.8% (4)	1.5% (6)		
Child 24h 10-item dietary diversity score	4.2 (1.2)	4.2 (1.2)	4.2 (1.2)	0.66⁺	5
Child 24h 7-item dietary diversity score	3.8 (0.9)	3.9 (0.9)	3.8 (0.9)	0.92⁺	5
Household's main source of staple food				0.091*	0
Own production	46.1% (244)	41.1% (58)	47.9% (186)		
Purchase	40.1% (212)	41.8% (59)	39.4% (153)		
Share cropping, labour exchange or begging	13.0% (69)	14.9% (21)	12.4% (48)		
Other	0.8% (4)	2.1% (3)	0.3% (1)		

* Pearson's chi-squared, ⁺ Two sample *t*-test

Table 5.21: Nutritional status of mother and child in migrant and non-migrant households in the Growth Monitoring Study follow-up 2018

Nutritional status	**Total** Mean (SD) *n*=529	**Non-migrant household** Mean (SD) *n*=141	**Migrant household** Mean (SD) *n*=388	***p*-value**	***n* missing**
Height-for-age *z*-score (HAZ)	-1.6 (0.9)	-1.5 (1.0)	-1.6 (0.9)	0.32⁺	1
Stunting (HAZ <-2), % (n)	31.6% (167)	27.7% (39)	33.1% (128)	0.24*	1
BMI-for-age *z*-score (BMIZ)	-1.3 (0.9)	-1.1 (0.8)	-1.4 (0.9)	0.003⁺	1
Thinness (BMIZ <-2), % (n)	20.8% (110)	14.9% (21)	23.0% (89)	0.043 *	1
Weight-for-age *z*-score (WAZ)	-2.0 (1.0)	-1.8 (1.0)	-2.0 (0.9)	0.011⁺	0
Underweight (WAZ <-2), % (n)	47.3% (250)	39.7% (56)	50.0% (194)	0.036 *	0
Maternal BMI (non-pregnant mothers), median (IQR)	20.8 (18.8-23.2)	21.6 (18.8-24.4)	20.5 (18.9-22.8)	0.015‡	30
Maternal BMI categories (non-pregnant mothers)				0.099 *	30
Underweight (BMI<18.5)	21.2% (106)	20.5% (27)	21.5% (79)		
Normal weight (BMI ≥18.5 and <25.0)	65.9% (329)	61.4% (81)	67.6% (248)		
Overweight/ obese (BMI ≥ 25.0)	12.8% (64)	18.2% (24)	10.9% (40)		
Mean maternal height	150.9 (5.5)	150.7 (5.3)	150.9 (5.5)	0.75	4

‡ Wilcoxon rank-sum, * Pearson's chi-squared, ⁺ Two sample *t*-test

6 Determinants of infant growth in Dhanusha district, Nepal

Summary

The aim of this chapter is to identify the determinants of infant growth in the Growth Monitoring Study cohort. I used mixed-effects linear regression controlling for multiple measurements within individuals to examine the impact of household and maternal factors, feeding practices and infection on infant length-for-age z-score (LAZ). Maternal factors related to both the environment in-utero and in postnatal life were the most important determinants of infant growth. These findings call for public health interventions targeting girls and young women.

6.1 Background

In low-income settings, linear growth is an overall marker of children's well-being and indicates the extent to which their needs for overall care, adequate nutrition, stimulation, and hygiene are fulfilled. Poor child growth is therefore indicative of living conditions that do not allow children to thrive and develop to their full potential (de Onis & Branca, 2016). Infancy and the prenatal period are periods of rapid growth and development but are also the time when children are most sensitive to insults that could limit their growth and development. The first 1000 days of life, from conception to two years, are thus considered an important window of opportunity in which interventions to improve breastfeeding, complementary feeding, hygiene, protection from infectious diseases, childcare and stimulation are expected to be most effective (Martorell, 2017).

Child growth faltering or stunting, defined as length/height more than two standard deviations below the age-sex specific median of a healthy reference population, is associated with important long-term consequences. Stunted children are more likely to have reduced motor development and cognition in childhood (Sudfeld et al., 2015), and lower earnings in adulthood (Dewey & Begum, 2011; Stewart et al., 2013). These associations are unlikely to be causal but stem from common causes such as inadequate nutrition, and stunting is primarily a marker of a deficient environment for healthy growth and development. Stunted children are likely to grow up to be short adults (Adair et al., 2013) and for women short stature increases the risk of adverse perinatal outcomes. Maternal stunting can restrict uterine blood flow and growth of the uterus, placenta, and foetus, and thus cause intrauterine growth restriction (IUGR) (Dewey & Begum, 2011). IUGR increases the risk of many adverse outcomes such as asphyxia and neurological problems for the baby. Short mothers with a narrow pelvis are also more likely to have obstructed labour which greatly increases the risk of perinatal mortality and birth asphyxia (Dewey & Begum, 2011).

The potential causes of child growth faltering occur in nearly all aspects of infant life, from the maternal environment in utero, to breastfeeding and complementary feeding practices, infection, stimulation, hygiene, and general care at home. The WHO conceptual framework on Childhood Stunting (Stewart et al., 2013, own adaptation in Figure 6.1) comprehensively summarises these potential direct causes and embeds them in the upstream contextual factors that enable deficient environments for child growth and development. Which causal factors are most relevant is context-dependent and the relative importance of each is likely to differ between populations and settings.

The aim of this chapter is to establish the most important determinants of infant growth in terms of length-for-age *z*-score (LAZ) in the Growth Monitoring Study (GMS) cohort in Dhanusha district, Nepal. Such findings will help inform future programmes to tailor their interventions to the needs specific to this population. By providing an overview of the most important determinants of infant growth, this chapter will also set the scene for my later analysis on the impact of paternal migration on the growth of the left-behind child.

6.2 Methods

The selection of participants and methods of data collection were described in detail in Chapter 4. Briefly, the growth monitoring study cohort consists of 602 infants who were enrolled at birth in 2012 and followed up every 28 days until they were two years old. The aim of this study was to determine the risk factors for growth faltering in Dhanusha district. Infant length was measured at every visit, diet and morbidity were assessed at every third visit.

Conceptual framework

We used the causes listed in the "WHO conceptual framework on Childhood Stunting" (own adaptation in Figure 6.1) as described in Stewart et al. (2013) to select potential determinants of stunting.

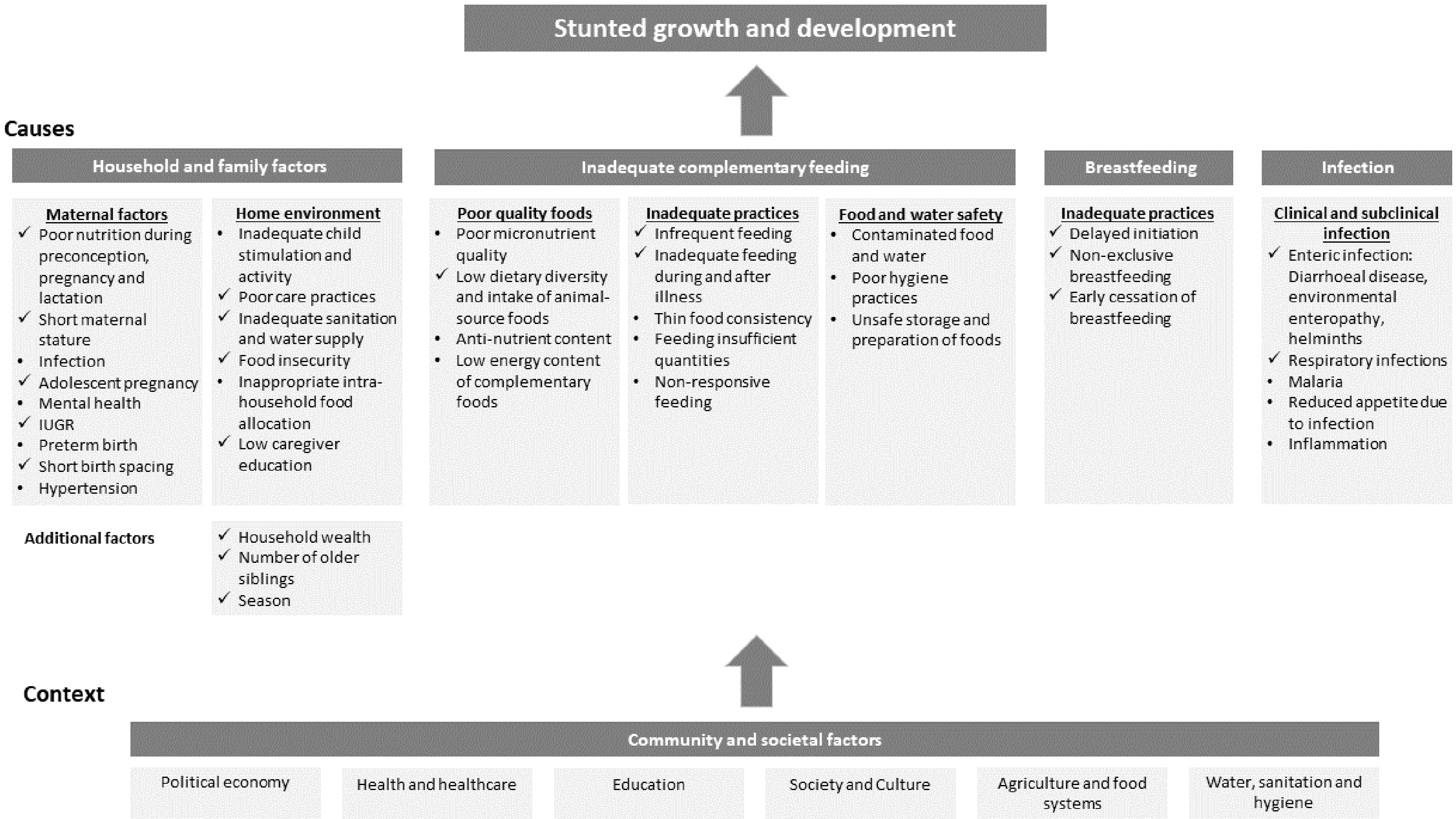


Figure 6.1: Conceptual framework (own adaptation of the WHO conceptual framework on Childhood Stunting: Context, Causes and Consequences with an emphasis on complementary feeding (Stewart et al., 2013). The causes included in this analysis are marked with a ✓.)

Maternal factors

We did not have any information regarding the mother's nutritional status or nutritional intake before pregnancy and during lactation, but shortly after birth the mothers were asked to quantify their diet in the last trimester of their pregnancy and whether they had eaten more, the same or less compared to before. A deliberate reduction of food intake during pregnancy due to cultural beliefs or fear that consumption of large amounts of food leads to a larger baby which in turn will increase the risk of a difficult birth has been mentioned in the literature. A study in Sarlahi district, nearby Dhanusha district, found this practice of "eating down" to be less common but that women often reduced food intake for other reasons such of aversion to certain foods or lack of appetite (Parul Christian et al., 2006). Eating less during pregnancy can reduce the diet quality and maternal weight gain (Harding et al., 2017).

Maternal height was measured at the six-year follow-up and included as a continuous variable. One mother was 13 and three were 16 years at the time of the study child's birth, and they might have continued growing until the maternal height measurement at the six-year follow-up. But for most of the mothers the measurement will reflect their height during pregnancy.

Adolescent pregnancy was defined as a mother being 19 years or younger at the time of the study child's birth. The continued growth during adolescence competes with the nutritional demands of the growing foetus (Scholl, Hediger, Schall, Khoo, & Fischer, 1994) and can thus increase the risk of stunted growth.

The birth-to-pregnancy interval describes the time between the mother's previous child's birth or end of pregnancy, and conception of the study child (WHO, 2005a). It was calculated by subtracting the date when the last pregnancy ended from the study child's birth date, and then subtracting the 280 days of pregnancy. If intervals between pregnancies are short the mother's nutrient reserves may not have enough time to replete which can have adverse effects for mother and child (Dewey & Cohen, 2007). Furthermore, an overlap between breastfeeding and pregnancy can have negative implications for the breastmilk composition and negatively affect growth of the later baby (Conde-Agudelo, Rosas-Bermúdez, Castaño, & Norton, 2012). I used the cut-off of

24 months as the recommended minimum birth-to-pregnancy interval (WHO, 2005a) and added two additional categories, for primigravidae and for those mothers who did not remember the date of the end of the previous pregnancy.

I used low birthweight defined as birthweight <2500g as a measure of intrauterine growth restriction (UNICEF, 2004). Only one baby was born preterm (at seven months gestation), therefore I could not include the factor preterm birth in my analysis. I had no information regarding hypertension or infections during pregnancy.

Home environment

Food insecurity was assessed using the FANTA Household Food Insecurity in Access category (Coates et al., 2007) which captures the respondent's perceived level of household food insecurity over the 30 days preceding the interview. The questionnaire contains nine questions which cover three domains of food insecurity: 1) anxiety and uncertainty about the household food supply, 2) insufficient quality of foods, and 3) insufficient quantity of foods and its physical consequences. The original indicator groups households into four categories: Food secure, or mildly, moderately, or severely food insecure, but because most households self-identified as food secure, we created a binary indicator by collating all degrees of food insecurity. Food insecurity limits the household's access to sufficient amounts of high-quality foods which in turn can reduce the macro- and micronutrient intake of children.

To characterise the household's drinking water, I distinguished between those with their own source of drinking water and those who used a public or neighbour's source. This variable only allows limited inferences about the drinking water's cleanliness, but the absence of a drinking water source can impede good hygiene practices which are important tools to prevent environmental enteropathy. I used a binary variable indicating whether the household used any kind of toilet or defecated in the open to describe the type of toilet facility.

Only very limited information was available regarding infant care practices. On every third visit the mother was asked whether she had been working away from the home in the past three months and how the child had been taken care of during her absence, especially with regard to feeding arrangements. I distinguished between mothers who did not work outside or took their child with them or took breaks between work to feed the baby, mothers who left the child with another carer in her absence, and mothers who did not work away from home. Especially in the exclusive breastfeeding period but also afterwards, babies need to be fed in frequent intervals and the mother's prolonged absence may cause inadequate nutrient intake for the baby. I expected that mothers who left the baby with another carer or who made no feeding arrangement had a lower LAZ than children whose mothers did not work away from home, took the child with them, or took breaks to feed the baby, and that the effect would be larger in the exclusive breastfeeding period when babies depend on their mothers to feed them, especially in a population where expressing breastmilk and feeding infant formula are uncommon. Under the care practices domain, I also included medical care during illness, which is described in the paragraph *Infection* below.

In order to describe maternal education, we created a binary variable indicating whether the mother had ever been to school. Since the literacy rate in this population is very low, especially among women, we could not use a more granulated differentiation between levels of maternal education. Maternal education has been shown to be positively associated with child nutrition outcomes, likely due to better caring practices (Stewart et al., 2013). Child stimulation and intra-household food allocation could not be considered because of a lack of data.

Inadequate Complementary Feeding and Breastfeeding

Feeding practices change over the first years of life, from the exclusive breastfeeding period to the complementary feeding period. This poses a challenge when analysing data that covers different periods, because indicators are only relevant in a certain time window and cannot be used over the whole age-range. I therefore separated the dataset into two feeding periods, the exclusive breastfeeding period from birth to six months, and the complementary feeding period between seven months and two years (the end of the monthly follow-up).

In an initial analytical approach, I attempted to use a feeding index that summarises the adherence to recommended feeding practices in a score which would allow me to analyse the whole age-range together. I calculated an infant and young child feeding

(IYCF) score following the method described by Ruel and Menon (2002) and adapted it to the available data (see Appendix B. 1 for details). At the model development stage, I found that the score was not a relevant determinant of infant growth, which was surprising as feeding practices are considered as one of the immediate risk factors for childhood stunting. One possible explanation was that while some components of the score are relevant, other may not be and that they "dilute" the validity of the score. I therefore decided to use not the score but instead the single feeding indicators, and to separate the dataset by the two feeding phases, as described above.

I principally used the WHO (2010) IYCF indicators as they are widely used standard indicators[16]. For the exclusive breastfeeding period I used the variables Initiation of breastfeeding within one hour of birth (corresponding to IYCF indicator 1), and Exclusive breastfeeding in the first six months (IYCF indicator 2). I additionally included a variable indicating whether colostrum was fed to the new-born and not discarded, as is practised in many communities in the Hindu cultural region (Laroia & Sharma, 2006). Colostrum is important because it provides immune protection and helps to prepare the lining of the gut to receive the nutrients in milk (WHO, 2009a). In the complementary feeding period, I used the variables continued breastfeeding (corresponding to IYCF indicator 3), minimum dietary diversity (IYCF indicator 5), and minimum meal frequency (IYCF indicator 6). For the indicators regarding dietary diversity and meal frequency I also considered the dietary diversity score (range 1 to 7, WHO (2010)) and the number of feeding times per day as continuous variables, but I achieved better model fits with the binary variables. I did not have any information regarding micronutrient intake, the amount of vitamins and minerals that the child consumes, anti-nutrient content such as phytates which inhibit mineral absorption and frequently occur in the predominantly plant-based diets in poor populations (Gibson, Bailey, Gibbs, & Ferguson, 2010), energy content, consistency and quantity of complementary foods, or whether the mother practiced responsive feeding. The factors listed under the domain "Food and water supply" also could not be considered as no data was available.

[16] The 2008/2010 WHO/UNICEF IYCF indicators presented here were replaced in April 2021, during the writing of this thesis, by a revised set of indicators (WHO & UNICEF, 2021). I used the 2010 indicators because the data collection tools and the data analysis were designed with reference to those indicators and before the revised set of indicators had been published.

Infection

A high burden of infectious disease early in life is frequently cited as a critical proximal cause of childhood stunting, with diarrhoeal disease possibly being among the most important factors due to its role in the malabsorption of nutrients (Black et al., 2008). Diarrhoeal disease was determined by asking the mother whether the child had had loose stools more than three times a day in the two weeks preceding the interview. For those children with diarrhoea, I further assessed whether they had been fed appropriately during the illness, defined as continued (breast-)feeding and administration of oral rehydration therapy (UNICEF, 2019). Since the binary indicator for only diarrhoea received a better fit, we did not include the indicator for appropriate feeding during illness in the analysis. Respiratory infection was assessed by asking the mother whether the child had been coughing combined with rapid breathing in the two weeks preceding the interview. For children who had shown symptoms of respiratory infection, I further differentiated between those who had received care by a medical professional (e.g. hospital or health post) and those who had not been presented to a medical professional or for whom medical care was only sought from an unqualified source (e.g. a Shaman, at a medical shop) (UNICEF, 2019). The binary indicator for respiratory infection achieved a better model fit so that care-seeking was not included in the final model. Other enteric infections, malaria, reduced appetite due to infection, and inflammation could not be considered as no data were available.

Additional factors not mentioned in the WHO framework

Although household socioeconomic status is not explicitly mentioned in the framework, I decided to include it because resource availability has been identified as an important determinant of stunting in other regions of Nepal (Dorsey et al., 2018; MAL-ED Network Investigators, 2017). I calculated an asset score using principal component analysis and included the following variables: the husband's level of education, the materials of the house's wall and roof, the number of bedrooms in the house, land owned, ownership of these assets in the household: electricity, radio, colour TV, bicycle, ox cart, motorbike, landline or mobile phone, pump set. Households were stratified into asset score quartiles.

Siblings can be both a hindrance and a source of support for the healthy development of a small child (Kramer, Veile, & Otárola-Castillo, 2016). When birth intervals are short, pregnancy or the birth of a sibling can displace the infant from the mother's breast, and the baby becomes a competition for the mother's attention and time. Older siblings can be a source of support if they are old enough to help around the house and take care of the younger children. At the same time, they can increase the younger child's exposure to pathogens and infections, which in turn is a risk factor for growth failure. In resource-poor households, siblings may be a source of competition. I included the number of older siblings in the analysis, but no information was available regarding the birth of a younger sibling during the study period. Information on the age of older siblings was unfortunately not recorded.

In a population from this area of Nepal, seasonal patterns have been identified to be strongly correlated with maternal and newborn anthropometry and maternal dietary characteristics (Saville et al., 2021). I therefore included a categorical variable indicating in which of the four main seasons the child was measured: spring (months Chait to Jyesth in the Nepali calendar, corresponding to mid-March to mid-June), monsoon (Asad to Bhadau, mid-June to mid-September), autumn (Asoj to Mangsir, mid-September to mid-December), and winter (Paush to Phagun, mid-December to mid-March). At the child level, I furthermore included sex as a potential risk factor because I considered preferential treatment of boys over girls plausible in this population. At the same time, the fast absolute growth rate of male foeti and infants increases their risk of stunting if their higher energy requirements cannot be met (Saville et al., 2022).

Statistical methods

Analyses were restricted to children under 25 months and LAZ was the outcome of interest. I separated analyses by child age: 1) Birth to six months, corresponding to the exclusive breastfeeding period, and 2) 7 to 24 months, corresponding to the complementary feeding period.

I visually present the cohort's growth over the study period in terms of prevalence of stunting and the mean LAZ trajectory. The LAZ trajectory was created with smoothed conditional means using a `loess` model that was fitted using weighted least squares with the degree of smoothness specified by the default parameters in the R `loess` function.

I fitted multilevel linear regression models with child identifier as level-2 and measurement occasion as level-1. Multilevel models - also referred to as mixed-effects models - are suitable for dealing with longitudinal data because they consider the within-individual correlation among repeated measurements. The challenges of analysing longitudinal data and the advantages of multilevel models have been described in Chapter 4.3. Multilevel models include both fixed and random effects, with the fixed effects describing the population average curve, and the random effects allowing individual trajectories to differ from the population average. The models for both age groups included random intercepts which allow the intercept to vary between individuals. Throughout the model development process, I used the Bayesian information criterion (BIC) (Kuha, 2004) as criterion for model selection. All analyses were conducted in R (version 4.1.0) using the RStudio interface (version 1.4.1717). Mixed-effects models were fitted using the package `nlme` (Pinheiro, Bates, DebRoy, Sarkar, & R Core Team, 2018).

As mentioned earlier, children were measured every 28 days, but potential time-varying determinants of growth such as feeding practices and infection were only measured on every third visit. To be able to use all measurement occasions I carried the value of the respective determinant forward to the next two measurement occasions when only the children's anthropometric measurements had been recorded. For example, the value for diarrhoea at follow-up 12 was carried forward to follow-up 13 and 14. I decided to carry the values forward rather than backward because this corresponds to the chronological order in that the determinant precedes the outcome. The only exception is follow-up three when many time-varying determinants were measured for the first time and therefore had to be carried backwards to the preceding measurement occasions, too.

To develop the model, I created a subset of data with complete observations. I did not include maternal height at this point because it was measured at the six-year follow-up and therefore had a much higher proportion of missing values and would have considerably reduced the number of observations in the model-building dataset. In a first step, I fitted the function for age using natural cubic splines using the function `ns` from the R library `splines` (R Core Team, 2022). The approximate ages at which trajectories demonstrate breakpoints (the “knots” that define the splines) were visually pre-selected by plotting the mean growth curve. It is not possible to visually determine the exact timing of such knots (e.g., whether it is month 17 or 18) and I therefore tried different, yet similar, combinations of knots and selected the sets with the best fits as defined by BIC which then made up the age-only model. In the model from birth to six months, the knots were at one and two months, in the 7 to 24 months model, the knots were at 18, 19, and 20 months. In a second step I conducted forward selection of potential determinants of growth using univariable analyses: Each factor was individually added to the age-only model, and I checked whether it improved the model fit (Models 1). At this stage I also compared different indicators measuring the same concept and chose the one with the best model fit (e.g., maternal age as a continuous variable, with four categories, or as a binary variable indicating adolescence). I furthermore checked whether there was an interaction between the respective indicator and child sex or age. In a fourth step I conducted backwards selection: Using the variance inflation factor and χ^2-test, I checked whether the factors selected in Models 1 were collinear. I removed these factors consecutively and tested which combination of covariates achieved the best model fit. Models 2 include the sets of indicators with the best model fit at the respective age-period using the subsets of data with complete observations in the selected variables.

As a final step, I imputed missing values and repeated the analysis using the same model specifications as in Models 2 and additionally included maternal height (Models 3). Multivariate imputations by chained equations were conducted applying the `mice` (van Buuren & Groothuis-Oudshoorn, 2011) package, and using only those observations that had a non-missing value in the outcome LAZ. I used 20 imputations in each dataset and followed Rubin’s rules (Rubin, 1987) to combine the results of the corresponding regression parameters’ estimates into a final estimate.

The distributions of random effects and residuals were evaluated visually: Normality of random effects was assessed with histograms, constant variance of residuals was assessed using residuals plots, and normality of residuals was assessed with Q-Q plots (see Appendix B. 2).

6.3 Results

Missing observations

Each of the 602 children had up to 28 observations over the two-year study period, eight in the birth to six months age-period, 20 in the 7 to 24 months period. There was a total of 13,896 observations with a valid LAZ value. Of the 4,216 observations with valid LAZ in the birth to six months age-period, 279 (6.6%) had missing values in respiratory infection. Of the 9,511 observations with valid LAZ in the 7 to 24 months period, 472 (5.0%) had missing values in dietary diversity and 468 (4.9%) in maternal absence and feeding arrangement. Birthweight was missing in six (1%) of the 602 children enrolled. Maternal height was measured at the six-year follow-up and therefore had a higher proportion of missing at 13% (77).

Children who were not followed-up at six years and whose mothers' height could therefore not be measured, had lower LAZ in infancy, even after controlling for other covariates, thus I cannot assume that missingness occurred at random. I therefore report the results from the complete cases (Models 2) as the main results. However, the estimates from the complete cases (Models 2) and those from multiple imputations (MI, Models 3) were very similar and where differences occurred this was likely attributed to the fact that the models derived from MI (Models 3) included maternal height while the models with complete cases (Models 2) did not. For that reason, I report both the results from the complete cases models and the MI models where the estimates differ by 0.04 LAZ or more.

Growth trajectory and independent variables

The growth of the children in the GMS cohort and potential risk factors for growth faltering have been described in detail in Chapter 5. For clarity and ease of reading, I present again the growth trajectory (Figure 6.2), baseline characteristics (Table 6.1) and time-varying independent variables as included in the model (Table 6.2), and briefly outline key characteristics. At birth, 16% of babies were short for their age with a LAZ less than -2. At the first follow-up, six percent of those children born stunted had experienced accelerated growth and crossed the stunting threshold. After that, recovery from stunting was not observed at a population level and mean LAZ declined linearly until about 18 months when it reached around -2.0 and a stunting prevalence of 50% (Figure 6.2). Nearly one third of the children (31%) had low birthweight and only 33% of mothers had ever been to school. Most households (71%) were categorised as food secure (Table 6.1). Levels of diarrhoea peaked at follow-up 9 (February to May) when 50% of children had reportedly had loose stools more than three times a day in the past two weeks (Table 6.2).

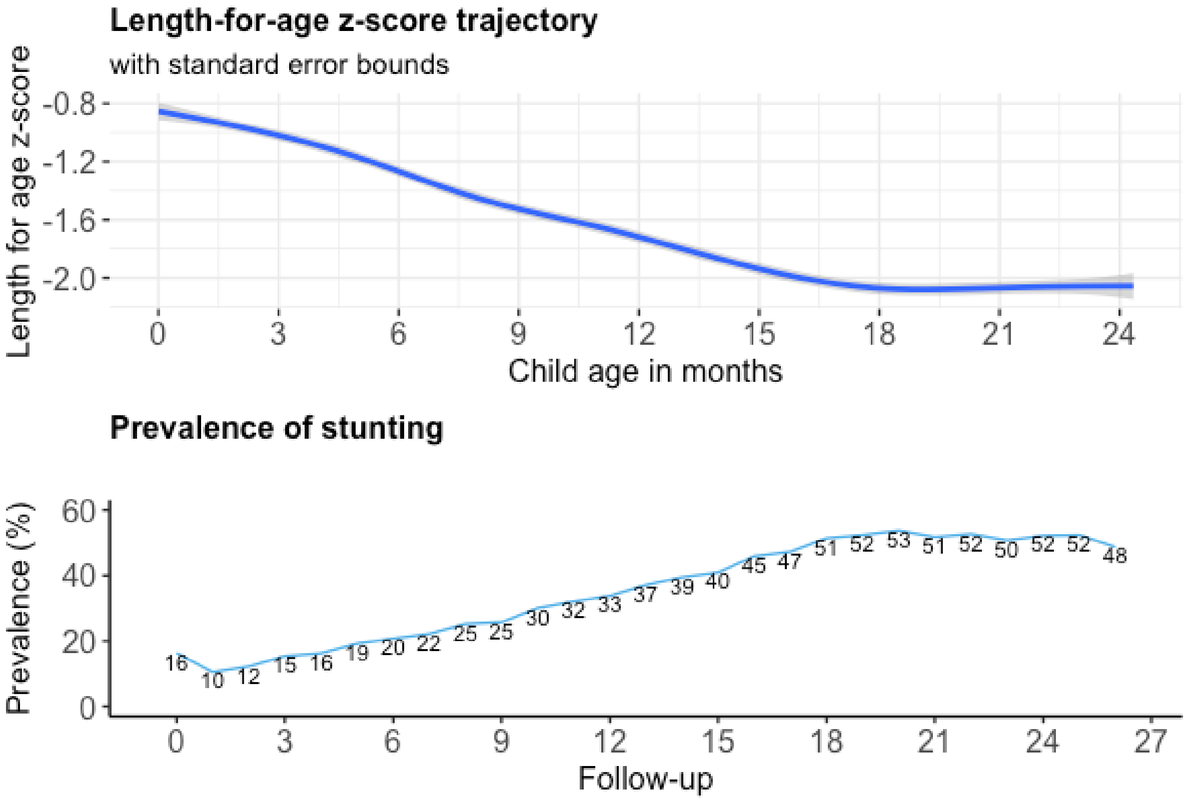


Figure 6.2: Length-for-age *z*-score (smoothed conditional means using `loess`) and stunting prevalence in the Growth Monitoring Study cohort 2012-2014.

Table 6.1: Baseline characteristics of the Growth Monitoring Study cohort. [1]

Baseline characteristics	**% (*n*)**
Sex of study child	
boy	52% (314)
girl	48% (288)
Household factors	
Asset quartile	
1 (worse off)	25% (150)
2	25% (150)
3	25% (150)
4 (better off)	25% (150)
Household experiences any degree of food insecurity	29% (177)
Water source	
Public/neighbours well, pump or tap	29% (176)
Own pump/well/tap/borehole	71% (426)
Household uses open defecation	78% (467)
Number of older siblings	
0	31% (186)
1	20% (120)
2 or more	49% (296)
Maternal factors	
Low birthweight	31% (185)
Birth-to-pregnancy-interval before study child	
Primigravida	26% (159)
<24 months	30% (181)
≥24 months	30% (178)
End date of previous pregnancy unknown	14% (84)
Mother adolescent (≤19y) at study child's birth	20% (123)
Mother has any level of education	33% (198)
Mother ate less, more or the same amount during the last trimester of pregnancy	
Less	36% (217)
Same	57% (342)
More	7% (43)
Maternal height (cm), mean (SD)	150.9 (5.5)
Breastfeeding practices	
Breastfeeding initiated within one hour after birth	27% (163)
Colostrum was discarded[1]	22% (135)
Total	**602**

[1] Missing observations: Low birthweight: 6, asset quartile: 2, colostrum: 2, maternal height: 77

Table 6.2: Time-varying independent variables in the Growth Monitoring Study Cohort 2012-2014: Childcare, infection and feeding.

Follow-up number	**3** ***n* =494**	**6** ***n* =530**	**9** ***n* =505**	**12** ***n* =503**	**15** ***n* =501**	**18** ***n* =506**	**21** ***n* =514**	**24** ***n* =489**
Mother's absence and care arrangement								
Doesn't work outside, takes break to feed the baby or takes baby with her	93% (459)	92% (485)	84% (425)	80% (404)	76% (381)	75% (377)	75% (386)	73% (355)
Baby is with another carer	2% (11)	2% (12)	6% (30)	8% (41)	10% (52)	12% (60)	10% (53)	14% (70)
No feeding arrangement	5% (24)	6% (33)	10% (50)	11% (55)	13% (63)	12% (63)	13% (69)	11% (53)
Missing	0% (0)	0% (0)	0% (0)	1% (3)	1% (5)	1% (6)	1% (6)	2% (11)
Diarrhoea (14d recall)								
No diarrhoea	91% (452)	83% (442)	50% (251)	67% (335)	80% (399)	73% (371)	76% (391)	68% (334)
Child had diarrhoea	9% (42)	17% (88)	50% (254)	33% (168)	19% (97)	26% (130)	23% (116)	29% (144)
Missing	0% (0)	0% (0)	0% (0)	0% (0)	1% (5)	1% (5)	1% (7)	2% (11)
Cough with fast breathing (14d recall)								
No cough and fast breathing	66% (324)	66% (348)	77% (388)	85% (429)	86% (430)	91% (458)	87% (449)	86% (422)
Child had cough with fast breathing	34% (170)	34% (182)	23% (117)	15% (74)	13% (66)	8% (43)	11% (58)	11% (55)
Missing	0% (0)	0% (0)	0% (0)	0% (0)	1% (5)	1% (5)	1% (7)	2% (12)
Continued breastfeeding								
Stopped breastfeeding	0% (0)	0% (2)	0% (1)	1% (3)	3% (13)	4% (22)	7% (37)	15% (73)
Continued breastfeeding at that timepoint	100% (494)	100% (528)	100% (504)	99% (500)	97% (487)	96% (484)	92% (475)	83% (406)
Missing	0% (0)	0% (0)	0% (0)	0% (0)	0% (1)	0% (0)	0% (2)	2% (10)

Follow-up number	3 *n* =494	6 *n* =530	9 *n* =505	12 *n* =503	15 *n* =501	18 *n* =506	21 *n* =514	24 *n* =489
Exclusive breastfeeding (24h recall)								
Child not exclusively breastfed	26% (130)	35% (186)						
Child exclusively breastfed	74% (364)	65% (344)						
Missing	0% (0)	0% (0)						
Minimum dietary diversity (24h recall)								
No minimum dietary diversity (<4/7 food groups)			96% (487)	80% (403)	82% (411)	78% (395)	70% (359)	64% (313)
Minimum dietary diversity (≥4/7 food groups)			4% (18)	20% (100)	17% (85)	21% (106)	29% (149)	33% (163)
Missing			0% (0)	0% (0)	1% (5)	1% (5)	1% (6)	3% (13)
Minimum meal frequency (24h recall)								
No minimum meal frequency			58% (295)	45% (224)	27% (137)	25% (125)	21% (110)	20% (98)
Minimum meal frequency			32% (163)	47% (234)	71% (354)	72% (362)	77% (396)	77% (378)
Missing			9% (47)	9% (45)	2% (10)	4% (19)	2% (8)	3% (13)

Determinants of LAZ

The final model for the age-period from birth to six months included low birthweight, maternal education, and maternal age at birth with age-interactions, and season, respiratory infection, and maternal height with main effects only. The final model for the age-period 7 to 24 months included low birthweight, water source, and maternal absence for work and feeding arrangements with age-interactions, and season, maternal education, minimum dietary diversity, household food insecurity and maternal height as main effects only. The full regression results are provided in the appendix as supplementary tables (Appendix B. 3, Table S 2 and Table S 3). For ease of reading, only the results of the final models (Models 2 with complete cases) are presented in Figure 6.3 for the age-period from birth to six months and in Figure 6.4 for the age-period 7 to 24 months. The effects of determinants with age-interactions are presented as predicted LAZ trajectories, the effects of determinants with main effects only are presented as coefficient plots.

Maternal factors

Low birthweight was by far the most important determinant of infant growth in both growth periods. At birth, low birthweight babies had -1.21 (-1.38, -1.05) lower LAZ than normal birthweight babies. In both age-periods, the effect of low birthweight attenuated with age, with low birthweight babies faltering at a lower rate (Figure 6.3, A), as denoted by the positive coefficients in the age-interactions (Table S 2). At seven months, the effect size had decreased, and low birthweight babies were -0.75 (-0.91, -0.59) LAZ shorter than normal birthweight babies, but birthweight remained the determinant with the largest effect size. In the models using MI which include maternal height, the effect size was somewhat smaller with low birthweight babies being -1.13 (-1.29, -0.96) and -0.63 (-0.78, -0.48) LAZ shorter in the birth to six months and 7 to 24 months age-period, respectively.

Maternal education was a relevant determinant in both age-periods, but the effect changed over time. At birth, there was no difference between babies of mothers with any education and those who had never been to school, but during the first six months of life babies of mothers with at least some education grew better (Figure 6.3, B), as indicated by the positive coefficients in the age-interactions (Table S 2). In the 7 to 24 months age-period, the effect of maternal education did not vary by child age and after adjustment children of mothers with education had a 0.22 (0.07, 0.38) higher LAZ than those of mothers without any education (Figure 6.4, D). In the model using MI including maternal height, the effect size was smaller with 0.18 (0.03, 0.32) LAZ.

In the first six months of life, babies of adolescent mothers were smaller than those of mothers who were 20 years or older at the time of birth, but the effect varied with child age. At birth, children of adolescent mothers had a -0.22 (-0.41, -0.03) lower LAZ, after adjustment for covariates, but caught up some of the difference between one and two months. After this, the trajectories diverged a little and tracked alongside until age six months when the difference disappeared (Figure 6.3, C). In the model using MI and including maternal height, the size of the main effect was larger and the babies of adolescent mothers were -0.26 (-0.44, -0.07) LAZ shorter, but the age-interaction remained the same. In the 7 to 24 months age-period I observed no difference in infant LAZ by maternal age.

In the first six months age-period I found no difference in LAZ by mother's absence from home for work and their baby feeding arrangements. In the age-period 7 to 24 months there were some, albeit very small, differences, especially around 18 months when children whose mothers worked outside the home but had not made feeding arrangements had a lower LAZ than children whose mothers did not work outside the home, took their child with them, fed the child during breaks, or left it with another carer (Figure 6.4, C).

Maternal height was a determinant of infant growth in both the birth to six months age-period (0.04 (0.02, 0.05)) and the 7 to 24 months age-period (0.06 (0.05, 0.07)).

In the univariable model in the birth to six months age-period, the birth-to-pregnancy interval variable did improve the model fit, but it was correlated with several other covariates and caused multicollinearity. I therefore dropped it from the final model. The univariable model suggested that babies conceived less than two years after the end of the previous pregnancy had a higher LAZ compared to those with a longer birth spacing (0.21 (0.00, 0.43)), but considering the wide confidence interval bordering a null effect this result should be considered with caution. The negative coefficients in the age-interactions show that this difference was attenuated during the first six months. Babies of primigravidae were smaller (-0.41 (-0.63, -0.18)) at birth compared to babies who were conceived at least two years after the end of the previous pregnancy, but the positive coefficients in the age-interaction show that this difference decreased during the first six months. Eating behaviour in the last trimester of pregnancy did not improve the model fit and was therefore not included in the final model.

Home environment

Household food insecurity was a determinant of infant growth in the 7 to 24 months age-period. After adjustment, children from food secure households had a 0.23 (0.07, 0.39) higher LAZ than children in households with some level of food insecurity (Figure 6.4, D). This effect size was smaller with 0.16 (0.01, 0.31) LAZ in the model from MI including maternal height.

The water source was also included in the final model with an age-interaction in the 7 to 24 months age-period. Initially, the predicted LAZ trajectories of children from households with their own water source and those who used a public or a neighbour's well, pump or tap were the same, but from around 18 months the trajectories diverged with children from households with their own water source having a slightly higher LAZ (Figure 6.4, B).

The risk factor older siblings was coded differently in the two age-periods. In the birth to six months age-period, differentiating between infants without siblings, one sibling, or two or more siblings resulted in the best fit, whereas in the 7 to 24 months age-period a binary variable indicating the presence of any older sibling resulted in the best model fit. In the unadjusted models, older siblings were relevant determinants of LAZ in both age-periods and showed age-interactions but were correlated with other covariates and therefore excluded from the final models. In the birth to six months model (unadjusted model), babies with one sibling were smaller than firstborns or babies with two or more siblings, but this difference disappeared after at around six months. In the 7 to 24 months age-period (unadjusted model), the age-interaction showed that children with any older sibling had a steeper decline in LAZ until around 18 months than children with no siblings, but afterwards little difference was discernible in the growth trajectories.

Asset quartile and toilet use were significant at 0.05 significance level and showed relatively consistent effect sizes in both growth periods, but because these two indicators did not improve the model fit using BIC they were not included in the final model. In the unadjusted models, children in asset quartiles three and four (from better off households) were around 0.3 LAZ taller than children in asset quartile one, and children from households that practise open defecation being around -0.2 LAZ smaller than those from households that use a toilet.

Breastfeeding

Initiating breastfeeding within one hour after birth was positively associated with LAZ in the birth to six months age-period (0.23 (0.06, 0.40)) but did not improve the model fit using BIC and was therefore not included in the final model. There was no association between exclusive breastfeeding or discarding of colostrum with infant growth.

Complementary feeding

Minimum dietary diversity had a positive, albeit very small, effect on LAZ in the 7 to 24 months age-period. Children who ate from at least four out of seven food groups had a 0.03 (0.01, 0.05) higher LAZ than those who ate from only three or less food groups (Figure 6.4, D). Continued breastfeeding was positively associated with LAZ and was significant at the 0.05 level (0.05 (0.01, 0.08)) but did not improve the model fit and was therefore not retained in the analysis. Minimum meal frequency was not found to be associated with child LAZ.

Infection

In the birth to six months age-period, children with symptoms of respiratory infection in the two weeks preceding the survey had a -0.10 (-0.14, -0.05) lower LAZ than those with no symptoms (Figure 6.3, D). I found no differences by respiratory infection in the 7 to 24 months period, or by diarrhoea.

Other factors

In the birth to six months age-period, season improved the model fit using BIC but was not significant at the 0.05 level (Figure 6.3, D). In the 7 to 24 months age-period, using spring as the reference category, children were 0.03 (0.01, 0.06) LAZ taller in monsoon and -0.06 (-0.08, -0.04) LAZ shorter in winter (Figure 6.4, D). It was not possible to include an age-interaction with season because not all ages have all seasons. I found no difference by child sex as a main effect or as an interaction with other covariates.

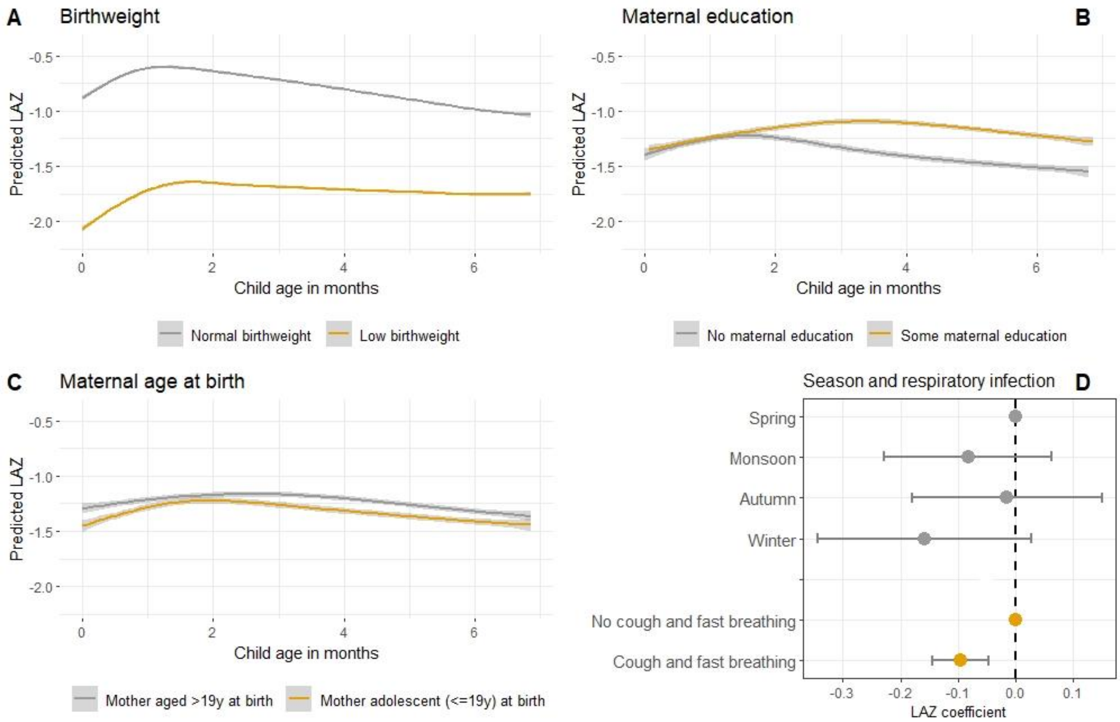


Figure 6.3: Summary of determinants of infant growth 0-6 months as predicted from the results presented in Table S 2. Determinants with age-interactions (low birthweight, maternal education, maternal age at birth) are presented as trajectories of predicted length-for-age *z*-score (with standard errors). Determinants with main effects only (season, cough with fast breathing) are presented in a coefficient plot.

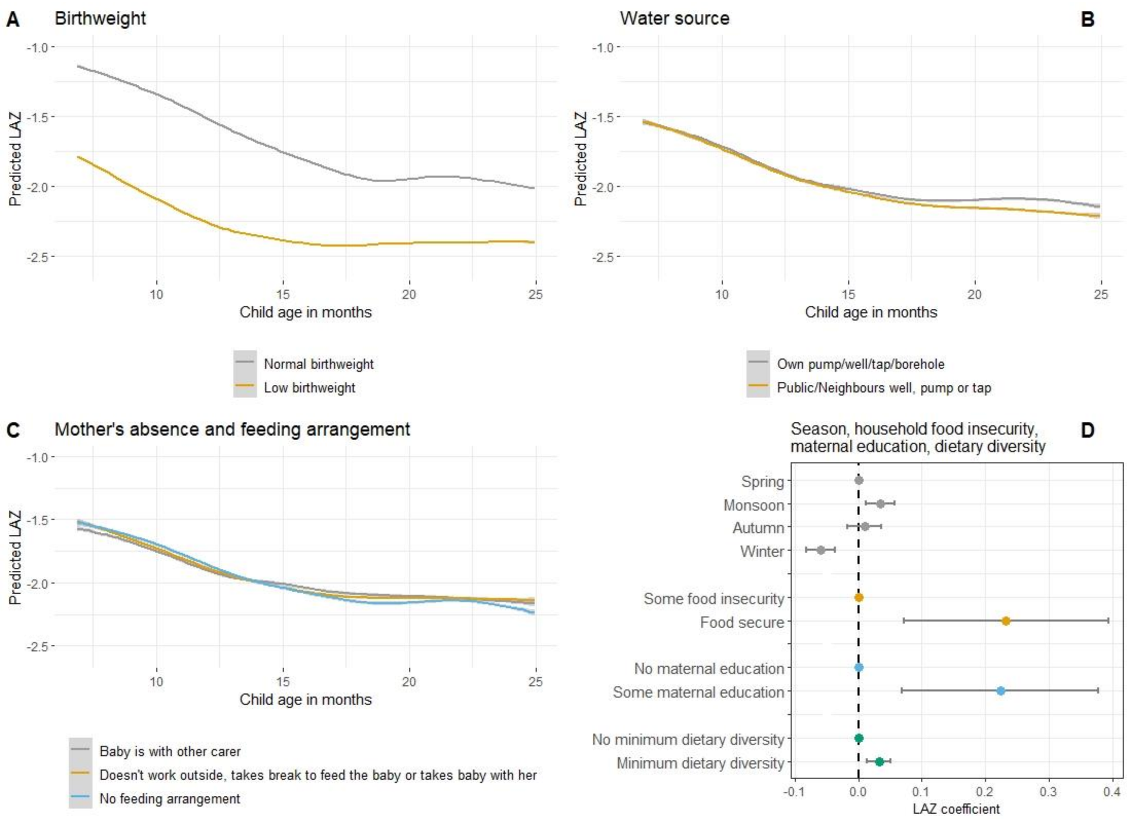


Figure 6.4: Summary of determinants of infant growth 7-24 months as predicted from the results presented in Table S 3. Determinants with age-interactions (low birthweight, water source, maternal absence and feeding arrangements) are presented as trajectories of predicted length-for-age *z*-score (with standard errors). Determinants with main effects only (season, food insecurity, maternal education, and minimum dietary diversity) are presented in a coefficient plot.

6.4 Discussion

Summary and discussion of main findings

The objective of this analysis was to establish the main determinants of infant growth in a birth cohort in Dhanusha district, Nepal. I found that maternal factors were the most important predictors of infant LAZ. Most importantly, low birthweight as an indicator of IUGR had the largest effect size and even after controlling for maternal height children born with a birthweight of less than 2500g were more than one LAZ smaller than those with normal birthweight. Although this difference attenuated over the two years, children born with low birthweight tracked far below that of children with normal birthweight. While the association between birthweight and length of the baby is by no means surprising since weight and size are closely associated, this finding is indicative of the importance of the prenatal period and the maternal environment for healthy growth and development, and corroborates previous studies (P. Christian et al., 2013; MAL-ED Network Investigators, 2017).

Maternal age at birth, specifically being adolescent, was a further maternal factor that determined the growth trajectory in the first six months of life. Babies born to mothers aged 19 years or younger were smaller at birth and continued to track below the growth trajectory of those babies born to older mothers, but differences did not persist beyond six months. Similarly, a joint analysis of birth cohort studies from five countries found that children born to adolescent mothers were shorter at two years (Fall et al., 2015). In an Indian study, adolescent pregnancy was associated with child growth through lower levels of education, lower socioeconomic status and poorer nutritional status among adolescent mothers (P. H. Nguyen, Scott, Neupane, Tran, & Menon, 2019). In the present cohort, however, adolescent mothers were more likely to have attended school, less likely to be among the poorest asset quartile, and were 0.5 cm taller at the six-year follow-up. The better non-biological drivers of child growth, i.e. the higher levels of education and higher socio-economic status, among adolescent mothers could explain the catch-up in growth over the first six months of life. The smaller size at birth in babies born to adolescent mothers may be explained by the initially mentioned competition for resources between the growing mother and the growing foetus (Scholl et al., 1994). A fraction of the effect of maternal age might also partly be explained by the fact that most - but sadly not all - of the adolescent mothers were primigravidae and the babies of primiparous women tend to be smaller than those of later births (Billewicz & Thomson, 1973).

Another maternal factor that determined infant growth throughout the first two years of life is education. At birth, I found no difference between children of mothers who had ever been to school, but from two months onwards, the LAZ of children whose mothers had attended school declined at a lower rate than of those whose mothers had never been to school, and the difference persisted until the end of the study. A similar pattern was found in a pooled analysis of 33 birth cohort studies from low-and middle-income countries where LAZ did not differ by maternal education at birth but became increasingly important over the child's first two years of life (Mertens et al., 2020). Using data from the same geographical area to study the association between age at marriage and child growth, and adjusting for maternal education, J. C. K. Wells et al. (2022) found that babies whose mothers had at least secondary education had lower odds of stunting than those of mothers without any education at age six to twelve months, but this was not found amongst neonates. Another study in the same geographical area as the GMS found that children of mothers with secondary education were taller than those of mothers with no education (Devakumar et al., 2017). A study from Nepal using nationally representative data found maternal education to be inversely associated with the risk of stunting (Dorsey et al., 2018). Using data from four rounds of Demographic and Health Surveys (DHS), authors found maternal education to be one of the main drivers of improvements in child linear growth in Nepal between 1996 and 2011 (Cunningham et al., 2017). A similar analysis additionally using the latest round of DHS from 2016 corroborated these findings (Hanley-Cook et al., 2022). The mechanism through which maternal education affects infant growth is likely through better knowledge about care and feeding practices. For example, children of mothers with no education have been found to be least likely to receive the minimum acceptable diet (National Planning Commission [Nepal], 2020a). In a community-level intervention focused on livestock management, maternal education was found to mediate the intervention's effect on child growth and practices related to better child growth such as dietary diversity and hygiene practices (Miller et al., 2017). The authors concluded that "Wealth accumulation at the household level may have allowed more educated women to influence childcare practices, resulting in improved hygiene, child growth, and diet."

I observed no difference in LAZ by maternal absence and feeding arrangement in the first six months, but a difference, albeit very small, at around 18 months. There are various possible explanations for the lack of association in the first six months and the very small difference in later life. Firstly, the number of mothers working away from home was very small at the younger ages (7% and 8% at follow-up three and six, respectively). Secondly, the indicator does not differentiate by the duration of absence and includes a wide range, between one and nine hours per day. Thirdly, it is unclear how children were cared for and what they were fed when they were with other carers. We know that as children grew older, from about 15 months, they were increasingly fed animal milk (up to 56% of children who were with other carers at follow-up 24). Feeding expressed breastmilk or sugar water was very uncommon, only one occasion was reported for each. But for most children, we have no information available about the quality of food and care received in the mother's absence. The age when children who were left at home without feeding arrangements while their mother worked away from home had a noticeably lower LAZ than the reference group (around 18 months) coincided with the seasons autumn and winter, which is the transition time between the lean season and harvest (Saville et al., 2021). Indeed, the duration of absence of those mothers who did work outside the home was highest at follow-up 18 (mean age 16.7 months) with 3.3 hours per day compared to 2.1 to 2.8 hours at the other occasions, probably due to the higher workload during harvest season. It is possible that food scarcity and prolonged duration of mother's absence without any feeding arrangements explains the slight drop in LAZ at this age. Another study in Nepal found mothers' workload to be negatively associated with child height-for-age *z*-score (HAZ) as well (Kulkarni, Frongillo, Cunningham, Moore, & Blake, 2021). The conflicting demands on mothers' time were also mentioned in a qualitative study exploring the factors that lead to the decline in stunting prevalence in Nepal. Mothers in communities mentioned that a decline in workload over the past two decades allowed them to dedicate more time to child feeding (Conway et al., 2020).

Season was included in the final models in both age-periods, but only in the later period (7 to 24 months) was there a significant difference in LAZ between seasons. Children had the lowest LAZ in winter and the highest in monsoon. This finding is consistent with that of Saville et al. (2021) in the same region of Nepal where authors found neonates to be shortest in winter and longest during the hot season. Additionally, they found a second peak in LAZ during spring which I did not observe in my cohort. In this population, the winter season is preceded by the lean post-monsoon season (Saville et al., 2021) and it is possible that there is a lagged effect of food scarcity on growth in height. This explanation was offered by other authors who observed similar patterns. A pooled analysis using data of eight cohort studies found that wasting or declines in weight-for-length *z*-score (WLZ) were followed by lower LAZ, and authors mentioned seasonality in agriculture or infectious diseases as one potential driver behind the variability in WLZ (Richard et al., 2012). Longitudinal studies in Malawi and the Gambia arrived at similar conclusions (Maleta, Virtanen, Espo, Kulmala, & Ashorn, 2003; Schoenbuchner et al., 2019). Likewise, the higher LAZ in the monsoon season could be a lagged effect of the higher food availability during spring where Saville et al. (2021) observed seasonal peaks in mid-upper arm circumference (MUAC) among mothers. There are different possible explanations for the lack of differences by season in the birth to six months growth period. Firstly, the growth of children under six months depends largely on the prenatal environment, breastfeeding and general care practices, and they are less dependent on the outer environment. Secondly, only the first 8% of babies enrolled in the study were born in spring, the majority was born in monsoon, and all the information that we have about the growth of the babies during spring in the birth to six months age-period comes from these birth measurements. The results therefore must be interpreted with caution.

Children with symptoms of respiratory infection had a 0.1 lower LAZ than children without symptoms in the first six months of life, but there was no effect in the later age-period. Although respiratory infection frequently gets listed as one of the risk factors for poor growth (Black et al., 2008; Black et al., 2013; Stewart et al., 2013), I am not aware of any study that found an association. A pooled analysis of seven cohort studies, including from Nepal, found no association between symptoms of acute lower respiratory infection and growth in under two-year-old children (MAL-ED Network Investigators, 2017). The observed effect might be explained by a loss of appetite during infection, or a diversion of energy away from growth towards recovery.

Minimum dietary diversity had an only very small effect on growth. On a conceptual level this is surprising as inadequate dietary intake is listed among the proximal determinants of child undernutrition (Black et al., 2008), but this finding is in line with previous studies that consistently show positive, but often small, effects of dietary diversity on child growth. In Nepal, a decomposition analysis using nationally representative data found that minimum dietary diversity only made a small contribution to the improvements in HAZ from 2001 to 2016 (Hanley-Cook et al., 2020). One reason for the small effect size may be the indicator used. A dietary diversity score is only a rough approximation of the children's micro- and macronutrient intake and does not consider the quantity of food eaten from a food group since even a small amount consumed is enough to be included in the score. This simplification comes at a price. Dichotomisation leads to loss of statistical power, masks the level of variability in outcome between groups and conceals non-linear associations (Altman & Royston, 2006). The further dichotomisation by a pre-defined threshold (≥4 food groups) aggravates these problems. Despite being a crude indicator, minimum dietary diversity is useful because it is simple to measure, standardised and enables comparison between studies and populations. The value of a diverse and high-quality complementary diet extends beyond its small contribution to child linear growth. The complementary feeding period is formative for the development of taste and food preferences (Agostoni et al., 2008) and with the increased availability of highly processed, inexpensive energy-dense foods and rising levels of obesity in low-and-middle-income countries, early exposure to a variety of fresh foods is paramount. As recent research from the Kathmandu valley is showing, the consumption of unhealthy snack foods and beverages among under two-year-olds is very high and negatively associated with LAZ (Pries et al., 2019).

As expected, household food insecurity was negatively associated with a LAZ in children aged 7 to 24 months, possibly be due to micronutrient deficiencies resulting from reduced consumption of nutrient-rich "luxury foods" in times of financial strain (Iannotti, Robles, Pachón, & Chiarella, 2012), or macronutrient deficiency due to a reduction of overall food intake. The evidence from other studies in Nepal has been mixed, with some showing no association (Busert et al., 2016; Dorsey et al., 2018; Osei et al., 2010) and others a higher risk of stunting in food insecure households (Paudel, Pradhan, Wagle, Pahari, & Onta, 2013; A. Singh, Singh, & Ram, 2014). It is possible that intra-household food allocation changes in times of food scarcity (Harris-Fry, Shrestha, Costello, & Saville, 2017) and offers some degree of protection for children at the expense of adults.

Children living in households with a drinking water source on their own premises grew better than those whose household relied on the neighbour's or a public water source, but this effect only appeared after 15 months. This indicator is unlikely to signal water quality but rather ease of access to water. It is likely that families who do not have a water source on their own premises find it more difficult to follow good hygiene practices such as frequent handwashing, cleanliness around the preparation of foods and disposal of baby stools. Poor access to water and sanitation is associated with environmental enteric dysfunction (EED), an acquired enteropathy of the small intestine which in turn has been associated with stunting (Tickell, Atlas, & Walson, 2019). The standard indicator to signal water quality, "improved source of drinking water", could not be used in this analysis because according to its definition, all households included in this study have access to an improved source. Similarly at the national level, where 97% of households in Nepal have access to an improved source of drinking water. However, it seems that this classification is not very meaningful since the water in 75% of households nevertheless contained *E. coli* bacteria (National Planning Commission [Nepal], 2020a).

Toilet use, a further component of the water, sanitation, and hygiene (WASH) realm did not improve the model fit and was therefore not included in the final model. This contrasts with the findings from an analysis of four rounds of DHS data where the drop in open defecation was identified as one of the drivers behind the improvements in LAZ in Nepal (Cunningham et al., 2017; Headey & Hoddinott, 2015). The authors, however, used open defecation at the community-level rather than at the household level, arguing that open defecation is a negative externality because household members are largely immune to much of their own bacteria (Headey & Hoddinott, 2015; Spears, 2013). At the time of this study, the prevalence of open defecation was very high in this population with 78% so that even those families who did use toilets will have been exposed to the faeces and bacteria of their neighbours.

Diarrhoea was not associated with LAZ in either age-period, despite being considered the most important infectious disease in the context of stunting (Black et al., 2008; Black et al., 2013). Like the present study, an analysis of seven birth cohort studies found no effect of diarrhoea on growth but showed that the presence of enteropathogens in non-diarrhoeal stools increased the risk of stunting in the first 24 months (MAL-ED Network Investigators, 2017). The role of subclinical inflammation and EED in the aetiology of child stunting has gained increased attention but could not be addressed in the study because of a lack of data.

In summary, the present study corroborates the central role of maternal factors in the aetiology of child stunting.

Study strengths and limitations

My analysis had several major strengths. The longitudinal design with many observations per child allowed a precise modelling of child growth. The wealth of data available allowed me to consider a large number of potential covariates, many of which were measured repeatedly, and to include factors that have received little attention in previous studies, such as maternal absence for work. Levels of missing data were low and were addressed with multivariate imputation with chained equations. Another important strength of my analysis is that I tested every potential covariate for age-interactions and was thus able to identify determinants that would have been overlooked had I only considered main effects. For example, the effect of water source only became apparent after including an age-interaction. Examining time-varying effects can reveal more specific target groups and important windows for intervention. My study is also subject to some limitations that need to be considered in the interpretation of its results. I used BIC as criterion of goodness of fit and benchmark for the retention of variables in the final models. BIC is a conservative criterion which penalises additional degrees of freedom, whereas other modelling strategies which for example rely on *p*-values <0.05 may be more inclusive. Factors such as mother's food intake in the last trimester of pregnancy, early initiation of breastfeeding, household food insecurity, toilet use, and asset quartile were significant in univariable analyses but did not improve the model fit according to BIC and were therefore not retained in the final models. Arguably, my approach could have resulted in the omission of relevant factors. My aim, however, was to determine the most important determinants of child growth in this population and therefore I decided that this conservative strategy served my purpose better.

My strategy of combining all relevant factors from univariable analyses in one final model might have resulted in two problems. Firstly, it is possible that I over-adjusted for mediators, for example in the case of household food insecurity where minimum dietary diversity could have been on the causal path to child LAZ. As a consequence, the estimated effect of exposure (here household food insecurity) on the outcome LAZ adjusted for the mediator (here minimum dietary diversity) will differ from the effect of exposure (household food insecurity) on the LAZ because the adjustment blocks the component of the effect that goes through the mediator (here minimum dietary diversity) (Hernán & Robins, 2020, p. 226). Secondly, two factors, namely the number of older siblings and the birth-to-pregnancy interval, had to be excluded from the final model in the age-period birth to six months because they caused multicollinearity, most importantly with the indicator adolescent mother. However, I do not believe that excluding these factors led to a loss of important determinants. In the case of birth-to-pregnancy interval, the only group with a discernibly different trajectory were primigravidae, which suggests that the indicator signals maternal age rather than the birth-to-pregnancy interval itself. Maternal age, however, is already included in a separate variable. In the case of the indicator number of siblings, after adjusting for other covariates this variable did not improve the model fit. An alternative modelling approach that could have avoided these two problems and is worth considering for future analyses would have been to fit separate models for each potential determinant, including only those covariates that were identified as relevant in a directed acyclic graph (DAG).

A final limitation relates to my use of the term “determinant” which could be understood to imply causality. As with all observational research, this study cannot ascertain that all the identified risk factors are causal and not merely correlates.

Conclusions

This study echoes previous research that emphasized the role of maternal factors and the prenatal environment in infant growth (Danaei et al., 2016; MAL-ED Network Investigators, 2017; Mertens et al., 2020; J. C. K. Wells et al., 2022). These findings call for public health interventions targeting girls and young women. In Nepal, where women typically get married before getting pregnant, interventions aimed at preventing early marriage must become a priority. While the implications of underage marriage go far beyond child growth faltering (Marphatia, Ambale, & Reid, 2017) and are ultimately a human rights issue, I want to briefly highlight how delaying marriage and consequently first pregnancy until adulthood is vital in the context of child malnutrition. Firstly, early marriage typically has negative consequences for the girls' education in South Asia (Marphatia et al., 2017) and as this study has shown, poor education in turn is negatively associated with child growth. Secondly, education is likely to have a positive effect on women's empowerment and bargaining power which have been shown to be positively associated with child growth in Nepal (Cunningham et al., 2015; Kulkarni et al., 2021). Thirdly, preventing adolescent pregnancy is likely to benefit offspring growth, as this study has shown. Lastly, a study in this population in Nepal has demonstrated that both early marriage and early pregnancy are independently associated with shorter maternal adult height (Marphatia et al., 2021). As this study and previous research consistently has shown, maternal height is an important predictor of child growth. Child marriage is illegal in Nepal and the age of marriage is set to 20 years (or 18 years with parental consent), however, this law has some gaps and is only very weakly enforced (Human Rights Watch, 2016). This is attested by the very high prevalence of child marriage in this cohort where 81% of mothers were married before the age of 18 (data not shown). This emphasis on the importance of the prenatal period and mothers should not imply a diversion of attention away from the postnatal period. Complementary feeding interventions and nutrition education have been shown to have positive, albeit small, effects on child linear growth (Lassi et al., 2020; Panjwani & Heidkamp, 2017) and deserve increased attention.

7 The association between paternal labour migration and the growth of the left-behind children in Dhanusha district, Nepal

Summary

In this chapter I addressed the main objective of this thesis, which is to determine the association between paternal migration for work and the growth of the left-behind children.

I specifically investigated

1. The overall association between fathers' labour migration and the linear growth of children from birth to six years
2. Whether this association between the fathers' labour migration and child growth differs by the duration he has been abroad
3. Whether some child age-periods are more sensitive to the impact of paternal migration
4. The association between paternal labour migration and other measures of child growth at six years, and whether the association differs by the timing of the migration relative to the children's life
5. The association between the cumulative lifetime exposure to net remittances and child linear growth, other measures of child growth (body circumferences, skinfold thickness, body composition, tibia length), and function (grip strength) at six years

I found that

1. Children of labour migrants were shorter than children whose father did not migrate.
2. Children of fathers who recently went abroad (≤ 12 months ago) were shorter than children of non-migrants, but there was no difference between children of longer-term migrants (>1 year) and children of non-migrants.
3. The negative association between fathers' labour migration and the growth of the left-behind children was only apparent at younger ages (≤ 6 months) but not at older ages (12-72 months).
4. Children of labour migrants had lower lean mass, smaller waist and calf circumferences, and smaller subscapular and suprailiac skinfold thickness compared to children whose fathers had never been abroad. I found no differences by fat mass, tibia length and grip strength. The associations differed by the timing of labour migration relative to the children's life but did not reveal consistent patterns.
5. There was no indication of an association between net remittances and any measure of child growth.

7.1 Introduction

Background

Nepal is a highly remittance-dependent economy. Around one fourth of the gross domestic product comes from the money that Nepali workers send home from abroad (World Bank Group, 2022) and much of Nepal's poverty reduction in the past decades has been attributed to the income from remittances (Lokshin et al., 2010; Wagle & Devkota, 2018). The most recent, yet somewhat outdated, Nepal Living Standards Survey (2011) stated that one in three households had at least one member who was currently absent from the household because she/he was abroad (Central Bureau of Statistics [Nepal], 2011). Although the reason for the absence was not reported, it is reasonable to assume that most of these absentees left Nepal for employment overseas.

While foreign remittances are clearly an important source of income for many households, the absence of a large share of men and women in their prime age has far-reaching consequences for the home communities, particularly for the left-behind families.

Children of labour migrants are typically left behind in the care of the remaining parent or relatives. The 2019 Nepal Multiple Indicator Cluster Survey found that 20% of children under 18 years have at least one parent living abroad, but the overwhelming majority of migrant parents are fathers (19% of children had migrant fathers) (National Planning Commission [Nepal], 2020a). It is reasonable to assume that the parent's decision to seek work abroad and leave the child(ren) behind is to some extent motivated by the hope that the additional income generated overseas can be geared towards better wellbeing and prospects for the child(ren). As I described in detail in the conceptual framework (Chapter 1.4), a parent's migration can potentially affect the left-behind child in both positive and negative ways, and it depends on circumstantial factors whether the costs outweigh the benefits. These include, among others, the age of the child, the duration of migration, whether mother, father or both go abroad and who takes care of them in their absence, and the costs and remittances of migration and how these are spent.

Linear growth is a potent marker of child overall wellbeing and the extent to which the child's needs for overall care, adequate nutrition, stimulation and hygiene are met (Tanner, 1992). Low height-for-age is therefore indicative of circumstances that do not allow children to thrive and develop to their full potential (de Onis & Branca, 2016). This makes linear growth a suitable outcome to study the effects of parental migration on the child's wellbeing. Although the prevalence of stunting, defined as height/length more than two standard deviations below the age-sex specific median of a healthy reference population, has been declining considerably in Nepal over the past decades, it remains high at 31.5% (National Planning Commission [Nepal], 2020a). In addition to linear growth, I included further measures of child growth as secondary outcomes to provide a more comprehensive picture of the impact of parental labour migration on the left-behind child's physical development.

The evidence on the association between parental migration and child growth is dominated by research on internal labour migration in China, while other countries and international labour migration have been studied much less (please see the systematic review in Chapter 2). I identified only one study from Nepal (Kunwar et al., 2020) using secondary cross-sectional data, which found no differences in undernutrition prevalence between left-behind children and children of non-migrants. The authors argued that it was possible that children of labour migrants initially had worse nutritional status and that the income from remittances had helped them catch-up with their non-migrant peers, but that longitudinal studies were needed to determine such processes.

Research questions and hypotheses

In this chapter I addressed the following research questions

Research question 1: Is there a difference between the linear growth of children of labour migrants and non-migrant fathers?

The findings from the systematic review presented in Chapter 2 indicate a negative effect of parental labour migration on child growth. However, most studies included in this review were from China where not just fathers but also mothers or even both parents migrate and leave their children in the care of grandparents, other relatives, or neighbours while they move to the cities within the country for work. In my study population, it is only the fathers who go overseas while the mothers generally remain at home, often within extended families. For the children this means that the main carers stay with them so I find it plausible to assume that the potential negative impact on the children will be smaller, whereas the children nevertheless may benefit from the increased income through remittances. For this reason, I expected a net benefit of father's migration for child growth.

Hypothesis 1: Children of migrant fathers are taller for their age than children of non-migrants.

Research question 2: Is there an association between the duration that the migrant fathers have spent abroad and the linear growth of the children?

In Chapter 5.8 I showed that sending a household member overseas is a substantial investment. Most men finance their migration by taking a loan from a traditional moneylender with a median interest rate of 36% per annum. Incorporating the considerable interests paid, the median total costs of migration amount to NPR 163,200 (IQR 136,000-204,000) (equivalent to GBP 1,142 (GBP 952-1,428)[17]). According to the Nepal Living Standards Survey (2010/2011), the median annual household income is NPR 127k (GBP 889) (Central Bureau of Statistics [Nepal], 2011), which means that sending a migrant abroad is an investment that corresponds to 128% of a household's annual income. Most migrants do send home money, but it takes a median of four months (IQR 3 to 5) until they can remit for the first time because it takes time to get settled in the destination country and earn enough money to send it back home. Considering the large investments made and the time lag until these are paid off and a net benefit is accrued, and taking into account that the father's going away can initially have a disruptive effect on the family, I assumed that there is an association between the duration of migration and the growth of the child.

Hypothesis 2a: Shortly after the fathers' going abroad the children's growth will be negatively affected and children of migrants are smaller than children of non-migrants.

Hypothesis 2b: Children of longer-term migrants grow better than children of recent migrants or non-migrants.

Research question 3: Is there an age-period when children's linear growth is more sensitive to the impact of fathers' migration?

In the first six months of life children are ideally exclusively breastfed and mostly rely on their mother's care in order to thrive, and I assume that breastfeeding practices and the quality of maternal care are unaffected by the father's migration status. Once the children are introduced to complementary foods, they need a nutritious and diverse diet to develop to their full potential, but high-quality foods are expensive. In Chapter 5.8 we saw that in 54% of migration cycles households used remittances to purchase food,

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[17] Using a NPR to GBP exchange rate of 0.007, the average exchange rate in 2016 (www.exchangerates.org.uk, n.d.-b)

so it is likely that households of migrants have a more nutritious diet, which ultimately benefits the growth of the child.

Hypothesis 3: The association between fathers' migration and child HAZ is larger in the complementary feeding period compared to the exclusive breastfeeding period.

Research question 4: Is there an association between the fathers' migration and other measures of child growth (body circumferences, skinfold thickness, body composition, tibia length) and function (grip strength) at six years, and does the association differ by the timing of the migration relative to the children's life?

Similar to the points made in relation to research questions one and three, it is plausible to assume that the presence of the mother as the main carer can protect the child from potential negative effects of paternal labour migration, but that the child can benefit from the increase in family income, especially after the exclusive breastfeeding period.

Hypothesis 4a: Children of migrants have wider body circumferences, skinfold thickness, larger amounts of fat and lean mass, longer tibia and higher grip strength compared to children of non-migrants.

Hypothesis 4b: The association between father's migration and these measures of child growth is larger in the complementary feeding period compared to the exclusive breastfeeding period.

Research question 5: Is there an association between the amount remitted and child HAZ and other measures of child growth (body circumferences, skinfold thickness, body composition, tibia length) and function (grip strength) at six years?

With a median total amount of remittances of NPR 400k (GBP 2800) from each cycle of migration, the additional income from migration is considerable, but it should be noted that there is substantial variability with an IQR of NPR 200k to 700k (GBP 1,400-4,900). When asked about how the remittances are used, many households mentioned factors that can ultimately benefit the growth of the child by improving their diet, medical care, and home environment: Purchase of food (54%), health and medical expenses (63%), or building a toilet (15%).

Hypothesis 5: There is a positive association between the amount remitted and child growth in terms of HAZ, and body circumferences, skinfold thickness, body composition, tibia length and grip strength

7.2 Methods

Outcomes

I used the original GMS data collected from 2012 to 2014 to determine the child's LAZ at birth, six months, one year, and two years of age, and the measurements taken in 2018 were used as the child's HAZ at six years. Hereafter, I will use the term HAZ to refer to both LAZ and HAZ. Body circumferences (head, mid-upper arm (MUAC), waist, hip), skinfold thickness (biceps, triceps, suprailiac, subscapular), body composition (lean mass (kg), fat mass (kg), fat mass index (kg/m^2), lean mass index (kg/m^2), lean mass *z*-score, fat mass *z*-score (using UK reference data (J. C. K. Wells et al., 2012)), tibia length and grip strength (kg) were measured at the six-year follow-up in 2018. Fat mass index and lean mass index are height-adjusted outcomes. All outcomes were continuous except for grip strength. The dynamometer used to measure grip strength has a lower threshold of 5kg and for those children who did not manage to pass this threshold no value was displayed. In order to be able to include those children for whom no grip strength could be measured I decided to use a categorical variable with one category for grip strength less than 5kg.

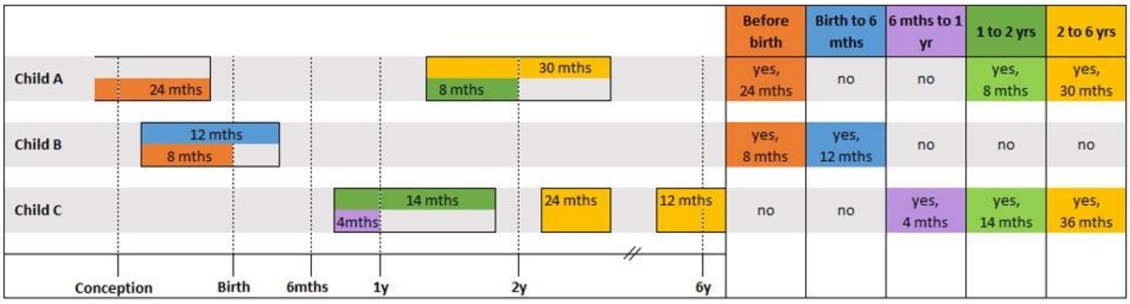
Calculation of father's duration abroad in relation to the child's lifetime

To determine the child's exposure prior to the selected time points (i.e., birth, one year, two years, six years) I had to calculate the father's exact dates of migration. In the 2018 follow-up questionnaire I had asked the respondents to only name the year and month that the migrant had left and returned. I did not ask for the day of the month because I suspected that most interviewees would not be able to remember and because that level of precision was not necessary. The dates were recorded in the Nepali calendar, but I had to convert them to the Gregorian calendar to be able to use the dates in statistical programmes. To do so, I assumed that the migrant had left/returned on the first day of the respective month in the Nepali calendar. After concatenating the event's year, month and day into the format YYYYMMDD, I used the Stata command `nepengdate` (written by James Beard, not published) to convert them to the Gregorian calendar. I then subtracted the child's date of birth from the date that the migrant had left or returned, which gave me the number of days that this event happened relative to the child's date of birth. A negative number of days meant that the event had happened before the child was born, a positive number indicated the child's age in days that the event had happened. For each of the selected time points (birth, six months, one year, two years, and six years) I calculated whether the child had been exposed to labour migration in the *preceding* time period, i.e., from the previous time point to this one (e.g., from birth to six months for time point 6 months, from six months to one year for time point one year, etc.).

If the child had been exposed to the father's migration in the preceding time period, I recorded the duration of exposure to this particular cycle of migration. I counted all migration cycles that extended into the respective time period. If the respective cycle started in an earlier time period, then this cycle was counted as well in its full duration. If the child had been exposed to more than one cycle of migration within one period, the duration of all of these migration cycles were added up. This was mostly relevant in the period preceding 72 months (six years) because this period spanned four years (from two to six years) in which several migration cycles could have taken place. I also considered migration before conception, but only if the respective cycle of migration ended less than one year before childbirth.

Figure 7.1, panel A visualises the paternal migration trajectories of three hypothetical examples in a timeline and demonstrates how these were summarised to convey the child's exposure to migration. Child A's father worked abroad for 24 months before the child was born and returned shortly before Child A's birth. Therefore, the duration of exposure to migration in the period before birth is 24 months. In the growth periods from birth to six months and six months to one year the father was not abroad and child A is coded as not having been exposed to migration. In the period between 12 and 24 months, the father migrated and had been away for eight months by the time the child was 24 months old. This migration cycle extended into the period two to six years and for the time point six years child A was coded to have been exposed to 30 months of paternal labour migration. Child B's father left for labour migration shortly after his/her conception and had been absent for eight months by the time he/she was born. This cycle of migration ended between birth and six months and child B was coded to have been exposed to 12 months of paternal labour migration when it was six months old. For the following time points (one, two and six years) child B was coded as not having been exposed to paternal labour migration. Child C's father left for the first time between six and 12 months and by the time she/he was one year child C had been exposed to four months of labour migration. This migration cycle only had a total duration of 14 months and ended before the second birthday, so child C was coded to have been exposed to 14 months of paternal labour migration in the period preceding two years (i.e., from one to two years). Between two and four years, child C's father left twice to work abroad. The first cycle of migration had a total duration of 24 months, the second was still ongoing by the time the child was six years and he had been absent for 12 months at the time. For the time point six years, child C was coded to have been exposed to paternal labour migration a total of 36 months. Panel B illustrates how these three children would have been coded in a data frame.

A



B

Child	age_months	abroad_months
A	0	24
A	6	0
A	12	0
A	24	8
A	72	30
B	0	8
B	6	12
B	12	0
B	24	0
B	72	0
C	0	0
C	6	0
C	12	4
C	24	14
C	72	36

Figure 7.1: Examples of fathers' migration trajectories relative to the children's age and their operationalisation into categories of exposure. Panel A visualises the paternal migration trajectories of three hypothetical examples in a timeline and demonstrates how these were summarised to convey the child's exposure to migration. Panel B illustrates how these three children would have been coded in a data frame.

Categorising duration of exposure to father's migration

I decided to use a categorical variable of father's duration of migration rather than a continuous variable because this allowed me to include one category for non-migrant fathers. In order to address research question 2, I differentiated between short- and long-term migrant fathers. To select appropriate cut-off points I first plotted the duration of the father's stay abroad against the child's HAZ (using the `loess` smoother (Cleveland, Grosse, & Shyu, 1992)) to see whether I could detect a pattern. I tried different cut-off points in terms of father's duration abroad and chose the one that had the best model fit in terms of BIC. I visualize the categories of migration duration over the study period in a stacked barchart and a horizontal line plot (using the package `longcateda` (Tueller, 2017)).

Calculation of fathers' net remittances

Most interviewees were unable to indicate the amount and frequency with which the migrant sent back home money and could only provide a lump sum of remittances over the migrant's whole migration cycle. For this reason, it was not possible to link remittances to specified child ages as I had done with the duration of father's migration. Instead, I could only calculate the cumulative amount remitted over the child's lifetime. We had no means of verifying the accuracy of the named lump sum, but I compared whether the total amount of remittances from one cycle of migration was different between households that remembered the amount and frequency of the money that they received and those who only indicated a lump sum. The median amount remitted was smaller for those who only indicated a lump sum (NPR 350k (IQR 175k-720k) or GBP 2450 (IQR 1225-5040)) compared to those who indicated regular remittances (NPR 602k (IQR 344k-1051k) or GBP 4216 (IQR 2411-7353)). I do not know whether this difference is because migrants who remit regularly also remit more and household members thus find it easier to remember those transfers, or because the respondents underreported or underestimated the received remittances. As noted in Chapter 5.8, international labour migration is a substantial investment and there is considerable variability in the total costs of migration. I therefore decided to calculate the *net* remittances by summing the father's total costs of migration across all migration cycles recorded over the seven-year recall period and subtract it from the total amount remitted in that same time period.

Potential confounding factors

Potential confounding factors in the relationship between the respective exposure and child growth were identified using Directed Acyclic Graphs (DAGs) and the software `DAGitty` (Textor, Hardt, & Knuppel, 2011). DAGs are causal diagrams representing the assumed relations between exposure, outcome and covariates, and are used to identify sources of bias in observational research (Greenland, Pearl, & Robins, 1999).

Research questions 1-4 – Association between paternal migration and child growth: As discussed in Chapters 1.4 and 4.3, migration is not at random but a very deliberate decision. I therefore had to determine factors that influence a father's decision to go abroad and that are also associated with child growth. I assumed that the decision to migrate depends on the potential migrant's ability and need to seek an income abroad. While the very poorest and uneducated might not be able to secure a migration loan, the better-off households with existing sources of cash income will feel no need to send any of their members overseas. I further assumed that food insecurity could drive a household's decision to send one of their males abroad. A further potentially confounding factor is whether any household member other than the father is also a migrant. On the one hand, migrant networks have been discussed in the literature to lower the costs of migration and make it easier to also seek work away from home (Haug, 2008). On the other hand, the remittances sent by another household member could lower the financial pressure on the father to also leave his family. Figure 7.2 visualises my assumptions of the potential confounding factors.

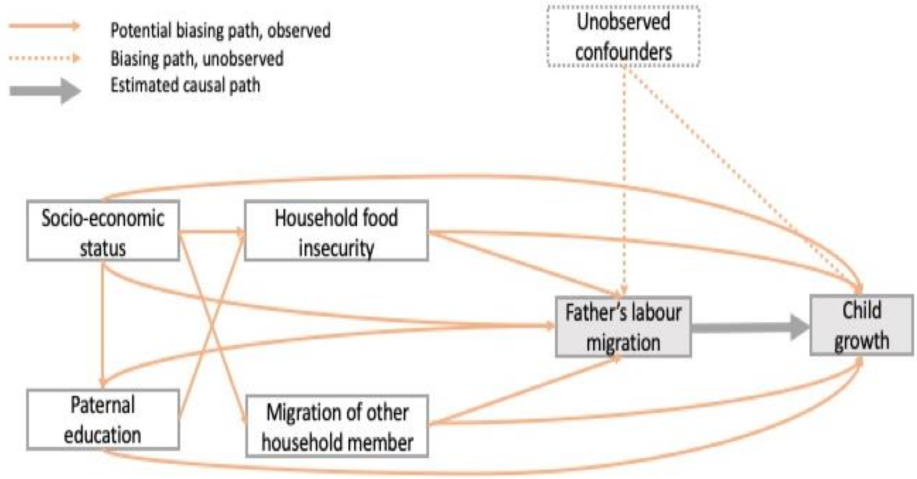


Figure 7.2: Directed Acyclic Graph (DAG) of the relationship between father's labour migration, child growth, and potential confounding factors.

Research question 5 – Association between father's net remittances and child growth: The amount of remittances that the father sends back home depends among other things on the destination country, the job that he obtains overseas, most importantly the salary and additional benefits such as employer-provided housing. One can assume that a potential migrant with higher education and better financial resources will be more likely to access trustworthy brokers and negotiate a better contract. If another member of the household is already overseas or has experience from past migration stints, he will be able to lower the costs of migration for the father by sharing information on good job opportunities, cheap remittance channels, and economical living overseas. These potentially confounding pathways are illustrated in Figure 7.3.

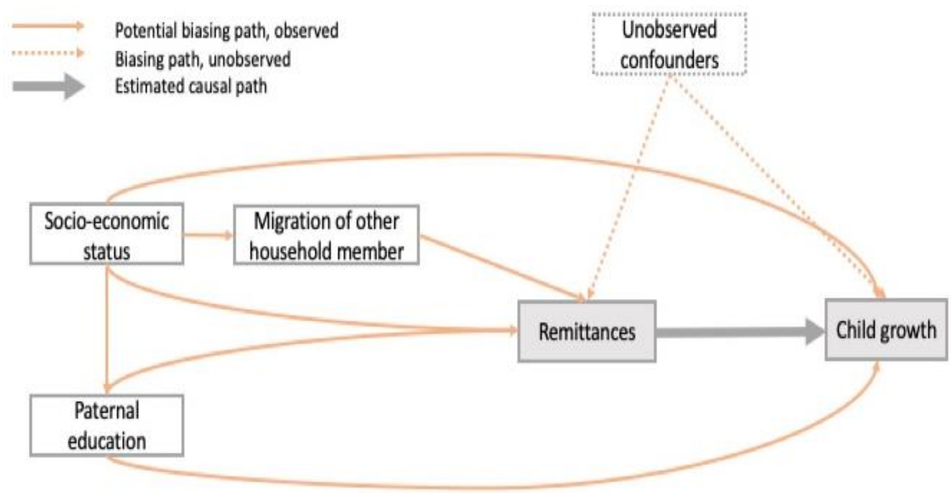


Figure 7.3: Directed Acyclic Graph (DAG) of the relationship between remittances, child growth, and potential confounding factors.

Socio-economic status: I calculated asset scores at baseline (childbirth) and the last follow-up (six years) using principal component analysis, and stratified households into score quartiles. I further adjusted for maternal height as an indicator of deprivation in the mother's early life and the family's long-term economic position. Including maternal height also adjusts for the genetic component of growth.

Paternal education: The father's level of education was included as a categorical variable: No education, primary to lower secondary education (class 1-8), secondary and above (class 9 and above).

Household food insecurity: Food insecurity was assessed at baseline and the six-year follow-up using the FANTA Household Food Insecurity in Access category (Coates et al., 2007) which captures the respondent's experience of household food insecurity over the 30 days preceding the interview. The questionnaire contains nine questions which cover three domains of food insecurity: 1) anxiety and uncertainty about the household food supply, 2) insufficient quality of foods, and 3) insufficient quantity of foods and its physical consequences. Because of the low number of households reporting food insecurity, I only classified households as either being food secure or suffering from any level of food insecurity but did not differentiate by severity of food insecurity.

Migration of another household member: To determine the exposure to another household member's migration I followed the same procedure as with the father's migration. I tested whether differentiating between duration of migration made a difference in terms of child HAZ but found that a binary variable indicating the migration of another household member in the preceding period resulted in the best model fit.

Regression analysis

Research questions 1-3: I fitted mixed-effects regression models to account for repeated measurements within children (see Chapter 4.3) using the R library `nlme` (Pinheiro et al., 2018). The child's age was fitted using splines and I used BIC (Kuha, 2004) to compare goodness of fit between models. The distributions of random effects and residuals were assessed visually: Normality of random effects was assessed with histograms, constant variance (homoscedasticity) of residuals was assessed using residuals plots, and normality of residuals was assessed with Q-Q plots.

Research question 4: I used linear regression models to estimate the relationship between father's migration and body circumferences, skinfold thickness, body composition and tibia length at six years. I visually checked normality and homoscedasticity of residuals. For the categorical outcome grip strength I fitted ordered logistic regression models using the `polr` command from the MASS package (Venables & Ripley, 2002).

Research question 5: I used linear regression to estimate the relationship between the cumulative amount of the fathers' net remittances over the children's lifetime and child HAZ, body circumferences, skinfold thickness, body composition, tibia length, and grip strength at six years. I visually checked normality and homoscedasticity of residuals.

7.3 Results

Descriptive results

The migration history was only available for those children who had been followed up at six years (*n*=529). Of these, four had missing information on maternal height and were excluded from the analysis, so that the final analytical sample included 525 children with a total of 2562 observations. One girl could not be measured at the six-year follow-up because she had acquired a disability and was unable to stand up or stretch her legs. Of the 356 households with migrant fathers, 309 had information on the sum of remittances sent. Observations with missing remittance data were not included in this part of the analysis.

Table 7.1: Sample characteristics (time-invariant variables) (*n*=525)

	Mean (SD)	*n*
Body circumferences (cm)		
Head	48.2 (1.3)	524
Mid-upper arm (MUAC)	15.1 (14.4-16.1)	525
Waist	49.2 (47.5-51.0)	525
Hip	52.5 (50.5-54.2)	525
Calf	20.3 (1.4)	525
Skinfold thickness (mm)		
Biceps, median (IQR)	4.1 (3.7-4.8)	524
Triceps, median (IQR)	6.0 (5.1-7.1)	523
Subscapular, median (IQR)	4.6 (4.1-5.1)	521
Suprailiac, median (IQR)	5.2 (4.4-6.2)	524
Body composition		
Lean mass (kg)	14.0 (1.7)	472
Lean mass index (kg/m²)	11.8 (0.9)	472
Lean mass z-score*	-1.9 (0.9)	472
Fat mass (kg), median (IQR)	2.2 (1.5-2.8)	472
Fat mass index (kg/m²), median (IQR)	1.8 (1.3-2.4)	472
Fat mass z-score*, median (IQR)	-1.6 (-2.4- -0.9)	472
Other outcomes		
Tibia length (cm), median (IQR)	235.5 (226.5-245.5)	515
Grip strength (kg)	6.6 (5.9-7.6)	490
Grip strength		524
<5kg	6.4% (34)	
5 - <6.5kg	41.0% (217)	
6.5 - <8kg	35.2% (186)	
≥8kg	17.2% (91)	
Covariates		
Total costs of father's migration in 10k NPR, median (IQR)	20.4 (15.8-31.3)	345
Total amount of father's remittances in 10k NPR, median (IQR)	60.0 (27.5-111.0)	319
Net remittances in 10k NPR, median (IQR)	32.3 (7.4-86.4)	309
Maternal height (cm)	150.9 (5.5)	525
Father's education		
Never went to school	44.8% (235)	
Primary to lower secondary (class 1-8)	32.2% (169)	
Secondary and above (class ≥9)	23.0% (121)	
Total *n*		525

*Calculated using UK reference data (Wells et al., 2012).

Figure 7.4 A shows a density estimate for the distribution of months that the migrant fathers had been abroad at the respective time point. The distribution is extremely skewed to the right, with a small number of fathers having been abroad for more than ten years. The dotted vertical line indicates the median number of months (26 months). To select appropriate cut-off points to differentiate between short and longer-term migrant fathers (research question 2) I first plotted the duration of the fathers' stay abroad against the children's HAZ to see whether I could detect a pattern. The `loess` function and its standard error bounds in Figure 7.4 B show that shortly after the fathers go abroad, the children's HAZ drops to a nadir at around 20 months of the fathers' going away, from there it increases again until about 40 months and rises at a smaller rate from there onwards. But the large standard error bounds indicate large variability in this trend.

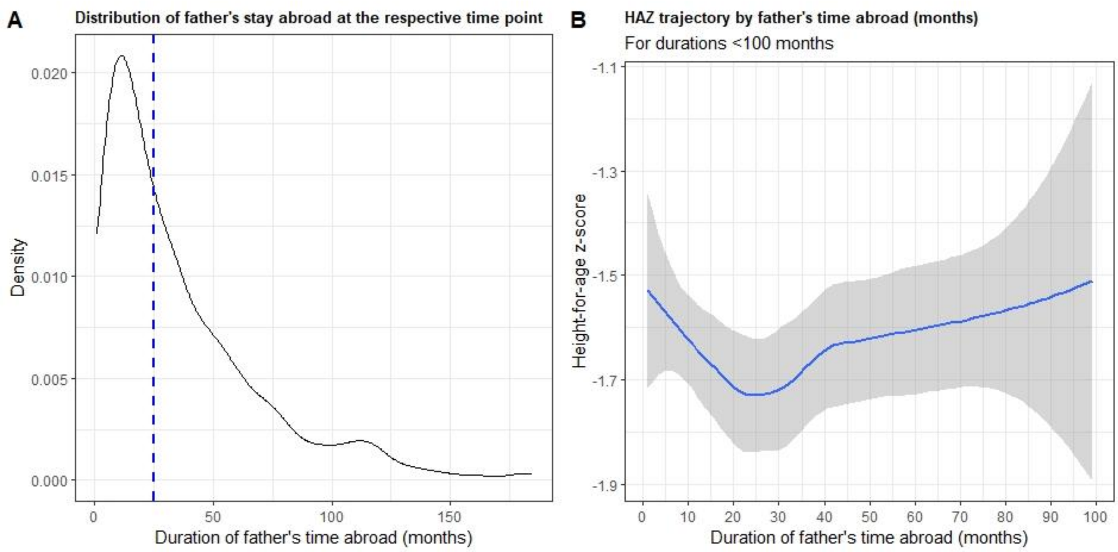


Figure 7.4: Distribution of father's time abroad (A) and height-for-age *z*-score (HAZ) trajectory by father's time abroad (B) (using `loess` smoother).

As described in Chapter 5, the mean HAZ dropped steadily in the first two years of life but had increased again by the time the children were six years old (Table 7.2). Only 32% of fathers had been abroad before the child was born, but the fraction of fathers who had migrated for work in the previous time period increased steadily as the child aged (Table 7.2 and Figure 7.5). At the last measurement, 65% of the fathers had worked overseas at some point between the child's second and sixth birthday. One third (33%, *n*=173) of fathers had never migrated for work within the recall period.

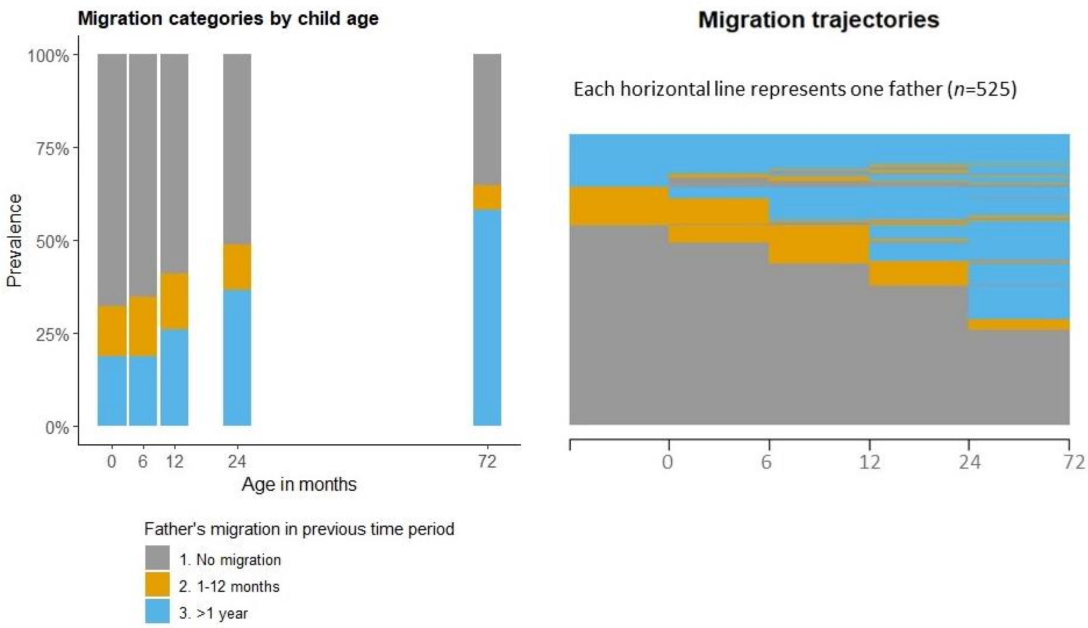


Figure 7.5: Distribution of father's migration and length of stay over the study period. The panel on the left shows the distribution of migration categories at each time point. The panel on the right is a horizontal line plot summarizing individual migration trajectories.

Table 7.2: Sample characteristics (time-varying)

	Birth	**6 mths**	**1 year**	**2 years**	**6 years**
	% (*n*)	% (*n*)	% (*n*)	% (*n*)	% (*n*)
Height-for-age *z*-score (mean, SD)	-1.0 (1.0)	-1.4 (1.0)	-1.7 (0.9)	-2.0 (1.0)	-1.6 (0.9)
Father's migration in the previous time period					
No migration	67.9% (356)	65.3% (335)	59.2% (299)	51.2% (256)	35.3% (185)
1-12 months	13.4% (70)	15.8% (81)	14.9% (75)	12.2% (61)	6.5% (34)
>1 year	18.7% (98)	18.9% (97)	25.9% (131)	36.6% (183)	58.2% (305)
Other household member(s) worked abroad in the previous time-period	9.2% (48)	9.6% (49)	10.9% (55)	13.0% (65)	22.5% (118)
Household suffers from food insecurity	29.6% (155)				26.1% (137)
Total *n*	524	513	505	500	524

Regression results

In the final regression models, I adjusted for paternal education, household food insecurity, maternal height, and migration of other household members. Asset quartile was excluded from the final model as it did not improve the model fit and showed strong collinearity with the remaining covariates but excluding it did not change the effect estimates. Models using data over the whole age range (0-72 months) and of older children (12-72 months) had random effects on both intercept and slope, models using data of younger children (0-6 months) only had random effects on the intercept. Visual assessments showed that random effects were normally distributed. Fixed-effect residuals were normally distributed and had constant variance (Appendix C. 1.).

The overall association between father's migration and child growth (research question 1): Compared to children whose father had not worked overseas in the previous time period, children of labour migrants had -0.08 (95% CI: -0.15, -0.00) lower HAZ (Table 7.3).

Differences in the association between father's migration and child growth by duration of absence (research question 2): Differentiating between children of recent and longer-term migrants revealed that children of migrants who had been abroad for up to 12 months had -0.12 (95% CI: -0.21, -0.04) lower HAZ compared to children of non-migrants. Children of longer-term migrants on the other hand showed no difference compared to children of non-migrants (Table 7.3).

Differences in the association between father's migration and child growth by child age (research question 3): Separating the dataset by child age (0-6 months vs. 12-72 months) showed that the association of HAZ with the fathers' migration was only apparent in the younger children (-0.15; 95% CI: -0.29, -0.01), but not the older ones (-0.05; 95% CI: -0.14, 0.03). Further differentiating by the duration of the father's migration showed that in both age-periods only the growth of children of recent migrants (≤12 months) was negatively affected (age-period 0-6 months: -0.22; 95% CI: -0.39, -0.05; 7-72 months: -0.10; 95% CI: -0.20, -0.01) (Table 7.3). Figure 7.6 visualizes the regression coefficients in Table 7.3. Although the lack of precision in the estimates does not allow inferences about differences between earlier and later age-periods, there appears to be a pattern in that the estimates for children between birth and six months are consistently lower than for children aged 12-72 months, indicating that younger children may be more negatively affected by the fathers’ migration.

Table 7.3: Results from mixed-effects regression to estimate the impact of father's migration and the duration of his stay abroad on child height-for-age *z*-score, at 0-72 months, 0-6 months, and 12-72 months.[1]

	0-72 months[2]			**0-6 months[3]**			**12-72 months[4]**		
	Coef	95% CI	*p*	Coef	95% CI	*p*	Coef	95% CI	*p*
Father is not a migrant	Ref			Ref			Ref		
Father is a migrant	-0.08	(-0.15, 0)	0.05	-0.15	(-0.29, -0.01)	0.03	-0.05	(-0.14, 0.03)	0.23
Father is not a migrant	Ref			Ref			Ref		
Father has been away ≤12 months	-0.12	(-0.21, -0.04)	0.01	-0.22	(-0.39, -0.05)	0.01	-0.10	(-0.20, -0.01)	0.03
Father has been away >1 year	-0.03	(-0.12, 0.06)	0.53	-0.09	(-0.26, 0.08)	0.32	0.00	(-0.10, 0.10)	1.00

[1] Mixed-effects regression adjusted for father's education, household food insecurity, maternal height, other household member's migration.

[2] Random effects on both intercept and slope. 2566 observations of 525 children.

[3] Random effects on intercept only. 1037 observations of 525 children

[4] Random effects on both intercept and slope. 1529 observations of 525 children

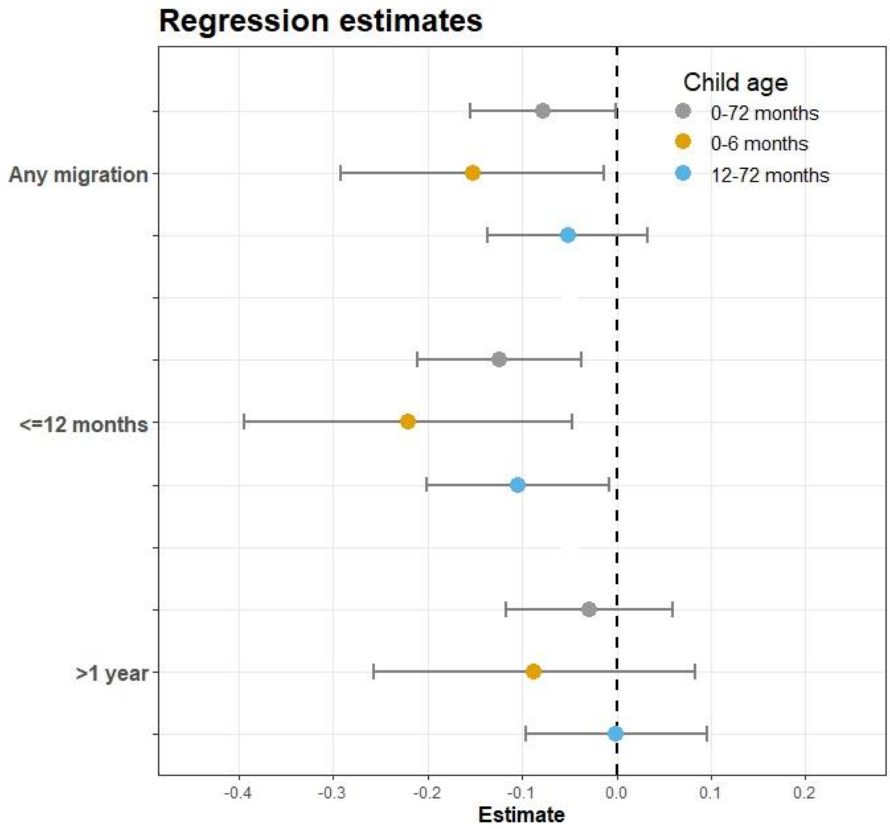


Figure 7.6: Regression estimates on the impact of father's migration and the duration of his stay abroad on child height-for-age *z*-score, at 0-72 months, 0-6 months, and 12-72 months.

The association between father's migration and other measures of child growth at six years (research question 4): The results of the linear regression analysis with measures of child growth and function (grip strength) are displayed in Figure 7.7 to Figure 7.10. The results are additionally presented in a table format in Appendix C. 2.

Children whose fathers migrated at any time in the children's life had a smaller waist and calf than children of fathers who did not migrate for work (Figure 7.7). Differentiating by the timing of migration relative to the child's age showed that migration in the first year of the children's life was negatively associated with head circumference. For some outcomes such as MUAC or head circumference the estimates did not reach or only just reached significance (at alpha-level 0.05) and confidence intervals were generally wide. It should, however, be noted that all estimates for body circumference outcomes were negative, indicating a trend towards smaller circumferences in left-behind children.

Left-behind children had a smaller subscapular and suprailiac skinfold thickness than children whose fathers had not worked overseas during the seven-year recall period (Figure 7.8). Differentiating by child age indicated that migration in the age-period from two to six years was most important. Similar to the results for body circumferences, the estimates were either negative or zero and confirm the overall pattern towards slightly smaller body sizes in left-behind children compared to children of non-migrants.

Children of labour migrants had lower lean mass than children of fathers who never migrated (Figure 7.9). Differentiating by the timing of migration in the child's life showed that migration before birth was not associated with child lean mass, lean mass index or lean mass *z*-score, but migration at any point during the child's life showed a tendency to be negatively associated with these outcomes even if the estimates were not significant. The height-adjusted lean mass index had smaller effect sizes than lean mass, indicating that the smaller amount of lean mass in left-behind children was partially explained by their shorter height. The association between father's migration and fat mass, fat mass index or fat mass *z*-score showed a different pattern. Migration at any point in the child's life was not associated with these outcomes but differentiating by the timing of migration in the child's life showed that migration before birth was negatively associated with measures of body fat, whereas father's migration during the child's life showed no association with these outcomes. Unlike lean mass, the height-adjusted fat mass index had the same effect size as fat mass, indicating that the difference persisted even after taking into account the children's height.

I found no association between father's labour migration and tibia length or grip strength (Figure 7.10).

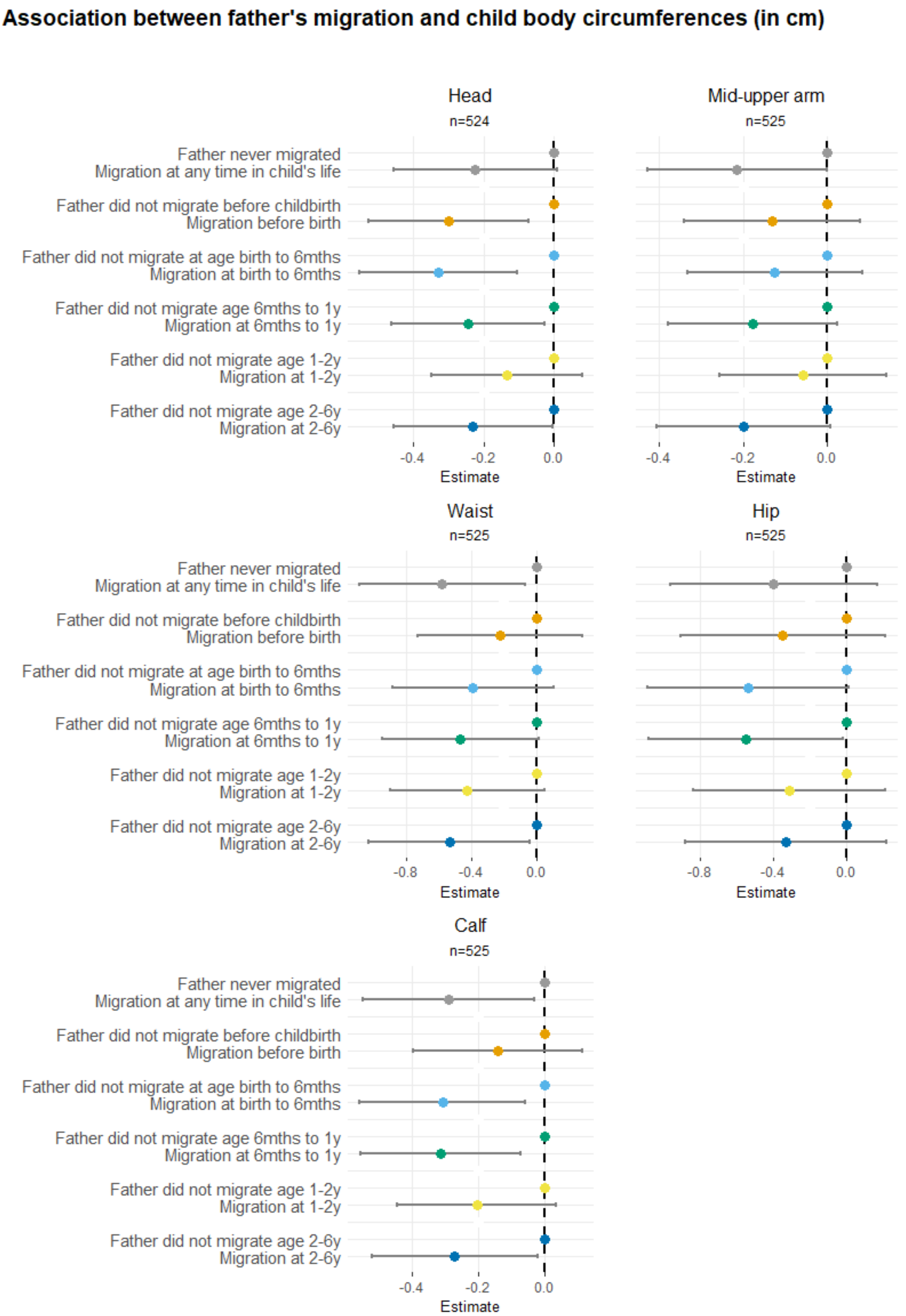


Figure 7.7: Association between paternal migration and body circumferences at six years.

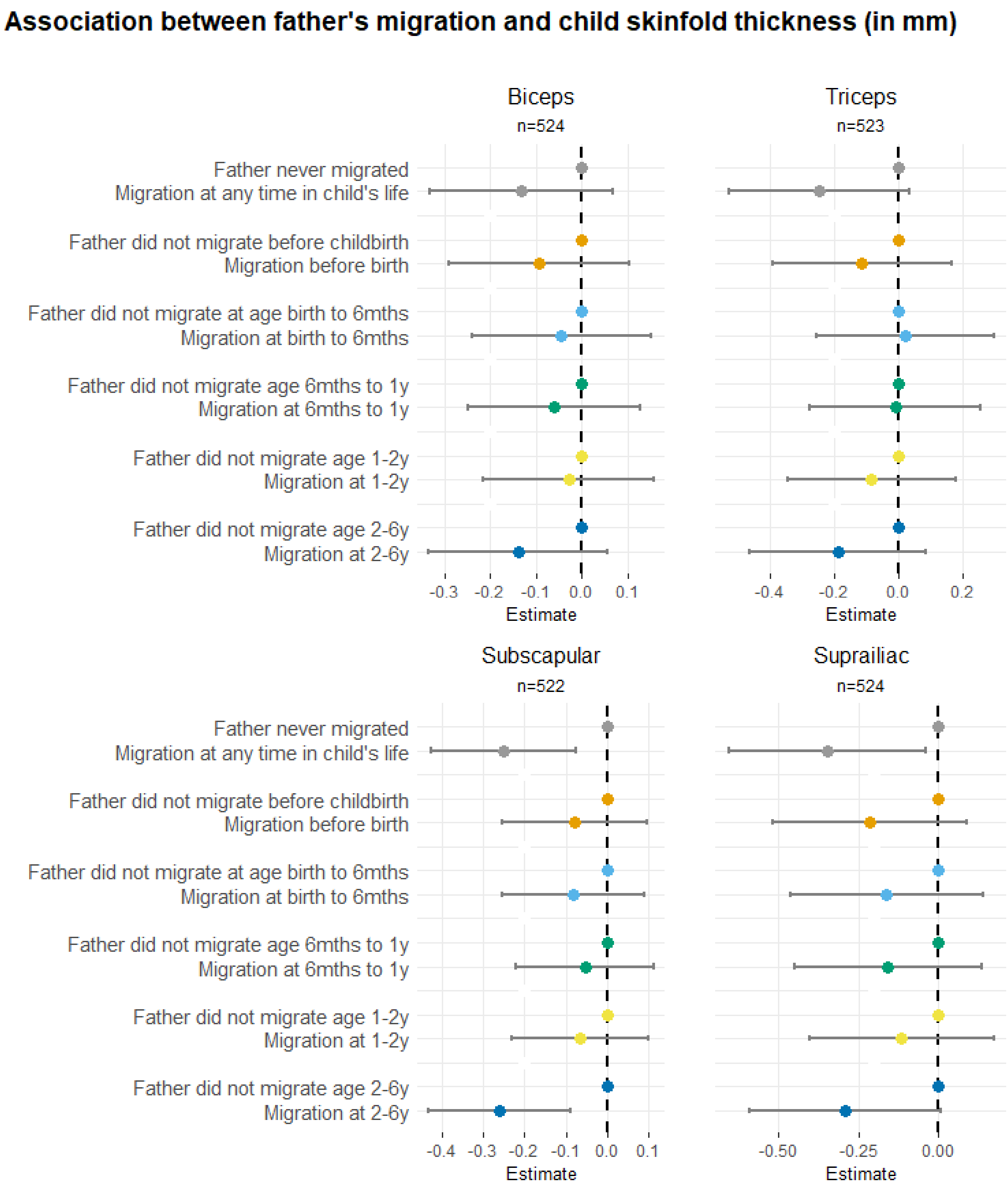


Figure 7.8: Association between father's migration and child skinfold thickness at six years.

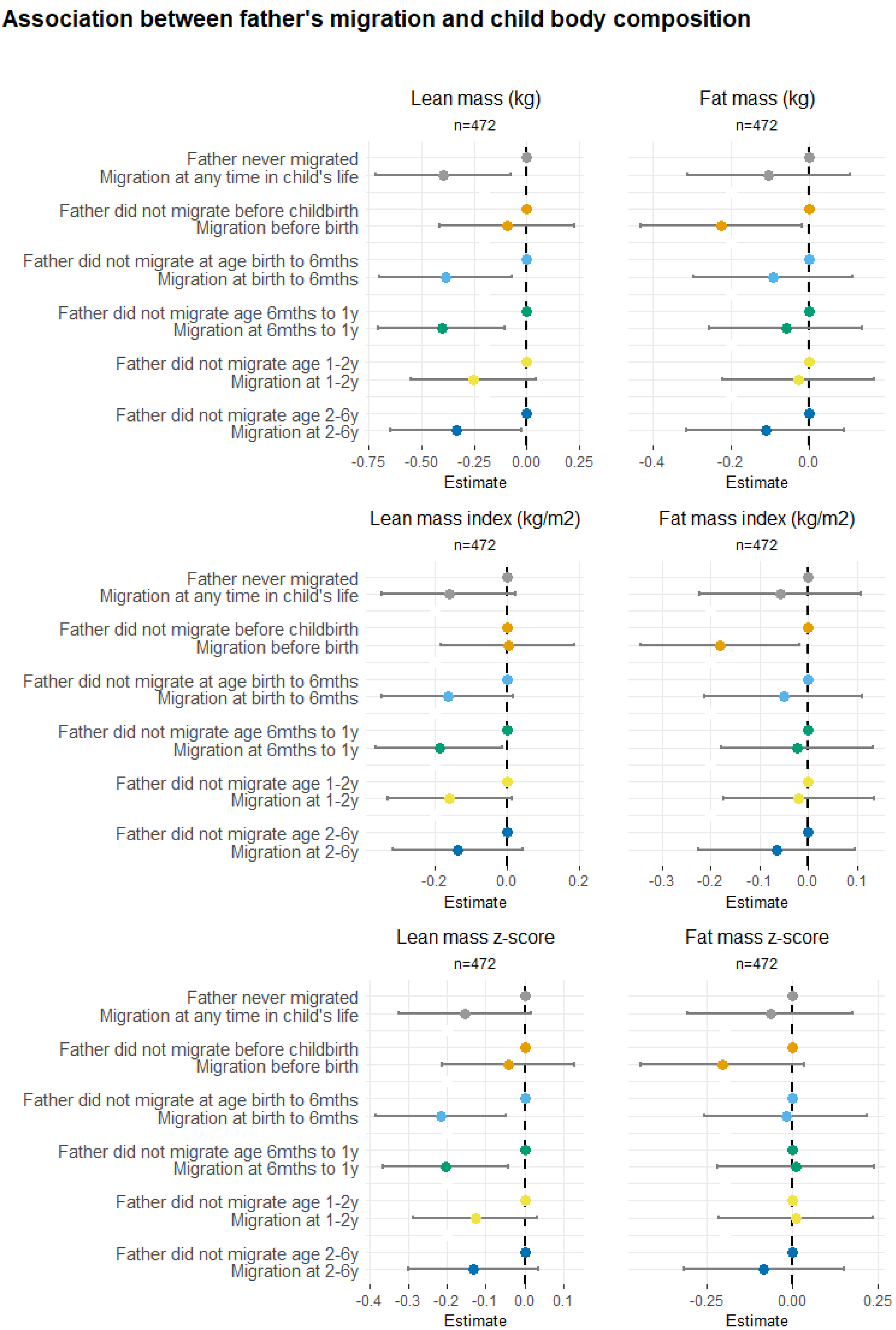


Figure 7.9: Association between father's migration and child body composition at six years.

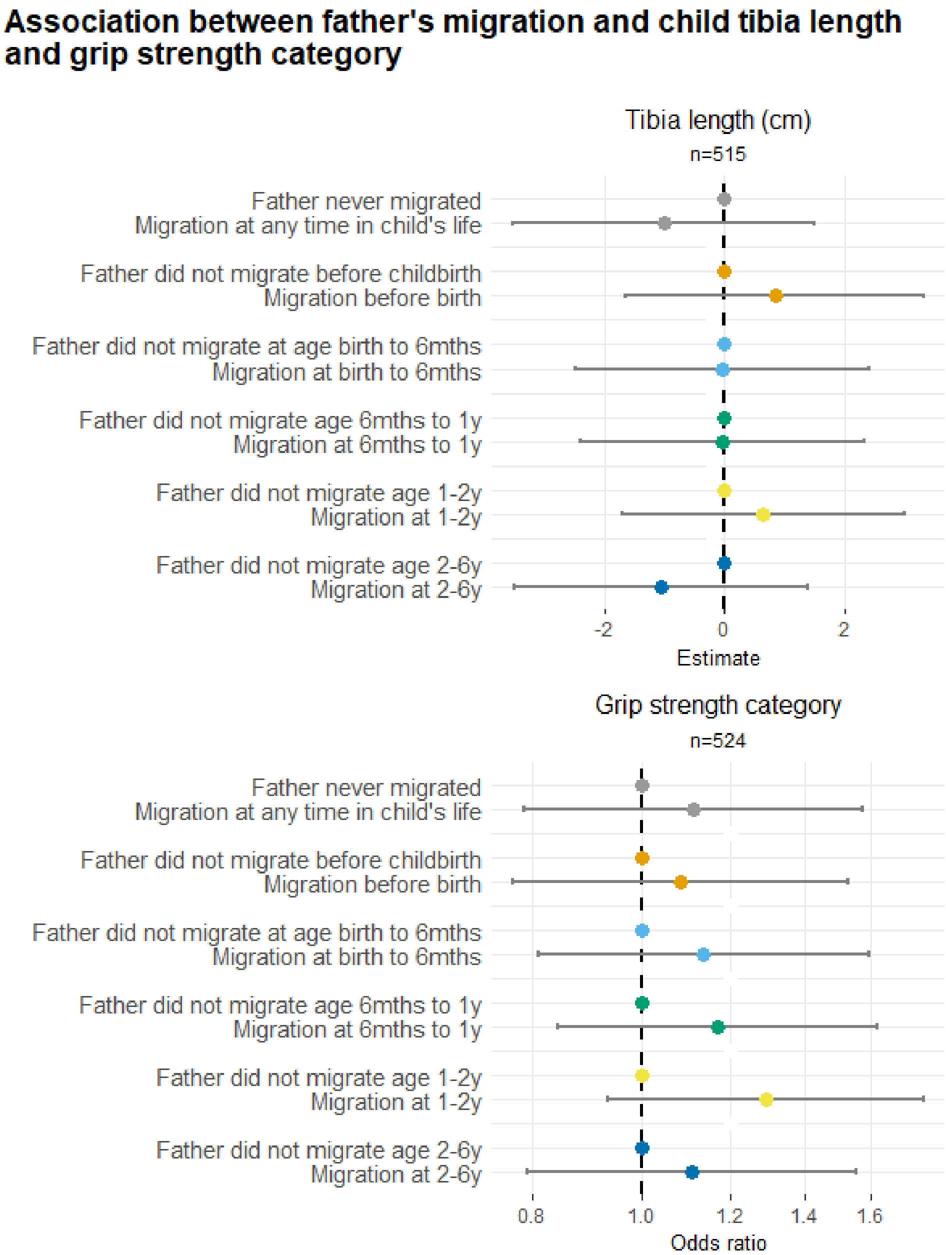


Figure 7.10: Association between father's migration and the child's tibia length and grip strength category at six years.

The impact of father's remittances on child HAZ and other measures of growth at 6 years (research question 5): In the final regression models I adjusted for maternal height, father's education and migration of other household members. Asset quartile was excluded from the final model as it did not improve the model fit and showed strong collinearity with the remaining covariates but excluding this variable did not change effect estimates. I found no association between the cumulative amount of net remittances sent by the father over the seven-year recall period any measure of child growth at six years (Figure 7.11).

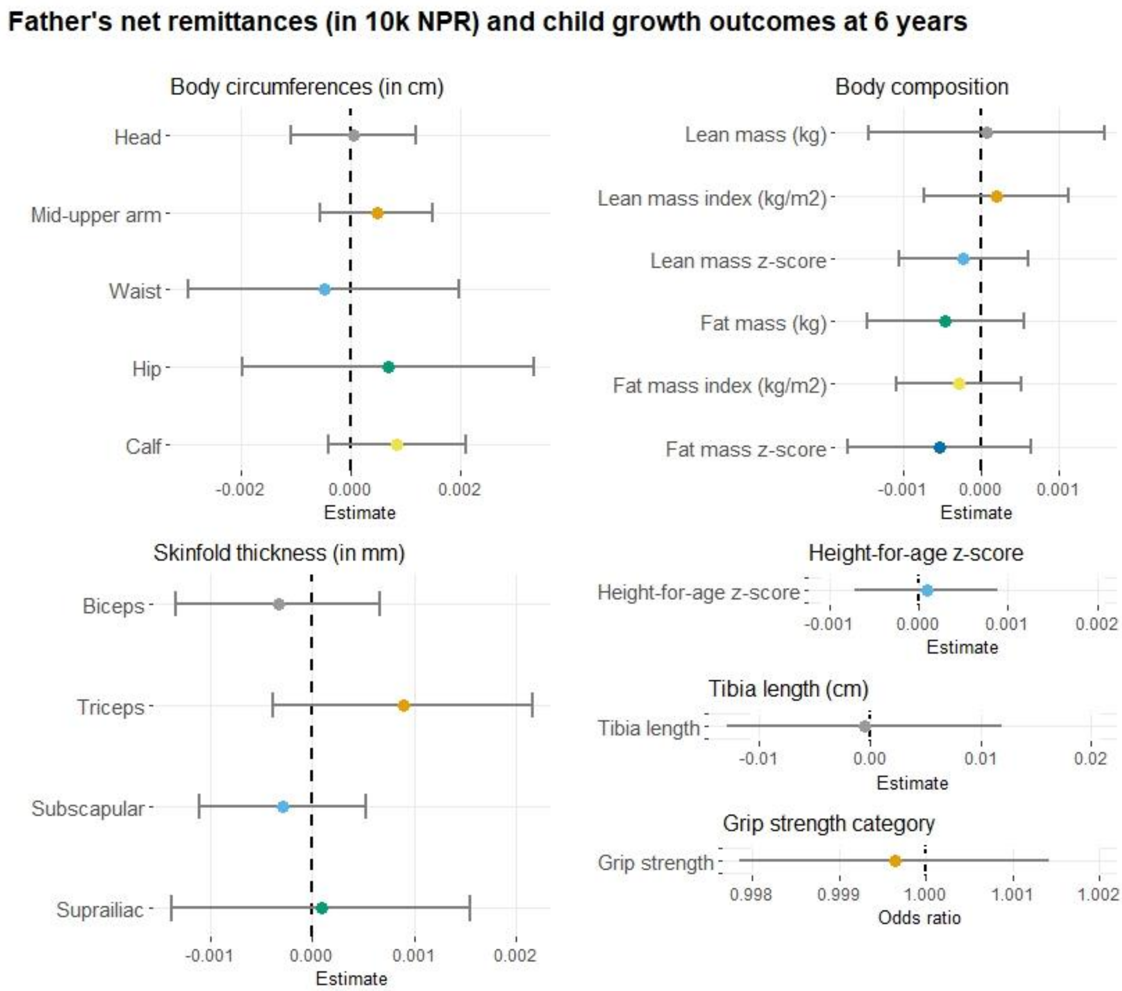


Figure 7.11: Association between father's net remittances (in 10k NPR) and outcomes of child growth and function (grip strength) at six years

7.4 Discussion

Summary and interpretation of findings

The overall association between father's labour migration and child growth (research question 1): I found that children of migrant fathers are shorter for their age than children of non-migrant fathers. This finding is in contrast to my initial hypothesis of a positive effect of migration on child growth, but in line with the evidence from many other studies and contexts as summarised in the systematic review.

Differences in the association between paternal migration and child growth by duration of absence (research question 2): Only children of fathers who recently left were negatively affected, whereas I found no difference in terms of HAZ between children of longer-term migrants and non-migrants. This finding is in line with my hypothesis and supported by theoretical reasoning in other pieces of research describing the disruptive effects of migration on the left-behind families (Antman, 2013; Davis & Brazil, 2016; Frank, 2005; Kanaiaupuni & Donato, 1999). I am not aware of any other study that investigated the effects of recent migration on child growth, but several studies from Mexico have found evidence of the disruptive effects of migration on the left-behind family. Kanaiaupuni and Donato (1999) found that each additional trip to the US lowered the odds of infant survival in the left-behind family, whereas each additional month of experience in the US improved the infant's odds of survival. Similarly, a study by Hamilton, Villarreal, and Hummer (2009) found that recent migration of a household member to the US increased the odds of infant mortality. Another study in Mexico found that wives of recent international migrants, indicated by their receipt of remittances for less than one year, had higher odds of giving birth to a low-birthweight baby while no effect was found in women who had received remittances for more than one year (Frank, 2005).

Differences in the association between paternal migration and child growth by child age (research question 3): After separating the sample by age group, only the earlier period showed a negative impact of father's migration, while there was no difference between children of migrants and non-migrants in the older age group. This result is in contrast to my initial hypothesis, but consistent with evidence from China where boys left behind in early childhood (age <6 years) were shorter for their age than sons of non-migrants (N. Zhang, Becares, & Chandola, 2015). No differences were found in girls and between children of labour migrants and non-migrants at later ages. In Mexico, Lu (2015) found that the negative effect of parental international migration on HAZ was stronger in younger left-behind children, but found no such pattern in Indonesia. A study from Guatemala found that the overall *positive* effect of living in a migrant household was larger in children under 30 months compared to children aged 30 to 71 months (Carletto, Covarrubias, & Maluccio, 2011). This study, however, looked at migration of any household member, not just parental migration.

Growth velocity is the highest in the first few months of life (Lejarrage, 2012; WHO, 2009b) so that insults to the healthy development of the baby will have a particularly detrimental effect. However, the pathways through which the father's migration affects the baby's growth are not clear. One potential pathway through which father's migration can negatively impact the young infant's growth is through elevated level of distress in the mother. In a qualitative study in the same area of Nepal, Clarke, Saville, Bhandari, et al. (2014) found that women described their husband's absence as a source of distress because he could not provide support, especially after the birth of a child or when she was ill. A hospital-based study in Lumbini, Nepal, compared wives of international labour migrants and non-migrants by their reproductive health, depression and experiences of gender-based violence (Aryal, Shrestha, & Pant, 2019). They found that left-behind women had higher depression scores and were more likely to experience gender-based violence by in-laws and neighbours. There is evidence that distressed mothers are more likely to experience breastfeeding problems (Dennis & McQueen, 2007), that stress impairs the breast milk supply (Dewey, 2001), and that reducing stress improves infant milk intake (Mohd Shukri et al., 2019) and infant weight gain (Dib, Wells, Eaton, & Fewtrell, 2022). A second pathway is the lack of support from the husband during pregnancy and in the postpartum period. The study by Aryal et al. (2019) found that left-behind women attended fewer antenatal care visits, and were less likely to report adequate diet, rest and support during pregnancy. In the puerperium, they were more likely to experience post-partum complications, and less likely to report adequate diet, rest, and support.

Association between father's migration and other outcomes of child growth and function (grip strength) (research question 4): There was high variability in other outcomes of child growth, only some outcomes showed significant results and only for exposure to migration in some age-periods in the child's life. It is difficult to ascertain the reasons for these differences between outcomes and exposure periods, and I want to refrain from overinterpreting these results as this particular piece of analysis has some limitations, as will be discussed further below. Nevertheless, there appeared to be a very consistent pattern in the outcomes skinfold thickness, body circumferences and lean mass in that left-behind children tended to be smaller than their peers whose fathers did not migrate. This finding matches the results of the main analysis for the outcome HAZ which showed that left-behind children did not grow as well as those of non-migrant fathers. Interestingly, measures of fat mass and lean mass showed very different patterns in that left-behind children had lower lean mass, but not fat mass, compared to children who had never migrated. This observation is consistent with findings from other studies that found lower lean mass, but not fat mass, in children who had experienced undernutrition. This may be because the body preserves fat stores, which may offer short-term benefits for survival, at the expense of functional tissue (J. C. K. Wells, 2019). I am not aware of any study using these outcomes to determine the impact of paternal labour migration on left-behind children and therefore cannot compare my findings.

Impact of father's remittances on child growth (research question 5): I found no indication of an effect of remittances on attained HAZ or other outcomes of child growth at six years. This finding is in contrast to my initial hypothesis but is in line with findings from many studies in other populations (Antón, 2010; Davis & Brazil, 2016; Kroeger & Anderson, 2014; Ponce et al., 2011).

There are plausible explanations for the lack of an effect: First, much of the remittance income is used for purposes that do not have an impact on child growth and overall well-being. Of the 667 migration cycles recorded in this study, 68% reported using remittances to pay for everyday consumption other than food, 62% for paying off the loan they took to finance the migration and 45% for other loans, 33% to build or rebuild their house, and 26% to finance special occasions such as wedding or funeral. These expenses will make up large shares of the overall remittances so that a relatively small amount may be left for investments that benefit the child. Secondly, there is a time lag between the migrants' departure and the first time they send remittances, and it is plausible that initially the remittances are used to pay off the migration loans. It would therefore take time until remittances are available for investments that benefit the left-behind children and most certainly not during the initial phase after departure, when children seem to be most vulnerable as this study has shown. Unfortunately, I do not have data on the changes of remittance spending over time to corroborate this reasoning.

In Chapter 6 I found that the most important determinant of infant growth is low birthweight as a measure of intrauterine growth restriction. It would be plausible to assume that the income from remittances could be used to improve the nutritional status of women before and during pregnancy, which would in turn result in better growth of the baby. However, research in this area of Nepal found that intra-household food allocation is inequitable and that pregnant women get smaller shares of food and nutrients compared to other adult members of the household (Harris-Fry et al., 2018). This could furthermore explain the lack of an association between receipt of remittances and child growth.

Study strengths and limitations

My analysis is an important addition to the literature and offers new insights into the topic of the effects of labour migration on left-behind children. Firstly, as found in the systematic review (Chapter 2), there is a dearth of evidence on *international* migration and from the major remittance-dependent countries, including Nepal. Secondly, unlike many other analyses studying the effects of labour migration on left-behind children that had to use secondary data collected for other purposes (Ban et al., 2017; C. Chen et al., 2011; Davis & Brazil, 2016; Islam et al., 2019; Kunwar et al., 2020; Lu, 2015; Mu & de Brauw, 2015; Schmeer, 2013), I collected the data specifically for the purpose of this analysis. I therefore had access to quality-controlled and detailed information regarding the migration patterns and could accurately link migration cycles to periods in the child's life. Thirdly, I was able to use longitudinal data which reduces the risk of reverse causation inherent in cross-sectional studies. Only four of the 29 studies (14%) included in my systematic review were based on longitudinal data and those only had two data points per child. Fourth, thanks to the detailed information and longitudinal data I was able to address potential moderating factors such as child age and duration of migration, and remittances as a potential mediating factor. This allowed me to identify periods in the child's life when it may be more sensitive to the disrupting effects of the father's migration. Fifth, apart from the last measurement point at six years, this study focusses on growth during the period of the first 1000 days during which children are most susceptible to insults limiting their growth, and which therefore deserves particular attention. With the exception of the study by Davis and Brazil (2016), the existing evidence outside of China predominantly draws on data from older children (Graham & Jordan, 2013; Lu, 2015; C. V. Nguyen, 2016; Schmeer, 2013).

My study has some limitations. As with all observational research, I must be cautious about claims of causality. I used a DAG to visualize my assumptions about potential causal mechanisms and to choose the covariates that I adjusted for in my regression analysis. However, there remains a possibility of residual confounding if a covariate did not appropriately signal the respective factor, for example if years of schooling did not appropriately capture the father's level of education and job qualification, or unobserved confounders where I did not include a confounder because I was not aware of it or did not collect this information. One example of a potential unobserved confounder is family structure. If a married couple recently separated from the extended household, their infant may be more vulnerable to growth faltering because they live in a precarious situation and have no family to support them in stressful situations, and the father may be more likely to seek work abroad. However, changes in family structure and their timing were not recorded in this study.

To select the covariates, I employed a combination of theory-driven DAGs and data-driven backward selection. The aim of this approach was to control for all potential confounders (DAGs) while at the same time reducing the risk of multicollinearity and increasing precision of estimates (data-driven backward selection). A simulation study found the DAG full-model analysis to be superior to the data-driven backward selection (Weng, Hsueh, Messam, & Hertz-Picciotto, 2009), so my approach can be considered a limitation of my analysis. However, only one variable (asset quartile) was removed from the models and the effect estimates remained the same, suggesting that this variable had only weak association with exposure and outcome. Therefore, these deliberations are purely theoretical and do not imply that my approach increased the risk of bias in this study. Another limitation relates to the analysis on the association between migration at different time points in the child's life with measures of child growth other than height (research question 4), which must be interpreted with caution. The measures of exposure differentiate poorly between children left-behind and children whose fathers did not migrate since children who were categorised as left-behind at one point may have been categorised as children of non-migrants at all other points, and vice versa. For example, about half of the fathers who were categorised as non-migrants in the period from birth to six months did migrate later in the child's life and this may have impacted the children's growth outcomes at six years. These findings are therefore merely indicative. But in the context of the results of the more nuanced longitudinal analysis on the outcome HAZ they nevertheless paint a coherent picture of poorer growth in left-behind children compared to children of non-migrants.

Since the data on the amount of remittances received relies solely on the respondents' accounts with no means to verify its accuracy, and financial questions are somewhat sensitive, there is a possibility that respondents did not correctly indicate the amount of remittances that the household received from the respective migrant, either on purpose because they wanted to present themselves as poorer or more economically successful than they actually were, or because they did not accurately remember. If there was a bias in the indicated amount of remittances, I assume that it would affect all households similarly and not be related to the outcome HAZ. I therefore think it unlikely that this could have biased the results of my analysis.

Directions for future work

Much of the evidence on the effects of labour migration on left-behind families comes from the field of econometrics which uses a different set of analytical strategies to address the risk of confounding in observational research. Future research on this cohort could explore whether such techniques, most notably instrumental variables and fixed effects linear regression, are applicable and could add further insights.

At the follow-up in 2018, children in migrant households had a lower BMI *z*-score and lower weight-for-age *z*-score than children in households that had reported no labour migration (see Chapter 5.8). Expanding the present analysis to include additional outcomes that capture other aspects of growth and nutritional status is therefore worth considering.

A systematic review on the health impacts of parental migration on left-behind children and adolescents found considerably higher risks of mental health problems such as depression and anxiety in children of migrants, but the evidence was predominantly from internal labour migration in China while other countries and international migration were greatly underrepresented (Fellmeth et al., 2018). A recent qualitative study among depressed adolescents in Nepal observed that grief and a change of role in the home due to a parent's migration were mentioned as triggers for their depression (Rose-Clarke et al., 2021). Future follow-ups of the GMS cohort should consider including mental health outcomes to explore how experiences of the loss of a parent due to migration affects adolescents.

Conclusion

I found no evidence of a positive association between paternal labour migration and the growth of the left-behind children. Instead, I observed that under certain circumstances such as very young age and during the disruptive period shortly after the father went abroad, left-behind children grew less well than children whose fathers did not migrate. It remains unclear whether these insults to their growth are permanent or can be compensated for through longer growth periods and later puberty.

8 Conclusions and recommendations

Summary

This final chapter brings together the results of my thesis. I begin with an overview of my findings against the three initially stated thesis objectives. I then discuss the strengths and limitations of my study. Building on the findings and limitations of my thesis, I formulate recommendations for research, programming, and policy in Nepal.

8.1 Overview of findings

Objective 1: To summarize the existing evidence on the effects of parental labour migration on the nutritional status of left-behind children and adolescents in low- and middle-income countries. (Chapter 2)

We identified 29 studies using data from eleven countries[18]. Almost three-quarters of the included studies (21 studies, 72%) were from China. Only four studies (14%) used longitudinal data. I found that left-behind children are at a higher risk of wasting (Risk Ratio (RR) 1.13 [1.02-1.24]) and stunting (RR 1.12 [1.00-1.26]) than children whose parents did not migrate. There was no evidence of a difference in terms of overweight and obesity, underweight, or anaemia between the study groups.

Objective 2: To identify determinants of infant growth in Dhanusha district, Nepal. (Chapter 6)

I used data from the Growth Monitoring Study (GMS) birth cohort (*n*=602) and fitted mixed-effects linear regression models controlling for multiple measurements within individuals to examine the impact of household and maternal factors, feeding practices and infection on length-for-age *z*-score (LAZ) from birth to two years. I ran separate analyses for the age periods birth to six months (exclusive breastfeeding period) and 7

[18] This systematic review was part of a larger systematic review including other outcomes (Fellmeth et al., 2018). Other authors contributed to the study search.

to 24 months (complementary feeding period) to check whether the importance of determinants differed by child age. Maternal factors related to both the environment in-utero and in postnatal life were the most important determinants of infant growth. The overall most important determinant of growth was low birthweight. At birth, babies born with low birthweight had a -1.21 (-1.38, -1.05) lower LAZ compared to normal birthweight babies. The difference in LAZ between low birthweight and normal birthweight babies attenuated with age but low birthweight remained the factor with the largest effect size. The second largest factor was maternal education. Infants of mothers with any level of education had a 0.22 (0.07, 0.38) higher LAZ in the 7 to 24 months age-period than those whose mothers had never been to school. Other relevant determinants were adolescent pregnancy, minimum dietary diversity, symptoms of respiratory infection, household food insecurity, season, and maternal absence. The importance of maternal factors for infant growth calls for public health interventions targeting girls and young women.

Objective 3: To determine the association between paternal labour migration and the growth of the children left behind in Dhanusha district, Nepal. (Chapter 7)

To address this objective, I broke it down into five research questions and hypotheses.

Research question 1: Is there a difference between the linear growth of children of labour migrants and non-migrant fathers?

Hypothesis 1: Children of migrant fathers are taller for their age than children of non-migrants.

Research question 2: Is there an association between the duration that the migrant fathers have spent abroad and the linear growth of the children?

Hypothesis 2a: Shortly after the fathers' going abroad the children's growth will be negatively affected and children of migrants are smaller than children of non-migrants.

Hypothesis 2b: Children of longer-term migrants grow better than children of recent migrants or non-migrants.

Research question 3: Is there an age period when children's linear growth is more sensitive to the impact of fathers' migration?

Hypothesis 3: The association between fathers' migration and child HAZ is larger in the complementary feeding period compared to the exclusive breastfeeding period.

Research question 4: Is there an association between the fathers' migration and other measures of child growth (body circumferences, skinfold thickness, body composition, tibia length) and function (grip strength) at six years, and does the association differ by the timing of the migration relative to the children's life?

Hypothesis 4a: Children of migrants have wider body circumferences, skinfold thickness, larger amounts of fat and lean mass, longer tibia and higher grip strength compared to children of non-migrants.

Hypothesis 4b: The association between father's migration and these measures of child growth is larger in the complementary feeding period compared to the exclusive breastfeeding period.

Research question 5: Is there an association between the amount remitted and child linear growth and other measures of child growth (body circumferences, skinfold thickness, body composition, tibia length) and function (grip strength) at six years?

Hypothesis 5: There is a positive association between the amount remitted and child linear growth, body circumferences, skinfold thickness, body composition, tibia length and grip strength.

I used length-for-age *z*-score (LAZ)[19] at birth, six months, one year and two years from the original GMS (2012-2014) and combined it with HAZ at age six years collected at my

[19] For ease of reading, I used HAZ to denote both length-for-age *z*-score (for children up to two years) and height-for-age *z*-score (for children aged six years).

2018 follow-up. Using the household migration history collected retrospectively in 2018, I calculated the exposure to father's migration at each data point. I fitted mixed-effects linear regression models to account for repeated measurements within children (research questions 1-3). Data on other child growth outcomes (body circumferences, skinfold thickness, body composition, tibia length, grip strength) and net remittances were collected in 2018 (research questions 4 and 5). I used linear regression models to estimate the association between fathers' migration and other measures of child growth at age six years (research question 4) and the association between exposure to net remittances and any child growth outcome at age six years (research question 5).

I found that

1) Children of labour migrants had a -0.08 (95% CI: -0.15, -0.00) lower HAZ than children whose father did not migrate. (Hypothesis 1 rejected)

2) Children of fathers who recently went abroad (≤ 12 months ago) were -0.12 (95% CI: -0.21, -0.04) shorter than children of non-migrants. (Hypothesis 2a not rejected)

   I found no difference between children of longer-term migrants (>1 year) and children of non-migrants. (Hypothesis 2b rejected)

3) The negative association between fathers' labour migration and the HAZ of the left-behind children was only apparent at younger ages (≤ 6 months, -0.15 (-0.29, -0.01) HAZ), but not at older ages (12-72 months, -0.05 (-0.14, 0.03) HAZ). (Hypothesis 3 rejected)

4) Children of labour migrants had lower lean mass, smaller waist and calf circumferences, and smaller subscapular and suprailiac skinfold thickness compared to children whose father had never been abroad. I found no differences by fat mass, tibia length and grip strength. There was no evidence of a positive association between father's migration and any of these growth outcomes. (Hypothesis 4a rejected)

   Differentiating by the timing of fathers' migration did not reveal any patterns supporting a stronger association in the complementary feeding period compared to the breastfeeding period. (Hypothesis 4b rejected)

5) There was no indication of an effect of net remittances on any measure of child growth. (Hypothesis 5 rejected)

In summary, I found no evidence of positive effects of paternal labour migration on any measure of child growth. On the contrary, at very young ages and in the first months after the fathers left, I found a negative association with child HAZ.

8.2 Strengths and limitations

The research presented in this thesis contributes to the limited body of evidence on the association between paternal labour migration and the growth of the left-behind children in one of the major labour-sending countries with high levels of growth faltering. Additionally, my analysis sheds further light on the determinants of infant growth in a population with high prevalence of child stunting.

One of the major strengths of my thesis is the rich pool of data I was fortunate to have access to. I used longitudinal cohort data with a high number of data points per child and a high frequency of measurements of both outcomes and covariates.

Most of the data points used were from the first “1000 days” (up to two years of age) in the children’s lives, a period when children are known to be most susceptible to growth-limiting insults. This sets apart my study from other pieces of research that aim to estimate the impact of parental migration on child growth as these have predominantly used data of older children.

Unlike most previous studies examining the association between parental labour migration and child nutrition, this thesis did not rely on secondary data collected for other purposes. The data on the household migration history was collected specifically for the purpose of this study which allowed me to accurately link migration cycles to child growth periods.

My research made a novel contribution by including growth outcomes other than height and/or weight. I am not aware of any other study using these outcomes.

There are also limitations to my research. First, all the research presented in this thesis is observational which means that I cannot make any claims of causality. Second, the findings of this study may have limited generalisability outside of Nepal or even outside of Dhanusha district. The labour migration patterns found in labour-sending countries vary in important aspects and so the implications for the left-behind families and in particular the children will be different. In this study population, only men migrate for work and the impact on the left-behind children may not be comparable to that in other countries such as Sri Lanka (Sri Lanka Bureau of Foreign Employment, 2021) or other areas of Nepal such as Kathmandu and Sindhupalchok (Government of Nepal, 2020) where there is also a high number of women (and mothers) seeking employment overseas. In Nepal, international labour migration is mostly aimed at Gulf countries and Malaysia and associated with considerable initial costs and often indebtedness for the migrant. In Tajikistan, another major labour-sending and remittance-dependant country (Azzarri & Zezza, 2011), labour migration is predominantly to Russia and associated with lower costs, better information pre-departure due to the shared language, and lower administrative barriers. The findings of my study also may not hold true in the future. Labour migration policy in Nepal is constantly changing and there are efforts to reform processes to better serve the migrant workers. Hopefully, my largely negative findings do not hold true in the future. The assumed impact of labour migration on the left-behind families therefore always has to be considered in the light of the prevailing circumstances.

A third limitation of my study is that it cannot tell us about the underlying mechanisms in the association between paternal labour migration and child growth. I have outlined potential pathways in my conceptual framework and supported them with qualitative findings from other studies in Nepal, but my analysis cannot tell us whether any of these explain the negative association observed in early infancy and in the first months after the fathers' departure.

8.3 Implications for future work

My findings and the limitations of my study point towards areas for future work.

Research

Qualitative research

Complementary qualitative research could help gain better understanding of the experiences of pregnant women und mothers of small babies whose partner is preparing for or who has already left for overseas employment. Knowledge about these women's living situation, needs, stressors and coping strategies could inform interventions aimed at supporting them in the transition phase in the months around the husband's departure.

Intervention research

I found a negative association between paternal migration and child growth at very young ages (birth to six months). This observation that growth very early in life, including the prenatal period, is very sensitive to insults fits with the finding that low birthweight, an indicator of growth in-utero, determines much of the postnatal growth. I also found that the negative association between paternal migration and child growth was only apparent in the twelve months following the father's departure, which lead me to assume that the stress and lack of support experienced by the mother in the time around the husband's migration may explain this association. Although this is purely speculative, other studies from Nepal point in the same direction. These found that left-behind women in Nepal often suffer from the gossip and scrutiny of their community, financial difficulties, lack of husband's support in the upbringing of their children (Adhikari & Hobley, 2015) and in conflicts with the in-laws (Clarke, Saville, Bhandari, et al., 2014). In the puerperium, left-behind women were also less likely to have adequate diet, rest and support than women whose husbands did not migrate (Aryal et al., 2019). I believe that the situation for married women is particularly difficult in the *Terai* where the GMS is located, due to its patriarchal society and patrilocal residence pattern. Upon marriage, often during adolescence, women become part of their husband's household where they typically rank low in the family hierarchy and are expected to take over a large share of the household chores and have children early. Married women are largely confined to the sphere of the marital home and are somewhat isolated from friends and family. They therefore often lack social networks that could help them transition into their new role and support them when they are feeling overwhelmed.

A natural progression from my observational study would be the design of an intervention that helps women cope with the stresses experienced during the husband's migration. Women's groups practising participatory learning and action (PLA) could be an appropriate intervention to address some of the difficulties described above. PLA is a participatory intervention strategy for community development where, under the guidance of a facilitator, groups identify and prioritise local problems, come up with solutions and implement them together. This approach has been successfully applied to health problems. A meta-analysis found that women's groups practising PLA can reduce maternal and neonatal mortality (Prost et al., 2013). Due to their participatory nature, women's groups can be an effective way to get women out of their isolation at home and create a sense of cohesion, support, and friendship between participants. Ideally, this would lead to fewer instances of gossiping about left-behind women, and also practical support in the day to day lives of those with small children. PLAs are furthermore a good format to discuss and challenge societal norms and the inequities that they may generate. Involving mothers-in-law may cultivate a sense of empathy towards their daughters-in-law and hence more supportive behaviour. I propose a format that is open to all women in the community, but focusses on left-behind women, particularly those who are pregnant or with small babies, and their mothers-in-law. Involving mothers-in-law can furthermore increase overall participation as daughters-in-law may otherwise not be allowed to attend meetings as they would leave the oversight of the mother-in-law. I would nevertheless reserve some meetings for mothers and pregnant women alone so that they have a safe space to discuss sensitive topics.

In the determinants of infant growth study, I found low birthweight to have by far the largest effect size. This finding points to the importance of the period in-utero for child growth and the need for interventions to improve maternal nutrition pre-conception and during pregnancy. In the same area of Nepal as the GMS, the Low Birthweight South Asia Trial tested PLA, PLA with cash transfer, and PLA with food (fortified wheat-soya) transfer for pregnant women (Saville et al., 2018). The study found the PLA with food transfer to improve birthweights by 78g, but differences did not persist into early childhood. For sustained improvements in infant growth there may be a need for interventions that continue beyond pregnancy and aim to enhance adherence to age-appropriate feeding practices. Besides, an intervention that builds largely on give-aways has limited sustainability and is only effective as long as the project duration. The two following examples may be more sustainable as they address some of the underlying root causes of maternal undernutrition such as gender norms and intra-household food allocation.

A nutrition education intervention in Bangladesh aimed to improve birth weights through practical demonstrations of preparing a balanced diet found that birth weights improved by 122g (Chowdhury et al., 2022). The intervention involved mothers-in-law and husbands to get their support, enable the purchase of more nutritious food, and improve intra-household food allocation. A promising approach is the group intervention *Sumadhur* where newly married women, their husbands, and mothers-in-law participate together in weekly interactive group sessions (Diamond-Smith et al., 2022). The intervention is located in the plains of Nepal and aims to improve the young wives' nutrition and gender norms in the home. The intervention targets newly married women because women in Nepal typically get pregnant within the first year of marriage and this strategy allows them to address pre-conception nutrition. In the piloting, the intervention was found to be highly feasible and acceptable; fewer women reported eating last in the family and there was improved knowledge about nutrition in preconception and pregnancy.

In Nepal where intra-household food allocation is inequitable (Harris-Fry et al., 2018) and young wives have low agency, approaches that involve mothers-in-law and husbands may be most effective and last beyond the period of pregnancy, and may even extend to domains other than nutrition. I furthermore suggest that interventions should start in preconception and extend into the first two years of children's' lives.

Programming

Recognizing the importance of labour migration for development and livelihoods in Nepal, several governmental and non-governmental organisations have implemented programs to improve the outcomes of migration for work. I will list insights gained from my study and explain how they may inform such programmes. That way these programmes may contribute to ameliorating the largely negative impact that paternal migration seems to have on child growth.

During pregnancy and in the first year of the children's lives, wives of migrants need additional support, particularly in the early stages of migration.

The Safer Migration Project (SaMi; Ministry of Labour, Employment and Social Security Nepal and HELVETAS Nepal) provides psychosocial counselling for returnee migrants and left-behind family members (HELVETAS Nepal, 2019). This intervention should particularly target left-behind women who are pregnant or have small children, especially in the months after the husband's departure. Although this is speculative, the findings of my own study in the context of the evidence from other qualitative research indicate that mothers and their small children are very vulnerable after the husband leaves. This may be due to the increased workload, a low status of daughters-in-law in the household due to the patrilocal residence pattern, gossip from the community and financial difficulties. The psychosocial counselling may help them learn coping strategies to deal with their stresses and escape the isolation of their home. In the absence of the husband as a facilitator between the wife and in-laws, a trained mediator could also help improve the relationship between family members.

Prospective migrants whose wives are pregnant, or their child is still very young, should consider the vulnerabilities of their family and plan accordingly.

Another major component of the SaMi programme constitutes information and awareness raising on the risks and benefits of migration through Migration Resource Centres (MRCs) at the district level. In the project districts, visits to the MRCs are an obligatory step in the passport application process. The MRC counsellors provide information about all aspects of migration and point out ways to make migration safer (HELVETAS Nepal, 2019). It would be good if counsellors factored in the personal situation of prospective migrants and made them aware that pregnancy and early infancy are periods when both mother and child are particularly vulnerable. The migrant should reflect to what extent mother and baby have sufficient support in his absence and if he finds that this is potentially insufficient, it might be advisable to wait until the child is slightly older. This should be complemented with advice on family planning so that no second child is conceived during the waiting period. Alternatively, or additionally to delaying departure, the prospective migrant should establish support mechanisms for his wife so that she can count on support by family and neighbours if she finds herself in difficulties.

There was no evidence of a positive association between paternal labour migration and the growth of left-behind children. Children and families as a whole may benefit more from employment at home.

Labour migration is and will continue to be in important livelihood strategy in Nepal, and efforts must be directed towards making it safer for migrants. At the same time, alternative employment opportunities in Nepal need to be developed. This is the approach taken by the Skills for Employment सीप ("seep") programme (UKAid) in partnership with the private sector in Nepal (UKAid, 2022). On the one hand it promotes vocational training in priority growth sectors such as construction and tourism. On the other hand, it also attempts to increase the safety and profitability of labour migration by for example providing low-interest loans. In my study, I found that migrants had a median return of investment of 176%, this means that for every NPR 100 that they invested, they received NPR 176 back after the costs were covered. This does not seem to be that much over a median of two years working abroad, and earnings may have been even greater had the money been invested in a small business in their home community.

Policy

In my study, there was no evidence of a net benefit of fathers' migration for the left-behind children. To the contrary, I found a negative association, particularly in the months following the fathers' departure, and I argued this may be partly attributed to the financial stresses and uncertainties surrounding the fathers' migration. To alleviate some of the stresses associated with the migrant's departure and to generally increase the benefits of migration for migrants and left-behind families, the Government of Nepal has to commit to fully implementing existing migration legislation designed to protect the interests of its migrants and adjust current policies. As it is, labour migration from Nepal poses high risks for migrants. In my study, 20% of respondents said that the benefits did not outweigh the costs, and 17% of migrants returned home more than a year earlier than initially planned, which hints at serious problems in the hosting country.

A comprehensive analysis of Nepal's migration policy framework is beyond the scope of this thesis, and I will only briefly point out the key issues observed by myself and highlighted by civil society organisations, journalists, and researchers.

1. Enforce the 2015 "Free Visa, Free Ticket" policy.

In July 2015, the Government of Nepal introduced the "Free Visa, Free Ticket" policy which states that foreign employers from Malaysia and the six GCC countries are required to pay for air tickets and visa processing costs. This policy also drastically reduced the amount that recruitment agencies can legally charge migrant workers from NPR 70,000 or NPR 80,000 (GBP 490 or 560, depending on the destination) to NPR 10,000 (GBP 70). This policy was met with huge backlash by recruitment agencies who refuse to abide by it. Therefore this policy effectively only exists on paper (Amnesty International, 2017; Shivakoti, 2022). Recruitment agencies, overseas employers, and even Nepali government officials have argued that with this policy, employing Nepalis will be too expensive and that its implementation would have negative consequences for the recruitment sector's profitability and Nepal's competitiveness on the global labour market (Amnesty International, 2017; Khadka, 2020). This statement is problematic for two reasons. First, if these overseas businesses cannot afford to absorb the costs of hiring, it seems cynical that they expect poor labourers from a low-income country to do so. Second, Nepalis face higher costs of migration and get lower earnings compared to other labour migrants from South Asia, and at the same time Nepalis are valued by foreign employers for their ability to work in extreme climate (Kern & Muller-Boker, 2015; Martin, 2016), so there clearly is room to adjust costs in the favour of migrant workers. The lack of implementation allows recruitment agencies to ignore the policy and continue charging the migrants for costs that should be borne by the employers (Amnesty International, 2017; Khadka, 2020). The Government of Nepal must fully commit to implementing the "Free Visa, Free Ticket" policy and enforce penalties against recruitment agencies who do not adhere to it. Ideally, such initiatives should be coordinated between South Asian countries and policy reforms implemented simultaneously.

2. Extend the "Free Visa, Free Ticket" policy to become "zero cost recruitment".

The ILO and the Global Compact for Migration recommend "zero cost recruitment" (Global Compact for Migration, 2018; ILO, 1997). To qualify as such, the policy in Nepal must be extended to include other fees paid by migrant workers pre-departure such as medical exams and insurance costs. The "Free Visa, Free Ticket" policy currently only includes the seven main destination countries which receive 85% of Nepali migrant workers. This should be extended to more destination countries.

3. Prosecute instances of fraud by manpower agencies.

At several stages in the migration process, manpower agencies fail to comply with the provisions of the 2007 Foreign Employment Act and as a result, migrant workers are subject to fraud. These include, among others, payment of excessive fees; lack of transparency of what is being paid for and to whom; denial of accurate receipts for fees paid; lack of compensation for payment of excess fees; and false, misleading, or substituted contracts. The Government of Nepal must strengthen the enforcement of current legislation (Amnesty International, 2017).

4. Prosecute illegally high loans.

The majority of migrants in my study financed migration through loans from local moneylender and the median annual interest rate was a staggering 36%, which other reports confirm (Amnesty International, 2017; Sijapati et al., 2017). But according to Nepali law (Muluki Ain, 1963; Chapter 17, no 6), private individuals may only charge interest rates up to ten percent. This practice of demanding illegally hight interest rates inflates the costs of migration and increases the risk of debt bondage. According to an Amnesty International report, there is no record of prosecutions against individuals who violated this law (Amnesty International, 2011). The Government of Nepal must start prosecuting this malpractice.

The above points point towards the weak role of the Government in enforcing existing legislation and formulating policies that serve the public rather than the interests of few, most importantly the recruitment sector (Shivakoti, 2022).

Besides improving its labour migration governance, the Government of Nepal must work towards developing more employment and entrepreneurial opportunities as an alternative to labour migration. Labour migration must not be the only option for Nepalis from rural areas. The COVID pandemic has highlighted the vulnerability of the labour migration sector and the need to diversify the labour market.

Concluding thoughts

My thesis has generated two major insights.

First, the paramount importance of maternal factors and very early life for child growth. Both my findings on the importance of low birthweight as an indicator of the growth in-utero (Chapter 6), and the large negative associations between paternal labour migration and infant growth in the first six months of life (Chapter 7), point towards the importance of pregnancy and very early life experiences for child growth. This does not imply that other periods in the children's lives are irrelevant. As my analysis has shown, factors such as household food insecurity are also important determinants of child growth. However, interventions and programmes starting in the pre-conception period and supporting women throughout early infancy – and ideally even beyond – may yield the best results.

Second, there was no evidence of benefits of migration for child growth. At the beginning of this thesis, I speculated that prospective migrants are likely motivated by the prospects of securing a better future for their children who stay at home. My study, however, did not find that to be the case. This is saddening as these migrants make immense sacrifices and take great risks when they seek work overseas. There remains a possibility that children do benefit from their fathers' migration in some way that my study did not capture. But the data presented in this thesis indicate only small profits that do not benefit the children. As it stands, international labour migration in Nepal primarily serves the interests of overseas employers and the recruitment sector, but not that of the labour migrants.

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Roles and contributions

Supervision

My primary supervisor was Prof Mario Cortina Borja, my secondary supervisors were Dr Naomi Saville, Prof Jonathan Wells, and Prof Delanjathan Devakumar.

Systematic review

The systematic review presented in Chapter 2 was part of a larger systematic review including a broad range of child and adolescent health outcomes. My own role and the contributions of others are specified at the beginning of the respective chapter.

Growth Monitoring Study 2012-2014

The original Growth Monitoring Study (2012-2014), on which this thesis builds, was designed by Vikas Paudel and Dr Naomi Saville with support from Prof Anthony Costello. Mother and Infant Research Activities (MIRA), directed by Prof Dharma S Manandhar, was the implementing partner in Nepal.

Development of electronic questionnaire for the 2018 GMS follow-up

Katharina Ricci was an intern in my project from February to April 2018. During that time, she helped me transfer the paper survey questionnaire to an Open Data Kit (ODK) digital questionnaire. While I did the essential programming, she supported me by troubleshooting the questionnaire. She also assisted in the training of field staff on survey questionnaire administration.

2018 Data collection

Data were collected by MIRA field staff Shyam Sundar Yadav (field coordinator), Dev Lal Biswakarma, Ram Sundar Yadav, and Mahendra Paswan.

`R` function to compute the technical error of measurement

Prof Mario Cortina-Borja wrote an `R` function to compute the technical error of measurement (TEM) of the anthropometric measurements. I assisted him by checking that the formulas were correct.

Isotope sample analysis

I diluted the deuterium doses and prepared all samples for analysis. Dr Simon Eaton analysed the samples using continuous flow isotope ratio mass spectrometry (IRMS).

Funding and outputs

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International Child Health Group Research Award 2017-18: £1500

Chadwick Trust Travelling Fellowship 2018: £2580

Stiftung fiat panis Dr. Hermann Eiselen Doktorandenförderung 2017: £2200

I presented my research at three conferences:

Nutrition and Growth, Amsterdam, March 2017

Nutrition Innovation Lab Symposium, Kathmandu, November 2018

Royal College of Paediatrics and Child Health Annual conference, Birmingham, May 2019

The results of my thesis have been published in this paper

Fellmeth, G., Rose-Clarke, K., Zhao, C., **Busert, L. K.**, Zheng, Y., Massazza, A., Sonmez, H., Eder, B., Blewitt, A., Lertgrai, W., Orcutt, M., Ricci, K., Mohamed-Ahmed, O., Burns, R., Knipe, D., Hargreaves, S., Hesketh, T., Opondo, C., & Devakumar, D. (2018). Health impacts of parental migration on left-behind children and adolescents: a systematic review and meta-analysis. The Lancet, 392(10164), 2567–2582. Doi: 10.1016/S0140-6736(18)32558-3

The following papers are currently under review

Marphatia, A.A., **Busert-Sebela, L.K.**, Gram, L., Cortina-Borja, M. Reid, A.M., Manandhar, D.S., Wells, J.C.K., Saville, N.M. (2023), Maternal mental health and autonomy in lowland rural Nepal: do parents-in-law provide constraint or support? Evolution, Medicine, and Public Health (Submitted in July 2022)

Marini, E., Stagi, S., Cabras, S., Comandini, O., Ssensamba, J.T., Fewtrell, M., **Busert-Sebela, L.K.**, Saville, N.M., Earthman, C.P., Silva, A.M., Wells, J.C.K. (2023), Body composition variability among populations and within the full spectrum of malnutrition. Clinical Nutrition (Submitted in August 2022).

The following papers will be submitted for publication

Busert-Sebela, L.K., Cortina-Borja, M., Paudel, V., Devakumar, D., Wells, J.C.K., Manandhar, D.S., Saville, N.S. (2023). Determinants of infant growth in the plains of Nepal*. To be submitted to Maternal & Child Nutrition*.

Busert-Sebela, L.K., Cortina-Borja, M., Eaton, S., Devakumar, D., Wells, J.C.K., Yadav, S. S., Paudel, V., Manandhar, D.S., Saville, N.S. (2023). The association between paternal labour migration and the growth of the children left behind in the plains of Nepal*. To be submitted to Journal of Migration and Health.*

Appendix A Growth Monitoring Study (Chapter 4)

A. 1 Open Data Kit Questionnaire 2018 Follow-up

Survey - Part I

name	type	label::en	hint::en	relevant	constraint	calculation	required
preliminaries	begin group	Preliminaries					
babyid	integer	What is the Baby ID?					yes
start	start	start					
end	end	end					
username	username	username					
interviewer	select_one interviewer	Interviewer					yes
consent	image	Take a picture of the signed consent form					yes
vdc_old	calculate					pulldata('partI', 'vdc', 'babyid_key', ${babyid})	
ward_old	calculate					pulldata('partI', 'ward', 'babyid_key', ${babyid})	
tole	calculate					pulldata('partI', 'tole', 'babyid_key', ${babyid})	
mwname	calculate					pulldata('partI', 'mwname', 'babyid_key', ${babyid})	
land_own	calculate					pulldata('partI', 'land_own', 'babyid_key', ${babyid})	

name	type	label::en	hint::en	relevant	constraint	calculation	required
land_shrcrp	calculate					pulldata('partI', 'land_shrcrp', 'babyid_key', ${babyid})	
landownb	calculate					pulldata('partI', 'landownb', 'babyid_key', ${babyid})	
landowndhur	calculate					pulldata('partI', 'landowndhur', 'babyid_key', ${babyid})	
landownk	calculate					pulldata('partI', 'landownk', 'babyid_key', ${babyid})	
sharelandb	calculate					pulldata('partI', 'sharelandb', 'babyid_key', ${babyid})	
sharelanddhur	calculate					pulldata('partI', 'sharelanddhur', 'babyid_key', ${babyid})	
sharelandk	calculate					pulldata('partI', 'sharelandk', 'babyid_key', ${babyid})	
dob_nep	calculate					pulldata('partI', 'babydob',	

name	type	label::en	hint::en	relevant	constraint	calculation	required
						'babyid_key', ${babyid})	
intmigrbl	calculate					pulldata('partI', 'intmigrbl', 'babyid_key', ${babyid})	
migrcountrybl	calculate					pulldata('partI', 'migrcountrybl', 'babyid_key', ${babyid})	
memwrkindia	calculate					pulldata('partI', 'memwrkindia', 'babyid_key', ${babyid})	
memwrkarab	calculate					pulldata('partI', 'memwrkarab', 'babyid_key', ${babyid})	
memwrkmalaysia	calculate					pulldata('partI', 'memwrkmalaysia', 'babyid_key', ${babyid})	
outsidenepal	calculate					pulldata('partI', 'outsidenepal', 'babyid_key', ${babyid})	
husbandliving	calculate					pulldata('partI', 'husbandliving', 'babyid_key', ${babyid})	

name	type	label::en	hint::en	relevant	constraint	calculation	required
checkidentity	begin group	Identity check					
checknames	select_one yesno	Is ${mwname} the name of the mother?					yes
mw_correct	text	Please go back and check whether you entered the correct Baby ID! If you are sure that you identified the correct household, but that the mother's name in our records is wrong, please enter the correct name.		${checknames}=0			yes
vdc_ver	select_one yesno	Is this VDC ${vdc_old}?	In the OLD political system!				yes
vdc_cor	integer	Please write the correct VDC number using the VDC list.		${vdc_ver}=0			yes
checkidentity	end group						
preliminaries	end group						
tothh	integer	In total, how many people (including adults, young children) are currently living in this household? (Including the respondent!)	Persons who share the same kitchen (pot), live together, and run the household expenditure from the same income comprise what is known as ‘household”.		.<35		yes
totaway	integer	In total, how many people are members of this household, but are currently absent because they migrated for work?			.<15		yes
tothhpastmigr	integer	How many of the ${tothh} people who are currently living in this household have migrated abroad for work in the past seven years but have already returned?					yes
totnonmigr	calculate					${tothh}-${tothhpastmigr}	
totmigr	calculate					${totaway}+${tothhpastmigr}	
hhall	calculate					${tothh}+${totaway}	

name	type	label::en	hint::en	relevant	constraint	calculation	required
remindermigr	begin group	Reminder about previous migration information					
migrbl	note	When the child was born on ${dob_nep}, the household said that they had at least one labour migrant in ${migrcountrybl}		${intmigrbl}=1			
nomigrbl	note	When the child was born on ${dob_nep}, the household said that none of their members was working abroad.		${intmigrbl}=0			
fathermigr2yr	note	When the child was just under 2 years, the father was ${husbandliving}.		${husbandliving} !=88			
othermigr2yr	note	Apart from the father, there were ${memwrkindia} household members in India, ${memwrkarab} household members in Arab countries, and ${memwrkmalaysia} household members in Malaysia when the child was just under 2 years old.		${outsidenepal}= 1			
noothermigr2yr	note	Apart from the father, there were no other international labour migrants in the household when the child was just under 2 years old		${outsidenepal}= 0			
missingothermig r2yr	note	We have no information about international labour migration in the household at the time when the child was just under two years.		${outsidenepal}= 88 and ${husbandliving} =88			
remindermigr	end group						
checkhhnumber s	select_one yesno	The respondent said that the household has a total of ${hhall} members (${tothh} in the home and ${totaway} currently working abroad), and that of the ${tothh} members who are currently in the home, ${tothhpastmigr} have migrated for work in the past seven years but have already returned back home. Is this correct?					yes
checkhhnumber swrong	note	Please go back and enter the correct numbers.		${checkhhnumb ers}=0			
nonmigr	begin group	Details about the ${totnonmigr} household members who did NOT migrate for work in the past seven years.					

name	type	label::en	hint::en	relevant	constraint	calculation	required
sex	begin group	gender distribution					
sexnote	note	Of the ${totnonmigr} household members who did not migrate, how many are ...					
male	integer	Male					yes
female	integer	Female					yes
	end group						
totsex	calculate					${male} +${female}	
correctsex	note	The respondent said that there are ${totnonmigr} household members who did not migrate, but the numbers add up to ${totsex}. Please go back and correct the mistake.		${totsex}!=${totnonmigr}			
age_f	begin group	Age distribution of female (non-migrant) household members		${female}>0			
agenote_f	note	Of these ${female} female household members, how many in each age group (running years)					
u5_f	integer	Children under 6 running years (under 5 complete years)					yes
_5to14_f	integer	Children aged 6-15 running years (5-14 completed years)					yes
_15to64_f	integer	Aged 16-65 running years (15-64 completed years)					yes
o65_f	integer	66 running years (65 completed years) and older					yes
	end group						
totage_f	calculate					${u5_f} + ${_5to14_f} + ${_15to64_f} + ${o65_f}	
correctage_f	note	The respondent said that there are ${female} female household members, but the numbers add up to ${totage_f}. Please go back and correct the mistake.		${female}!=${totage_f} and ${female}>0			

name	type	label::en	hint::en	relevant	constraint	calculation	required
age_m	begin group	Age distribution of male (non-migrant) household members		${male}>0			
agenote_m	note	Of these ${male} male household members, how many in each age group (running years)					
u5_m	integer	Children under 6 running years (under 5 complete years)					yes
_5to14_m	integer	Children aged 6-15 running years (5-14 completed years)					yes
_15to64_m	integer	Aged 16-65 running years (15-64 completed years)					yes
o65_m	integer	66 running years (65 completed years) and older					yes
	end group						
totage_m	calculate					${u5_m} + ${_5to14_m} + ${_15to64_m} + ${o65_m}	
correctage_m	note	The respondent said that there are ${male} male household members, but the numbers add up to ${totage_m}. Please go back and correct the mistake		${male}!=${totage_m} and ${male}>0			
schoolenrol	begin group	School enrolment					
schoolenrol_f	integer	Of the ${_5to14_f} female school aged children (6-15 running years (5-14 completed years)), how many are currently enrolled in school?		${_5to14_f}>0	.<=${_5to14_f}		yes
schoolenrol_m	integer	Of the ${_5to14_m} male school aged children (6-15 running years (5-14 completed years)), how many are currently enrolled in school?		${_5to14_m}>0	.<=${_5to14_m}		yes
	end group						
edu_f	begin group	Education of female (non-migrant) household members		${_15to64_f} >0			

name	type	label::en	hint::en	relevant	constraint	calculation	required
education_f	note	Of the ${_15to64_f} female members of working age, how many completed ···	Aged 16-65 running years (15-64 completed years)				
noedu_f	integer	No education (never went to school)			.<=${_15to64_f}		yes
nonformaledu_f	integer	Non-formal education			.<=${_15to64_f}		yes
primsome_f	integer	Some primary (class 1 - 5, but 5 not passed)			.<=${_15to64_f}		yes
primcomplete_f	integer	Completed primary (class 5 passed)			.<=${_15to64_f}		yes
secsome_f	integer	Some secondary (class 6-10, but 10 not passed)			.<=${_15to64_f}		yes
seccomplete_f	integer	Completed secondary (class 10 passed/ SLC)			.<=${_15to64_f}		yes
secplus_f	integer	More than secondary (class 11 and above)			.<=${_15to64_f}		yes
	end group						
totedu_f	calculate					${noedu_f} + ${nonformaledu_f} + ${primsome_f} +${primcomplete_f} +${secsome_f} +${seccomplete_f} +${secplus_f}	
correctedu_f	note	The respondent said that there are ${_15to64_f} female household members of working age, but the numbers add up to ${totedu_f}. Please go back and correct the mistake		${_15to64_f}!=${totedu_f} and ${_15to64_f}>0			
edu_m	begin group	Education of male (non-migrant) household members		${_15to64_m} > 0			
education_m	note	Of the ${_15to64_m} male members of working age, how many completed ···	Aged 16-65 running years (15-64 completed years)				
noedu_m	integer	No education (never went to school)			.<=${_15to64_m}		yes

name	type	label::en	hint::en	relevant	constraint	calculation	required
nonformaledu_m	integer	Non-formal education			.<=${_15to64_m}		yes
primsome_m	integer	Some primary (class 1 - 5, but 5 not passed)			.<=${_15to64_m}		yes
primcomplete_m	integer	Completed primary (class 5 passed)			.<=${_15to64_m}		yes
secsome_m	integer	Some secondary (class 6-10, but 10 not passed)			.<=${_15to64_m}		yes
seccomplete_m	integer	Completed secondary (class 10 passed/ SLC)			.<=${_15to64_m}		yes
secplus_m	integer	More than secondary (class 11 and above)			.<=${_15to64_m}		yes
	end group						
totedu_m	calculate					${noedu_m} + ${nonformaledu_m} +${primsome_m} +${primcomplete_m} +${secsome_m} +${seccomplete_m} +${secplus_m}	
correctedu_m	note	The respondent said that there are ${_15to64_m} male household members of working age, but the numbers add up to ${totedu_m}. Please go back and correct the mistake		${_15to64_m}!= ${totedu_m} and ${_15to64_m}>0			
dommigr	select_one yesno	In the past seven years (since Baishakh 2068), have any of the ${totnonmigr} non-migrant household members worked in another place within Nepal for three or more months at a time?					yes
dommigr_no	integer	How many of the ${totnonmigr} non-migrant household members worked in another place within Nepal?		${dommigr}=1	.<=${totnonmigr}		yes

name	type	label::en	hint::en	relevant	constraint	calculation	required
nonmigr	end group						
hh_migr	note	I am now going to ask you about the ${totmigr} people that migrated for work in the past seven years. Please start with the person who first left.		${totmigr}>0			
migrants	begin repeat	Details about the labour migrant(s) in the household		${totmigr}>0			
migr_no	calculate					position(..)	
namemigr	text	Name of the household member that migrated abroad					yes
gendermigr	select_one sex	Is ${namemigr} male or female?					yes
agemigr	integer	${namemigr}'s age (in running years).			.>12 and .<100		yes
relmigrf	select_one relmigrf or_other	What is ${namemigr}'s relationship to the child?		${gendermigr}=2			yes
relmigrm	select_one relmigrm or_other	What is ${namemigr}'s relationship to the child?		${gendermigr}=1			yes
att_schoolmigr	select_one yesno	Has ${namemigr} ever attended school?					yes
edulevelmigr	integer	What is the highest grade that ${namemigr} studied to? Record class no completed to grade 9, if SLC pass write 10, if plus two write 11, if bachelor write 12. if higher grade than this write 13. (If the household studied urdu, sanskrit or non-formal education but no other formal schooling record zero. However, if a person has studied urdu or sanskrit formally at a school and has a certificate record their class no.)	highest grade	${att_schoolmigr} = 1	.<14		yes
migr_nr	integer	How many times has ${namemigr} migrated for work for six months or more over the past 7 years?			.<10		yes
migrcycles	note	I would now like you to give details about each time that ${namemigr} migrated. Every work contract ${namemigr} has					

name	type	label::en	hint::en	relevant	constraint	calculation	required
		had abroad is treated as one cycle of migration. Please start with the first cycle of migration.					
migr_birthabs	select_one yesno	Was the father absent due to migration for work when the child was born on ${dob_nep}?		${relmigrm}=1			yes
cyclemigr	begin repeat	Cycle of migration number					
migrcycle_no	calculate					position(..)	
migr_durintend	integer	How many years or months did ${namemigr} INTEND to go for? [Record in months]	Enter 101 if unknown		.>=6		yes
migr_dur	integer	How many years or months did ${namemigr} actually stay? [Record in months] Enter 0 if ${namemigr} has not returned from that trip yet.	months		.>=6 or .=0		yes
migrdateleft	begin group	Dates of when the migrant left					yes
migr_lefty	select_one year	Which year did ${namemigr} leave?					yes
migr_leftm	select_one month	Which month did ${namemigr} leave?					yes
migrdateleft	end group						
migrdateret	begin group	Dates of when the migrant returned		${migr_dur}!=0			yes
migr_rety	select_one year	Which year did ${namemigr} return?					yes
migr_retm	select_one month	Which month did ${namemigr} return?					yes
migrdateret	end group						
migr_durcalc	calculate			${migr_leftm}!= 0 and ${migr_retm}!=0		(${migr_rety}- ${migr_lefty})*12+(${	

name	type	label::en	hint::en	relevant	constraint	calculation	required
						migr_retm}-${migr_leftm})	
mismatch	note	The respondent said that the migrant was away for ${migr_dur} months, but according to the dates given it was ${migr_durcalc}. Please go back and ask again.		(${migr_dur}-${migr_durcalc}) >2 or (${migr_dur}-${migr_durcalc}) < -2			
migr_dest	select_one migr_dest or_other	What is/was the destination of migration?					yes
migr_sec	select_multiple migr_sec or_other	Which sector does/did ${namemigr} work in while abroad?					yes
migr_cost	integer	How much in total did ${namemigr} pay to finance this migration? (probe: agent, transport, medical checks, passport, visa, insurance) [enter 101 if unknown]	Enter 101 if unknown				yes
migr_how	select_multiple migr_how	How did ${namemigr} finance this migration?			not(selected(.,'migr_finnone') and count-selected(.)>1) and not(selected(.,'migr_dk') and count-selected(.)>1)		yes
migr_fin_money	begin group	Who gave how much?		not(selected(${migr_how},'migr_finnone')) and not(selected(${migr_how},'migr_dk'))			

name	type	label::en	hint::en	relevant	constraint	calculation	required
migr_receive	note	How much money did ${namemigr} obtain from... ? [enter 101 if unknown]	The overall costs were ${migr_cost}				
migr_finfam_money	integer	Gift from family (sasural or maiti)	NRS	selected(${migr_how}, 'migr_finfam')			yes
migr_finborrow_money	integer	Borrow	NRS	selected(${migr_how}, 'migr_finborrow')			
migr_finloan_money	integer	Loan	NRS	selected(${migr_how}, 'migr_finloan')			yes
migr_finsaving_money	integer	Savings	NRS	selected(${migr_how}, 'migr_finsaving')			yes
migr_finassets_money	integer	Selling assets	NRS	selected(${migr_how}, 'migr_finassets')			yes
migr_finmort_money	integer	Land mortgage	NRS	selected(${migr_how}, 'migr_finmort')			yes
migr_finother_money	integer	Other	NRS	selected(${migr_how}, 'migr_finother')			yes
migr_fin_money	end group						
migr_lwho	select_multiple migr_lwho	Who provided the loan?		selected(${migr_how}, 'migr_finloan')			yes

name	type	label::en	hint::en	relevant	constraint	calculation	required
loan_a	begin group	Loan provided by Family		selected(${migr_lwho}, 'a')			
migr_lcol_a	select_one yesno	Did you pledge any collateral to secure this debt or loan?					yes
migr_lcolwhich_a	select_one migr_lcolwhich or_other	What collateral is pledged to secure this debt or loan?		${migr_lcol_a}=1			yes
migr_ldur_a	integer	Duration of loan? [enter 101 if unknown]	months				yes
migr_lintr_a	select_one migr_lintr	What type of interest is incurred?					yes
migr_lpct_a	decimal	What is the interest on the loan? [enter 101 if unknown]	%/yr		.<102		yes
migr_lrpaid_a	select_one migr_lrpaid	Has this debt been repaid?					yes
migr_loutstd_a	integer	How much is still outstanding? [enter 101 if unknown]		${migr_lrpaid_a}=0			yes
loan_a	end group						
loan_b	begin group	Loan provided by Relatives who are not members of the household		selected(${migr_lwho}, 'b')			
migr_lcol_b	select_one yesno	Did you pledge any collateral to secure this debt or loan?					yes
migr_lcolwhich_b	select_one migr_lcolwhich or_other	What collateral is pledged to secure this debt or loan?		${migr_lcol_b}=1			yes
migr_ldur_b	integer	Duration of loan? [enter 101 if unknown]	months				yes
migr_lintr_b	select_one migr_lintr	What type of interest is incurred?					yes
migr_lpct_b	decimal	What is the interest on the loan? [enter 101 if unknown]	%/yr				yes

name	type	label::en	hint::en	relevant	constraint	calculation	required
migr_lrpaid_b	select_one migr_lrpaid	Has this debt been repaid?					yes
migr_loutstd_b	integer	How much is still outstanding? [enter 101 if unknown]		${migr_lrpaid_b}=0			yes
loan_b	end group						
loan_c	begin group	Loan provided by Manpower company / recruitment agency		selected(${migr_lwho}, 'c')			
migr_lcol_c	select_one yesno	Did you pledge any collateral to secure this debt or loan?					yes
migr_lcolwhich_c	select_one migr_lcolwhich or_other	What collateral is pledged to secure this debt or loan?		${migr_lcol_c}=1			yes
migr_ldur_c	integer	Duration of loan? [enter 101 if unknown]	months				yes
migr_lintr_c	select_one migr_lintr	What type of interest is incurred?					yes
migr_lpct_c	decimal	What is the interest on the loan? [enter 101 if unknown]	%/yr				yes
migr_lrpaid_c	select_one migr_lrpaid	Has this debt been repaid?					yes
migr_loutstd_c	integer	How much is still outstanding? [enter 101 if unknown]		${migr_lrpaid_c}=0			yes
loan_c	end group						
loan_d	begin group	Loan provided by Friend		selected(${migr_lwho}, 'd')			
migr_lcol_d	select_one yesno	Did you pledge any collateral to secure this debt or loan?					yes

name	type	label::en	hint::en	relevant	constraint	calculation	required
migr_lcolwhich_d	select_one migr_lcolwhich or_other	What collateral is pledged to secure this debt or loan?		${migr_lcol_d}=1			yes
migr_ldur_d	integer	Duration of loan? [enter 101 if unknown]	months				yes
migr_lintr_d	select_one migr_lintr	What type of interest is incurred?					yes
migr_lpct_d	decimal	What is the interest on the loan? [enter 101 if unknown]	%/yr				yes
migr_lrpaid_d	select_one migr_lrpaid	Has this debt been repaid?					yes
migr_loutstd_d	integer	How much is still outstanding? [enter 101 if unknown]		${migr_lrpaid_d}=0			yes
loan_d	end group						
loan_e	begin group	Loan provided by Pawnbroker		selected(${migr_lwho}, 'e')			
migr_lcol_e	select_one yesno	Did you pledge any collateral to secure this debt or loan?					yes
migr_lcolwhich_e	select_one migr_lcolwhich or_other	What collateral is pledged to secure this debt or loan?		${migr_lcol_e}=1			yes
migr_ldur_e	integer	Duration of loan? [enter 101 if unknown]	months				yes
migr_lintr_e	select_one migr_lintr	What type of interest is incurred?					yes
migr_lpct_e	decimal	What is the interest on the loan? [enter 101 if unknown]	%/yr				yes
migr_lrpaid_e	select_one migr_lrpaid	Has this debt been repaid?					yes
migr_loutstd_e	integer	How much is still outstanding? [enter 101 if unknown]		${migr_lrpaid_e}=0			yes

name	type	label::en	hint::en	relevant	constraint	calculation	required
loan_e	end group						
loan_f	begin group	Loan provided by Savings and credit coop		selected(${migr_lwho}, 'f')			
migr_lcol_f	select_one yesno	Did you pledge any collateral to secure this debt or loan?					yes
migr_lcolwhich_f	select_one migr_lcolwhich or_other	What collateral is pledged to secure this debt or loan?		${migr_lcol_f}=1			yes
migr_ldur_f	integer	Duration of loan? [enter 101 if unknown]	months				yes
migr_lintr_f	select_one migr_lintr	What type of interest is incurred?					yes
migr_lpct_f	decimal	What is the interest on the loan? [enter 101 if unknown]	%/yr				yes
migr_lrpaid_f	select_one migr_lrpaid	Has this debt been repaid?					yes
migr_loutstd_f	integer	How much is still outstanding? [enter 101 if unknown]		${migr_lrpaid_f}=0			yes
loan_f	end group						
loan_g	begin group	Loan provided by Moneylender (sau)		selected(${migr_lwho}, 'g')			
migr_lcol_g	select_one yesno	Did you pledge any collateral to secure this debt or loan?					yes
migr_lcolwhich_g	select_one migr_lcolwhich or_other	What collateral is pledged to secure this debt or loan?		${migr_lcol_g}=1			yes
migr_ldur_g	integer	Duration of loan? [enter 101 if unknown]	months				yes
migr_lintr_g	select_one migr_lintr	What type of interest is incurred?					yes

name	type	label::en	hint::en	relevant	constraint	calculation	required
migr_lpct_g	decimal	What is the interest on the loan? [enter 101 if unknown]	%/yr				yes
migr_lrpaid_g	select_one migr_lrpaid	Has this debt been repaid?					yes
migr_loutstd_g	integer	How much is still outstanding? [enter 101 if unknown]		${migr_lrpaid_g}=0			yes
loan_g	end group						
loan_h	begin group	Loan provided by Bank		selected(${migr_lwho}, 'h')			
migr_lcol_h	select_one yesno	Did you pledge any collateral to secure this debt or loan?					yes
migr_lcolwhich_h	select_one migr_lcolwhich or_other	What collateral is pledged to secure this debt or loan?		${migr_lcol_h}=1			yes
migr_ldur_h	integer	Duration of loan? [enter 101 if unknown]	months				yes
migr_lintr_h	select_one migr_lintr	What type of interest is incurred?					yes
migr_lpct_h	decimal	What is the interest on the loan? [enter 101 if unknown]	%/yr				yes
migr_lrpaid_h	select_one migr_lrpaid	Has this debt been repaid?					yes
migr_loutstd_h	integer	How much is still outstanding? [enter 101 if unknown]		${migr_lrpaid_h}=0			yes
loan_h	end group						
loan_i	begin group	Loan provided by Other		selected(${migr_lwho}, 'i')			
migr_lcol_i	select_one yesno	Did you pledge any collateral to secure this debt or loan?					yes

name	type	label::en	hint::en	relevant	constraint	calculation	required
migr_lcolwhich_i	select_one migr_lcolwhich or_other	What collateral is pledged to secure this debt or loan?		${migr_lcol_i}=1			yes
migr_ldur_i	integer	Duration of loan? [enter 101 if unknown]	months				yes
migr_lintr_i	select_one migr_lintr	What type of interest is incurred?					yes
migr_lpct_i	decimal	What is the interest on the loan? [enter 101 if unknown]	%/yr				yes
migr_lrpaid_i	select_one migr_lrpaid	Has this debt been repaid?					yes
migr_loutstd_i	integer	How much is still outstanding? [enter 101 if unknown]		${migr_lrpaid_i}=0			yes
loan_i	end group						
rem	select_one yesno	Did your household receive any remittances from ${namemigr}?					yes
remittances	begin group	Remittances		${rem} = 1			
rem_time	integer	How long after ${namemigr} left did he/she first send money? Indicate in months	Enter 101 if unknown				yes
rem_reg	select_one yesno	Does/did ${namemigr} remit in regular intervals?					yes
rem_freqwhich	integer	In which intervals does/did ${namemigr} remit money? Indicate in months.		${rem_reg} = 1			yes
rem_regnrs	integer	How much does/did ${namemigr} remit money on each remittance?	NRS	${rem_reg} = 1			yes
rem_sum	integer	Please indicate in NRS the combined value of all remittances.	Enter 101 if unknown	${rem_reg} = 0			yes
rem_occ	select_one yesno	Did ${namemigr} remit money on special occasions such as Holi, Chhath, Tihar, Dashain, weddings, etc.?		${rem_reg} = 1			yes

name	type	label::en	hint::en	relevant	constraint	calculation	required
rem_occextra	select_one yesno	If yes and they had regular payments, was this additional to the regular payments you received?		${rem_occ} = 1			yes
rem_occextra_nrs	integer	How much did ${namemigr} additionally remit on special occasions? (Please indicate in NRS the combined value of all additional remittances.)	Enter 101 if unknown	${rem_occextra} = 1			yes
rem_use	select_multiple rem_use or_other	What did your household mainly use ${namemigr}'s remittances for?		${rem} = 1			yes
remittances	end group						
cyclemigr	end repeat						
rem_g	select_one yesno	Has this household received any goods from ${namemigr}?					yes
rem_gtype	select_multiple rem_gtype or_other	What type of goods has this household received from ${namemigr}?		${rem_g}=1			yes
problems	select_one yesno	Did ${namemigr} share that he/she had any problems while being abroad?					yes
problemswhich	select_multiple problems or_other	What problems did ${namemigr} face?		${problems}=1			yes
netbenefit	select_one yesno	Overall, would you consider ${namemigr}'s migration to be successful? (According to you, do the benefits of labour migratin outweigh the costs and difficulties?)					yes
migr_work	select_one migr_work	In the period just before ${namemigr} went to live away, what was the main activity that ${namemigr} spent most time doing?					yes
agr	select_multiple agr	What kind of agricultural work?		${migr_work}=6			yes

name	type	label::en	hint::en	relevant	constraint	calculation	required
livestock	select_multiple livestock	What kind of livestock?		${migr_work}=7			
migrants	end repeat						
rem_ext	select_one yesno	In the past seven years, has your household received remittances from someone who is not a member of your household?					yes
remext	begin group	Remittances from people outside the household					
rem_pers	select_multiple rem_pers	By whom?		${rem_ext}=1			yes
rem_sumext	integer	Please indicate in NRS the combined value of all remittances.	Enter 101 if unknown	${rem_ext}=1			yes
rem_useext	select_multiple rem_use or_other	What did your household mainly use the remittances for?		${rem_ext}=1			yes
remext	end group						
india	select_one yesno	In the past seven years (since Baishakh 2068), have any of the household members worked in India for less than six months at a time?					
india_nr	integer	How many of your household members worked in India? (for <6 months and in the past seven years)		${india}=1			yes
india_rem	integer	Please indicate in NRS the combined value of all remittances.	Enter 101 if unknown	${india}=1			yes
migrnetwork	integer	From your personal network, how many people do you know who have migrated abroad for work? (Not counting household members)					yes
migrinfo	select_one migrinfo or_other	Do you know where to get information about labour migration/foreign employment?					yes
hhconsumption	note	**12 months household consumption**					

name	type	label::en	hint::en	relevant	constraint	calculation	required
hh_consum	select_multiple hh_consum	Which of the following goods and services did your household purchase or acquire in some other way in the past 12 months?			not(selected(.,'hh_consum_none') and count-selected(.)>1)		yes
consum_rem	begin group	Consumption from remittances		(${totaway}>0 or ${tothhpastmigr}>0 or ${rem_ext}=1) and not(selected(${hh_consum}, 'hh_consum_none'))			
hhconsumrem	note	For which of these did you use remittances to pay for them?					
clothesadult_rem	select_one yesnodk	Clothes and shoes for adults, including any materials or fabric		selected(${hh_consum}, 'clothesadult')			yes
clotheschild_rem	select_one yesnodk	Clothes and shoes for children, including any materials or fabric		selected(${hh_consum}, 'clotheschild')			yes
school_rem	select_one yesnodk	School expenses (transport, books, fees etc. excluding clothes & shoes)		selected(${hh_consum}, 'school')			yes
tuition_rem	select_one yesnodk	Private tuition		selected(${hh_consum}, 'tuition')			yes
furnit_rem	select_one yesnodk	Furniture, other floor coverings for the house		selected(${hh_consum}, 'furnit')			yes
medic_rem	select_one yesnodk	Health care (Medication, Laboratory tests & Doctor’s fees)		selected(${hh_consum}, 'medic')			yes

name	type	label::en	hint::en	relevant	constraint	calculation	required
festiv_rem	select_one yesnodk	Festival or other celebration (Festivals, wedding, pilgrimage, Arghau Funerals Shraddha, Bratabandha birthday pasani (rice feeding ceremony))		selected(${hh_consum}, 'festiv')			yes
agri_rem	select_one yesnodk	Agricultural inputs (seed, fertiliser, insecticide, irrigation, tractor costs, thresher hire, etc)		selected(${hh_consum}, 'agri')			yes
insurance_rem	select_one yesnodk	life insurance		selected(${hh_consum}, 'insurance')			yes
house_rem	select_one yesnodk	Construction or repairing of house		selected(${hh_consum}, 'house')			yes
animal_rem	select_one yesnodk	Farm animals		selected(${hh_consum}, 'animal')			yes
cosmetic_rem	select_one yesnodk	Cosmetic/ hygiene items		selected(${hh_consum}, 'cosmetic')			yes
hhitems_rem	select_one yesnodk	Household utensils		selected(${hh_consum}, 'hhitems')			yes
remext	end group						
hhaelectr	select_one hhaelectr	Do you have electricity in the house where you are staying at the moment? (If the electricity has been cut for more than one month because the family cannot pay for it (not because the electricity supply is broken) record no.)					yes
hhaelectr_rem	select_one yesnodk	Did your household use remittances to pay for the access to electricity?		(${hhaelectr}=1 or ${hhaelectr}=3) and (${totaway}>0 or ${tothhpastmigr			yes

name	type	label::en	hint::en	relevant	constraint	calculation	required
				}>0 or ${rem_ext}=1)			
assets	select_multiple assets	What things do you have in the house you stay in?					yes
assetsfromremit	begin group	What assets were paid from remittances?		${totaway}>0 or ${tothhpastmigr}>0 or ${rem_ext}=1			
hharemuse	note	Did your household use remittances to pay for this?					
hharadio_rem	select_one yesnodk	Radio		selected(${assets}, 'hharadio')			yes
hhamonotv_rem	select_one yesnodk	Black and white TV		selected(${assets}, 'hhamonotv')			yes
hhacolourtv_rem	select_one yesnodk	Colour TV		selected(${assets}, 'hhacolourtv')			yes
hhabicycle_rem	select_one yesnodk	Bicycle		selected(${assets}, 'hhabicycle')			yes
hhaownrickshaw_rem	select_one yesnodk	Own rickshaw		selected(${assets}, 'hhaownrickshaw')			yes
hhaoxcart_rem	select_one yesnodk	Ox cart		selected(${assets}, 'hhaoxcart')			yes
hhamotorbike_rem	select_one yesnodk	Motorcycle		selected(${assets}, 'hhamotorbike')			yes
hhatractor_rem	select_one yesnodk	Tractor		selected(${assets}, 'hhatractor')			yes

name	type	label::en	hint::en	relevant	constraint	calculation	required
hhavehicle_rem	select_one yesnodk	Bus/Truck/Jeep/ car/tempo		selected(${assets}, 'hhavehicle')			yes
hhathresher_rem	select_one yesnodk	Thresher		selected(${assets}, 'hhathresher')			yes
hhapumpset_rem	select_one yesnodk	Pump		selected(${assets}, 'hhapumpset')			yes
hhafixedphone_rem	select_one yesnodk	Fixed telephone		selected(${assets}, 'hhafixedphone')			yes
hhabatteryset_rem	select_one yesnodk	Battery set		selected(${assets}, 'hhabatteryset')			yes
hhasolarset_rem	select_one yesnodk	Solar set		selected(${assets}, 'hhasolarset')			yes
hhasewingmach_rem	select_one yesnodk	Sewing Machine		selected(${assets}, 'hhasewingmach')			yes
hhamobilephone_rem	select_one yesnodk	Mobile Phone		selected(${assets}, 'hhamobilephone')			yes
hhacamera_rem	select_one yesnodk	Camera		selected(${assets}, 'hhacamera')			yes
hhacdplayer_rem	select_one yesnodk	CD player		selected(${assets}, 'hhacdplayer')			yes

name	type	label::en	hint::en	relevant	constraint	calculation	required
hhavcdplayer_rem	select_one yesnodk	Video/dvd player		selected(${assets}, 'hhavcdplayer')			yes
hhagenerator_rem	select_one yesnodk	generator		selected(${assets}, 'hhagenerator')			yes
hharicemill_rem	select_one yesnodk	Rice mill		selected(${assets}, 'hharicemill')			yes
hhapc_rem	select_one yesnodk	Computer / laptop		selected(${assets}, 'hhapc')			yes
hhafridge_rem	select_one yesnodk	Fridge		selected(${assets}, 'hhafridge')			yes
assetsfromremit	end group						
incomesource	select_multiple incomesource or_other	What are your or your family's sources of income?					yes
mainfood	select_one mainfood	What is your family's main staple food?					yes
ms	begin group	Ranking sources of staple food					
staplesource	select_one rank_source	Please rank your household's main sources of staple food from 0 to 5.					
msownprod	select_one rank_source	Own production			.=0 or (. != ${mscrop} and . != ${mslex} and . != ${mspurchase} and . != ${msbegging})		yes

name	type	label::en	hint::en	relevant	constraint	calculation	required
mscrop	select_one rank_source	Share- Cropping (bataiya)			.=0 or(. != ${msownprod} and . != ${mslex} and . != ${mspurchase} and . != ${msbegging})		yes
mslex	select_one rank_source	Labour exchange paid in food			.=0 or (. != ${msownprod} and . != ${mscrop} and . != ${mspurchase} and . != ${msbegging})		yes
mspurchase	select_one rank_source	Purchase of food			.=0 or (. != ${msownprod} and . != ${mscrop} and . != ${mslex} and . != ${msbegging})		yes
msbegging	select_one rank_source	Begging			.=0 or (. != ${msownprod} and . != ${mscrop} and . != ${mslex} and . != ${mspurchase})		yes
ms	end group						
garden	select_one yesno	Do you grow your own fruits and/or vegetables in a garden or plot?					yes

name	type	label::en	hint::en	relevant	constraint	calculation	required
landown_check	select_one yesno	When your child was born we were told that your household owns ${landownb} bigha, ${landowndhur} dhur, and ${landownk} katha. Is that still true?		${land_own}=1			yes
landown	begin group	Land ownership - Own Land		${landown_check}=0			
bigha	decimal	land in bigha					yes
katha	decimal	land in katha					yes
dhur	decimal	land in dhur					yes
landown	end group						
landshrcrp_check	select_one yesno	When your child was born we were told that your household has ${sharelandb} bigha, ${sharelanddhur} dhur, and ${sharelandk} katha of sharecropped land. Is that still true?		${land_shrcrp}=1			yes
landshrcrp	begin group	Land ownership - Sharecropped		${landshrcrp_check}=0			
bigha	decimal	land in bigha					yes
katha	decimal	land in katha					yes
dhur	decimal	land in dhur					yes
landshrcrp	end group						
serespondent	select_one serespondent	Who was the main respondent for the socio-economic and migration questions above?					yes
notes	text	Write a note if the household somehow did not fit the questionnaire or if you encountered any other problems.					

Survey - Part II

name	type	label::en	hint::en	relevant	constraint	calculation	required
babyid	integer	What is the Baby ID?					yes
interviewer	select_one interviewer	Interviewer					yes
mwname	calculate					pulldata('partII', 'mwname', 'babyid_key', ${babyid})	
dob_eng	calculate					pulldata('partII', 'babydob_eng', 'babyid_key', ${babyid})	
sex	calculate					pulldata('partII', 'sex', 'babyid_key', ${babyid})	
floor_prev	calculate					pulldata('partII', 'floor', 'babyid_key', ${babyid})	
toilet_prev	calculate					pulldata('partII', 'toilet', 'babyid_key', ${babyid})	

toiletshare_prev	calculate					pulldata('partII', 'toiletshare', 'babyid_key', ${babyid})	
roof_prev	calculate					pulldata('partII', 'roof', 'babyid_key', ${babyid})	
wall_prev	calculate					pulldata('partII', 'wall', 'babyid_key', ${babyid})	
watersource_prev	calculate					pulldata('partII', 'watersource', 'babyid_key', ${babyid})	
numrooms_prev	calculate					pulldata('partII', 'numrooms', 'babyid_key', ${babyid})	
fuel_prev	calculate					pulldata('partII', 'fuel', 'babyid_key', ${babyid})	

home_prev	calculate					pulldata('partII', 'currenthome', 'babyid_key', ${babyid})	
today	today	today					
start	start	start					
end	end	end					
username	username	username					
checkidentity	begin group	Check identity					
checknames	select_one yesno	Is ${mwname} the name of the mother?					yes
mw_correct	text	Please go back and check whether you entered the correct Baby ID! If you are sure that you identified the correct household, but that the mother's name in our records is wrong, please enter the correct name.		${checknames}=0			yes
municipality	select_one municipality	In which municipality is the household located?	In the NEW political system!				yes
ward	integer	In which ward is the household located?	Enter 101 if unknown		.<35 or .=101		yes
mobile	select_one yesnodh	It is possible that we would like to contact you again at a later point. Would you mind giving us your mobile number?					yes

mobile_no	text	Enter mobile number		${mobile}=1			yes
checkidentity	end group						
mw_loc	select_one yesno	Are you interviewing the mother?					yes
missing_mw	select_one missing_mw	Why not?		${mw_loc}=0			yes
dod_mw_nep	integer	When did the mother die? (Record year 0000, month 00, day 00)	Nepali calendar	${missing_mw}=0	.>20690000 and .<20760000		yes
loc	select_one yesno	Did you meet the child?					yes
missing	select_one missing	Why did you not meet the child?		${loc}=0			yes
dod_nep	integer	When did the child die?	Enter as YYYYMMDD. If day or month not known, enter YYYYMM00 or YYYY0000	${missing}=0	.>20710000 and .<20760000		yes
deathreason	text	Why did the child die?		${missing}=0			yes
migrhh	select_one migrhh	In the first part of the interview, did the respondent say that any of the household members migrated abroad for work in the past seven years?					yes
name	text	What is the child's name?		${missing}!=0			

house	begin group	Questions about the house					
home_check	select_one yesno	When the child was born you said that you live in ${home_prev}. Do you still live there?		${home_prev}!=0			
movetime	integer	How many months ago did you move?		${home_check}=0			
home	select_one home or_other	Whose house are you staying in at the moment?		${home_check}=0 or ${home_prev}=0			
stove	select_one stovetype	In the household where you are staying at the moment, what kind of fireplace do you usually use for cooking family foods?					yes
fuel_check	select_one yesno	When the child was born you said that the fuel that you mainly use was ${fuel_prev}. Is that still true?		${fuel_prev}!=0			yes
fuel	select_one fuel	Which fuel do you use more than any other?		${fuel_check}=0 or ${fuel_prev}=0			yes
watersource_check	select_one yesno	When the child was born you said that your main source of drinking water was ${watersource_prev}. Is that still true?		${watersource_prev}!=0			yes
watersource	select_one watersource	What is the main drinking source of your household?		${watersource_check}=0 or ${watersource_prev}=0			yes

waterfar	select_one waterfar	From the house where you are staying at the moment how long does it take to go there, get water and come back?						yes
toilet_check	select_one yesno	Toilet: When your child was born you said that you used ${toilet_prev}. Is that still true?		${toilet_prev}!=0				yes
toilet	select_one toilet	What kind of toilet do your household members mainly use?		${toilet_check}=0 or ${toilet_prev}=0				yes
toiletshare_check	select_one yesno	When your child was born you said that you ${toiletshare_prev}. Is that still true?		${toiletshare_prev}!=0				yes
toiletshare	select_one yesno	Do you share your toilet with other households?		${toiletshare_check}=0 or ${toiletshare_prev}=0				yes
floor_check	select_one yesno	When your child was born the floor was mainly made of ${floor_prev}. Is that still true?		${floor_prev}!=0				yes
floor	select_one floor	What is the floor mainly made of?	You can answer this question from your own observations, you do not need to ask the respondent	${floor_check}=0 or ${floor_prev}=0				yes
wall_check	select_one yesno	When the child was born the wall was mainly made of ${wall_prev}. Is that still true?		${wall_prev}!=0				yes

wall	select_one wall	What are the walls of your house mainly made of?	You can answer this question from your own observations, you do not need to ask the respondent	${wall_check}=0 or ${wall_prev}=0				yes
roof_check	select_one yesno	When the child was born the roof was mainly made of ${roof_prev}. Is that still true?		${roof_prev}!=0				yes
roof	select_one roof	What is the roof of the house where you are staying at the moment mainly made of? (observe and tick the correct response)	You can answer this question from your own observations, you do not need to ask the respondent	${roof_check}=0 or ${roof_prev}=0				yes
numrooms_check	select_one yesno	When the child was born you said that there are a total of ${numrooms_prev} rooms in the home that you live in. Is that still true?		${numrooms_prev}!=0				yes
numrooms	integer	How many rooms are there in total in the house you usually live in?		${numrooms_check}=0 or ${numrooms_prev}=0				yes
newhouse	select_one newhouse	Some things around the house are different compared to when the child was born. Did you move or build a new house?		${floor_check}=0 or ${wall_check}=0 or ${roof_check}=0 or				yes

				${toilet_check}=0 or ${numrooms_check}=0			
newhouse_rem	select_one yesnodk	Did you finance this through remittances?		(${newhouse}=1 or ${newhouse}=2 or ${newhouse}=3) and ${migrhh}!=1			yes
house	end group						
foodcomp	begin group	**24 hour food consumption**		${missing}!=0			
dietrecall	note	I would like you to remember everything your child ate and drank yesterday in the day and night from getting up in the morning yesterday to when it woke up this morning (24 hours). Please describe the foods (meal and snacks) that your child ate or drank yesterday during the day and night. Start with the first food or drink of the morning.					

dds	select_multiple foodgrps	Referring to the list of foods that the child ate, please tick all the food groups and check again with the respondent if anything is unclear.			not(selected(.,'dk') and count-selected(.)>1) and not(selected(.,'nothing') and count-selected(.)>1)		
meat	select_multiple meat	What kind of meat?		selected(${dds}, 'meat')			yes
tea	select_one tea	Did the tea contain milk or sugar?		selected(${dds}, 'tea')			yes
boughtfood	select_one yesnoabsent	In the last 24 hours (since this time yesterday), did your child eat any shop bought foods such as Wei Wie, biscuits, dalmoth or cheeseballs?					yes
mealfreq	integer	In the last 24 hours (since this time yesterday), how many times did the child eat a meal or a snack?	Enter 101 if unknown		.<15 or .=101		yes
foodcomp	end group						
hfias	begin group	**Food security and vulnerability**					
askquestionsfood	note	I am now going to ask you some questions about food and food access in the house where you stay. Please answer about the					

		last 30 days only and please answer for yourself and your household. By 'resources' we mean money or food.					
worriesfood	select_one worriesfood	In the past 4 weeks, did you worry that your household would not have enough food?					yes
worriesfoodfrq	select_one frq	If you worried that you would not have enough food how often?		${worriesfood} = 1			yes
canteatpref	select_one canteatpref	In the past 4 weeks, were you or any household member not able to eat the kinds of food you preferred because of lack of resources?					yes
canteatpreffrq	select_one frq	If you were not able to eat foods you preferred how often?		${canteatpref} = 1			yes
smallvariety	select_one yesno	In the past 4weeks, did you or any household member have to eat a limited variety of foods due lack of resources?					yes
smallvarietyfrq	select_one frq	If Yes how often?		${smallvariety} = 1			yes
unlikedfood	select_one yesno	In the past 4 weeks, did you or any household member have to eat some foods that you really did not want to eat because of lack of resources to obtain other types of food?					yes
unlikedfoodfrq	select_one frq	If Yes how often?		${unlikedfood} = 1			yes

smallermeals	select_one yesno	In the past 4 weeks, did you or any household member eat smaller meals than you felt you needed because there was not enough food?					yes
smallermealsfrq	select_one frq	If Yes how often?		${smallermeals} = 1			yes
fewermeals	select_one yesno	In the past 4 weeks, did you or other household member have to eat fewer meals in a day because there was not enough food?					yes
fewermealsfrq	select_one frq	If Yes how often?		${fewermeals} = 1			yes
nofood	select_one yesno	In the past 4 weeks, was there ever no food to eat of any kind in your household because there were no resources to get food?					yes
nofoodfrq	select_one frq	If Yes how often?		${nofood} = 1			yes
sleephungry	select_one yesno	In the past 4 weeks, did you or any household member go to sleep hungry at night because there was not enough food?					yes
sleephungryfrq	select_one frq	If Yes how often?		${sleephungry} = 1			yes
noteatallday	select_one yesno	In the past 4 weeks, did you or any household member go a whole day and night without eating because there was not enough food?					yes

noteatalldayfrq	select_one frq	If Yes how often?		${noteatallday} = 1			yes
mnthsfood	select_one yesno	Over the last 12 months, were there any months in which you did not have enough food to meet your family's needs?					yes
nofood_month	select_multiple nofood_month	If Yes which months?		${mnthsfood} = 1			yes
hfias	end group						
hygiene	begin group	**Hygiene behaviours**					
safewater	select_multiple safewater	What do you usually do to make water safer to drink?			not(selected(.,'safewater_nothing') and count-selected(.)>1) and not(selected(.,'safewater_dk') and count-selected(.)>1)		
handwash	select_multiple handwash	What do you generally use to wash your hands?					

soap	select_multiple soap	What are the instances in which you use soap/other cleansing agent/ash when washing your hands?		selected(${handwash}, 'handwash_soap')	not(selected(.,'soap_none') and count-selected(.)>1)		
hygiene	end group						
education	begin group	**Education**		${missing}!=0			
current_schooling	select_one yesno	Is the child currently attending school?					yes
reasonnoschool	select_multiple reasonnoschool or_other	Why is the child not in school yet?		${current_schooling} = 0			yes
current_class	select_one current_class	If yes, which class is your child in now?		${current_schooling} = 1			yes
schoolkind	select_one schoolkind	Which kind of school does your child attend?		${current_schooling} = 1			yes
age_pre_primary	integer	At what age (running years) did your child start pre-primary schooling?		${current_schooling} = 1	.>2 and .<8		yes
education	end group						
childworkload	begin group	**Child 24h activities recall**		${missing}!=0			

hoursspent	note	Yesterday how many hours did your child spend···	Enter 101 if unknown				
chrschool	decimal	At school	Number of hours				yes
chrschoolw	decimal	doing schoolwork	Number of hours				yes
chrplay	decimal	Playing or doing nothing	Number of hours				yes
chrworkin	decimal	Doing household chores (washing dishes, cleaning the house, helping prepare food, etc.) .)	Number of hours				yes
chrworkout	decimal	Working away from home (collect fodder, make cowdung patties, work on the field, etc.)	Number of hours				yes
chrworkwater	decimal	collecting water	Number of hours				yes
chrlabour	decimal	helping parents with their labour away from home	Number of hours				yes
chrsib	decimal	Looking after younger siblings	Number of hours				yes
chrsleep	decimal	Sleeping	Number of hours				yes
chrother	decimal	other	Number of hours				
childworkloadcalc	calculate	childworkloadcalc				${chrschool} + ${chrschoolw} + ${chrplay} + ${chrworkin} + ${chrworkout} + ${chrworkwater} + ${chrlabour} +	yes

						${chrsib} + ${chrsleep} +${chrother}	
childworkload	end group						
childworkloadcalcnote	note	The hours you inserted add up to ${childworkloadcalc}. Please check again.		(${childworkloadcalc} > 24 and ${childworkloadcalc} <101) or ${childworkloadcalc} < 22			
morbidity	begin group	**Child morbidity and healthcare**		${missing}!=0			
introductionschildmorbidity	note	Introduction: Now I want to ask you about how your child's health has been recently and how you cared for your child during illness.					
childill	select_one childill	Has your child been ill in the last two months?					yes
lastilldays	integer	How many days did the most recent illness last?	Enter 101 if unknown	${childill} = 1			yes
diarr	select_one yesnoabsent	Has your baby had diarrhoea (loose stools more than 3 times a day) in the last 2 weeks?		${childill} = 1 or ${childill} = 3			yes
diarrgrp	begin group	**Diarrhoea**		${diarr} = 1			

blood	select_one yesno	Was there any blood in the stools?					yes
diatreat	select_one yesno	Did you seek any treatment when the child had diarrhoea?					yes
diarr_treat	select_one treat	Who did you go to for treatment when the child had diarrhoea?		${diatreat} = 1			yes
diarr_feed	select_multiple diarr_feed	Was he/she given any of the following at any time since he/she started having the diarrhoea [probe]					yes
diarliquid	select_one diarliquid	I would like to know how much your child was given to drink during the diarrhoea. During the time your child had diarrhoea, was he/she given much less than usual, less than usual, about the same amount, or more than usual to drink?					yes
diarsolid	select_one diarsolid	During the time your child had diarrhoea, was he/she given much less, less than usual to eat, about the same amount, more than usual, or nothing to eat?					yes
diastill	select_one yesno	Does your child still have diarrhoea?					yes
diarrgrp	end group						
fever	select_one yesnoabsent	Has your child been ill with a fever at any time in the last 2 weeks?		${childill} = 1 or ${childill} = 3			yes

fevergrp	begin group	**Fever**		${fever} = 1			
fevertreat	select_one yesno	Did you seek any treatment when the child had fever?					yes
fever_treat	select_one treat	Who did you go to for treatment when the child had fever?		${fevertreat} = 1			yes
feverstill	select_one yesno	Does your child still have fever?					yes
fevergrp	end group						
cough	select_one yesnoabsent	Has the child been ill with a cough at any time in the last 2 weeks?		${childill} = 1 or ${childill} = 3			yes
coughgrp	begin group	**Cough**		${cough} = 1			
ctbreath	select_one yesno	When the child had an illness with a cough, did he/she breathe faster than usual with short, rapid breaths or have difficulty breathing?					yes
chest	select_one yesno	When the child had this illness, did he/she have a problem in the chest or a blocked or runny nose?					yes
coughtrt	select_one yesno	Did you seek any treatment when the child had cough?					yes
cough_treat	select_one treat	Who did you go to for treatment when the child had cough?		${coughtrt} = 1			yes

coughstill	select_one yesno	Does your baby still have cough?					yes
coughgrp	end group						
bednet	select_one yesnoabsent	Did the baby sleep under bed net last night?					yes
morbidity	end group						
mwcareg	note	**Questions about the mother/primary caregiver**		${missing_mw}!=1 and ${missing_mw}!=2			
migrexperience	begin group	Mother's experience during migration		${missing_mw}!=1 and ${missing_mw}!=2 and ${migrhh}!=1			
personalquestions	note	Some of the following questions are personal. Make sure that the mother is alone when she answers these questions, as the presence of another family member might influence her answers.					
experiencequestions	note	I would now like to ask you some questions about your experience while your household member is away.					

migr_m	select_one migr_m	Overall, thinking about yourself, how would you describe your daily life now compared to before your household member moved away for work?					yes
migr_mp	select_multiple migr_mp or_other	If your daily life has become easier, in which ways has it become easier?		${migr_m} = 1 or ${migr_m} = 2 or ${migr_m} = 6			yes
migr_mn	select_multiple migr_mn or_other	In what ways has the quality of your life been reduced?					yes
migrexperience	end group						
ghq12	begin group	GHQ12		${missing_mw}!=1 and ${missing_mw}!=2			
ghq12_intro	note	In the last four weeks...					
ghq12_1	select_one ghq12_no1	have you been able to concentrate on whatever you are doing?					yes
ghq12_2	select_one ghq12_yes1	have you lost much sleep over worry?					yes
ghq12_3	select_one ghq12_no1	have you felt that you are playing a useful part in things?					yes

ghq12_4	select_one ghq12_no1	have you felt capable of making decisions about things?					yes
ghq12_5	select_one ghq12_yes1	have you felt constantly under strain?					yes
ghq12_6	select_one ghq12_no1	have you felt you could overcome your difficulties?					yes
ghq12_7	select_one ghq12_no1	have you been able to enjoy your normal day to day activities?					yes
ghq12_8	select_one ghq12_no1	have you been able to face up to your problems?					yes
ghq12_9	select_one ghq12_yes1	have you been feeling unhappy and depressed?					yes
ghq12_10	select_one ghq12_yes1	have you been losing confidence in yourself?					yes
ghq12_11	select_one ghq12_yes1	have you been thinking yourself as a worthless person?					yes
ghq12_12	select_one ghq12_no1	have you been feeling reasonably happy, all things considered?					yes
ghq12score	calculate					${ghq12_1}+${ghq12_2}+${ghq12_3}+${ghq12_4}+${ghq12_5}+${	

						ghq12_6}+${ghq12_7}+${ghq12_8}+${ghq12_9}+${ghq12_10}+${ghq12_11}+${ghq12_12}	
ghq12	end group						
ghqreferral	note	Her GHQ12 score is ${ghq12score}. Please advise her to get support from the Safer Migration Psychosocial Counselling service.		${ghq12score}>5 and ${migrhh}=3			
mwhrsspent	begin group	**Mother 24h activities recall**		${missing_mw}!=1 and ${missing_mw}!=2			
mwhrs1d	note	Yesterday, how many hours did you spend ...					
mwhrs1d_field	decimal	... tending to crops and animals in the fields or away from home?	Number of hours				yes
mwhrs1d_business	decimal	...engaged in business activities/money-making activities neither in the fields nor at home?	Number of hours				yes
mwhrs1d_home	decimal	...doing domestic chores, caring for your children and elderly/sick members of your family at home?	Number of hours				yes

mwhrs1d_leisure	decimal	...resting, on leisure activities and/or sleeping?	*Not counting the hours the mother/caregiver slept during the night.*				yes
mwhrscalc	calculate	mwhrscalc				${mwhrs1d_field} + ${mwhrs1d_business} + ${mwhrs1d_home} + ${mwhrs1d_leisure}	
mwhrsspent	end group						
mwhrscalcnote	note	The hours you inserted add up to ${mwhrscalc}. Please check again.		${mwhrscalc} > 20 and ${mwhrscalc} <101			
inlaws	begin group	In-laws		${mw_loc}=1			
mwinlawalive	select_one yesno	Is the mother-in-law currently alive?					yes
fatinlawalive	select_one yesno	Is the father-in-law currently alive?					yes
mwinlawhouse	select_one inlawhouse	Are you currently living together with your mother-in-law?		${mwinlawalive} =1			yes
fatinlawhouse	select_one inlawhouse	Are you currently living together with your father-in-law?		${fatinlawalive}= 1			yes

inlaws	end group						
decmaking	begin group	Household decision making		${mw_loc}=1			
emp1	select_one decmaker or_other	Who usually makes decisions about making major household expenditures (such as buying a land, paying for marriage, or sending someone abroad)?					yes
emp2	select_one decmaker or_other	Who physically receives and safeguards the household income?					yes
emp3	select_one hhincome or_other	Does ${emp2} receive all of household income or only part of it?					yes
emp4	select_one decmaker or_other	Who normally goes out shopping and brings food for the household?					yes
emp5	select_one decmaker or_other	Who makes decisions on saving, borrowing and lending household money?					yes
decmaking	end group						
secretremit	begin group	Husband's (secret) remittances		${mw_loc} = 1 and ${migrhh} =3			

remcollect	select_one remcollect or_other	Who collects your husband's remittances?					yes
remdec	select_one decmaker or_other	Who decides how your husband's remittances are spent?		${remcollect}!=8			yes
matrem	select_one yesnocannotanswer	Did you receive money from your hushand that the other household members do not know about?					yes
matrem_nrs	integer	How much money has your husband sent you since he went away?	NRS	${matrem} = 1			yes
matrem_use	select_multiple matrem_use or_other	What did you do with that money?		${matrem} = 1			yes
secretremit	end group						
respwithmother	select_one respwithmother	Did the mother answer the questions herself or was she assisted by another family member?		${mw_loc} = 1			yes
respondent	select_one respondent	If the mother could not be interviewed because she could not be located, the questions should have been answered by the primary caregiver of the child. Who was interviewed?		${mw_loc} = 0			yes

thankyou	note	**THANK THE RESPONDENT AND COMPLETE THE INTERVIEW**					
gps	geopoint	Record your location.					
notes	text	Write a note if the household somehow did not fit the questionnaire or if you encountered any other problems.					

Choices Part I & II

		<u>**Part I**</u>				<u>**Part II**</u>	
list_name	**name**	**label::en**	**filter**	**list_name**	**name**	**label::en**	**filter**
interviewer	1	Shyam		yesno	0	No	
interviewer	2	Dev Lal		yesno	1	Yes	
interviewer	3	Mahendra		yesnodk	0	No	
interviewer	4	Ram Sundar		yesnodk	1	Yes	
yesno	0	No		yesnodk	2	Don’t know/can’t remember	
yesno	1	Yes		yesnoabsent	0	No	
yesnodk	0	No		yesnoabsent	1	Yes	
yesnodk	1	Yes		yesnoabsent	2	Don’t know, the child was not present.	

		Part I				Part II	
list_name	**name**	**label::en**	**filter**	**list_name**	**name**	**label::en**	**filter**
yesnodk	2	Don't know/can't remember		yesnocannotanswer	0	No	
currenthome	1	own home (Sasural)		yesnocannotanswer	1	Yes	
currenthome	2	parental home (Maiti)		yesnocannotanswer	2	Unable to answer, interview is observed by other family members	
currenthome	3	Other		interviewer	1	Shyam	
sex	1	Male		interviewer	2	Dev Lal	
sex	2	Female		interviewer	3	Mahendra	
schlabsenthh	1	No the child has not been absent from school		interviewer	4	Ram Sundar	
schlabsenthh	2	the child has been absent from school more than 1 month in the last 12 months		missing_mw	0	Mother died	
reasonnoschool	1	Distance to school		missing_mw	1	Mother alive but temporarily absent	
reasonnoschool	2	Poor quality teaching		missing_mw	2	Guardian did not give permission to interview the mother	
reasonnoschool	3	Absent teacher		missing_mw	3	Mother is working abroad	

list_name	name	Part I label::en	filter	list_name	name	Part II label::en	filter
reasonnoschool	4	Poor performance in school (learning slowly)		missing	0	Child died	
reasonnoschool	5	Education is not important		missing	1	Child alive but temporarily absent	
reasonnoschool	6	Family cannot afford to send children to school		missing	2	Child is away in boarding school	
reasonnoschool	7	Needed to work at home		municipality	1	Aurahi Rural Municipality	
reasonnoschool	8	Looked too small for school		municipality	2	Bateshwor Rural Municipality	
reasonnoschool	9	Not interacting with others		municipality	3	Chhireshwor Municipality	
reasonnoschool	10	Learning slowly, to send to school		municipality	4	Dhanauji Rural Municipality	
reasonnoschool	11	illness		municipality	5	Dhanusadham Municipality	
reasonnoschool	12	Other reason		municipality	6	Ganeshman Charnath Municipality	
current_class	1	Nursery		municipality	7	Hansapur Municipality	
current_class	2	Lower kindergarten		municipality	8	Janaknandini Rural Municipality	
current_class	3	Kindergarten		municipality	9	Janakpur Sub-Metropolitan City	
current_class	4	Upper kindergarten		municipality	10	Kamala Municipality	

		Part I				Part II	
list_name	**name**	**label::en**	**filter**	**list_name**	**name**	**label::en**	**filter**
current_class	5	Class 1		municipality	11	Laxminiya Rural Municipality	
current_class	6	Class 2		municipality	12	Mithila Bihari Municipality	
schoolkind	1	private		municipality	13	Mithila Municipality	
schoolkind	2	government		municipality	14	Mukhiyapatti musaharmiya Rural Municipality	
schoolkind	3	both		municipality	15	Nagarain Municipality	
schoolkind	4	Madarsa		municipality	16	Sabaila Municipality	
nepal	1	Kathmandu		municipality	17	Sahidnagar Municipality	
nepal	2	Janakpur		municipality	18	Videha Municipality	
nepal	3	Other place within Dhanusha district		municipality	19	Don’t know/can’t remember	
nepal	4	Other place outside Dhanusha district		yesnodh	0	No	
relmigrm	1	Father		yesnodh	1	Yes	
relmigrm	2	Brother		yesnodh	2	Don't have mobile phone	
relmigrm	3	Grandfather		home	1	own home (sasural)	

		Part I				Part II	
list_name	**name**	**label::en**	**filter**	**list_name**	**name**	**label::en**	**filter**
relmigrm	4	Maternal uncle		home	2	parental home (Maiti)	
relmigrm	5	Paternal uncle					
relmigrm	6	Cousin male		migrhh	1	No labour migration was reported	
relmigrf	1	Mother		migrhh	2	labour migration by household members other than/NOT including the child's father	
relmigrf	2	Sister		migrhh	3	labour migration by household members INCLUDING the child's father	
relmigrf	3	Grandmother		waterfar	0	Less than 30 minutes	
relmigrf	4	Maternal aunt		waterfar	1	More than 30 minutes	
relmigrf	5	Paternal aunt		newhouse	1	Renovated the house or rebuilt parts of it	
relmigrf	6	Cousin female		newhouse	2	Built a new house	
year	2060	2060		newhouse	3	Moved into a different house, but did not build or rebuild house	

list_name	name	Part I label::en	filter	list_name	name	Part II label::en	filter
year	2061	2061		newhouse	4	This is the very same house but the information from the previous survey was incorrect	
year	2062	2062		source	1	Produced at home	
year	2063	2063		source	2	Purchased	
year	2064	2064		source	3	Some purchased, some produced at home	
year	2065	2065		worriesfood	1	Yes I worried	
year	2066	2066		worriesfood	0	No I did not worry	
year	2067	2067		frq	1	Rarely (once or twice in the past 4 weeks)	
year	2068	2068		frq	2	Sometimes (3-10 times in the past 4 weeks)	
year	2069	2069		frq	3	Often (>10 times in the past 4 weeks)	
year	2070	2070		canteatpref	1	Yes we were not able to eat	
year	2071	2071		canteatpref	0	No	
year	2072	2072		nofood_month	1	Baisakh (April – May)	

		Part I				Part II	
list_name	**name**	**label::en**	**filter**	**list_name**	**name**	**label::en**	**filter**
year	2073	2073		nofood_month	2	Jyesth (May -June)	
year	2074	2074		nofood_month	3	Asad (Jun-July)	
year	2075	2075		nofood_month	4	Shrawan (Jul -August)	
month	1	1		nofood_month	5	Bhadau (Aug- Sep)	
month	2	2		nofood_month	6	Asoj (Sep- Oct)	
month	3	3		nofood_month	7	Kartik (Oct- Nov)	
month	4	4		nofood_month	8	Mangsir (Nov- Dec)	
month	5	5		nofood_month	9	Push (Dec- Jan)	
month	6	6		nofood_month	10	Magh (Jan- Feb)	
month	7	7		nofood_month	11	Falgun (Feb-March)	
month	8	8		nofood_month	12	Chait (March- Apr)	
month	9	9		safewater	safewater_nothing	Nothing	
month	10	10		safewater	safewater_boil	Boil	
month	11	11		safewater	safewater_bleach	Add Bleach/Chlorine/Calcium Carbonate/alum	

list_name	name	Part I label::en	filter	list_name	name	Part II label::en	filter
month	12	12		safewater	safewater_strain	Strain through a cloth	
month	0	Don’t know		safewater	safewater_filter	Use water Filter (Ceramic/Sand/Mixed)	
migr_dest	1	India		safewater	safewater_stand	let it stand and settle	
migr_dest	2	Arab Countries (Saudi Arabia,Qatar,Baharain,UAE,Dubai,Oman,Jordan,Kuwait,Israel,Afganistan,Iraq)		safewater	safewater_dk	don't know	
migr_dest	3	Malaysia		handwash	handwash_water	Water only	
migr_sec	1	Construction		handwash	handwash_soap	Soap/detergent	
migr_sec	2	Manufacturing		handwash	handwash_ash	Ash	
migr_sec	3	Agriculture/farming		handwash	handwash_mud	Mud	
migr_sec	4	Health (nurse, caregiver, paramedic)		soap	soap_toilet	after toilet use	
migr_sec	5	Security		soap	soap_beforeeating	before eating	
migr_sec	6	Driver		soap	soap_childstool	after attending to a child who has defecated	

		Part I				Part II	
list_name	**name**	**label::en**	**filter**	**list_name**	**name**	**label::en**	**filter**
migr_sec	7	Tourism, restaurants, other service jobs - contact with customers (e.g. waiter, receptionist)		soap	soap_aftereating	after eating	
migr_sec	8	Tourism and restaurants, other service jobs - no contact with customers (e.g. gardener, cleaner)		soap	soap_beforecooking	before preparing food	
migr_sec	9	Wholesale, retail		soap	soap_beforefeeding	before feeding child	
migr_sec	10	Domestic work private household		soap	soap_dung	cleaning cow dung	
migr_sec	11	Office job		soap	soap_fieldwork	after working in field	
migr_sec	12	Education		soap	soap_none	None of the above	
migr_sec	13	Don't know/can't remember		reasonnoschool	1	Distance to school	
migr_how	migr_finfam	Gift from family (sasural or maiti)		reasonnoschool	2	Poor quality teaching	

list_name	name	Part I label::en	filter	list_name	name	Part II label::en	filter
migr_how	migr_finborrow	Borrow		reasonnoschool	3	Absent teacher	
migr_how	migr_finloan	Loan		reasonnoschool	4	Poor performance in school (learning slowly)	
migr_how	migr_finsaving	Savings		reasonnoschool	5	Education is not important	
migr_how	migr_finassets	Sells assets		reasonnoschool	6	Family cannot afford to send children to school	
migr_how	migr_finmort	Land mortgage		reasonnoschool	7	Needed to work at home	
migr_how	migr_finnone	Didn’t have to pay		reasonnoschool	8	Looked too small for school	
migr_how	migr_finother	Other		reasonnoschool	9	Not interacting with others	
migr_how	migr_dk	Don’t know/can’t remember		reasonnoschool	10	Learning slowly, to send to school	
migr_Iwho	a	Family (incl. maiti)		reasonnoschool	11	Child is ill often	
migr_Iwho	b	Relatives who are not members of your household		current_class	1	Nursery	
migr_Iwho	c	Manpower company / recruitment agency		current_class	2	Lower kindergarten	
migr_Iwho	d	Friend		current_class	3	Kindergarten	

		Part I				Part II	
list_name	name	label::en	filter	list_name	name	label::en	filter
migr_Iwho	e	Pawnbroker		current_class	4	Upper kindergarten	
migr_Iwho	f	Savings and credit coop		current_class	5	Class 1	
migr_Iwho	g	Moneylender (sau)		current_class	6	Class 2	
migr_Iwho	h	Bank loan		schoolkind	1	private	
migr_Iwho	i	Other		schoolkind	2	government	
migr_Icolwhich	1	House/land		schoolkind	3	both	
migr_Icolwhich	2	Animals		schoolkind	4	Madarsa	
migr_Icolwhich	3	Machinery		24hdietdiff	1	Yes the child ate foods that the HH did not	
migr_Icolwhich	4	Household items		24hdietdiff	0	No, the child ate the same as the household	
migr_Icolwhich	5	Personal items		foodgrps	cereal	Rice/roti/ other cereals	cereal
migr_Icolwhich	6	Bank book/bank deposits		foodgrps	pulses	Dal and other pulses	pulses
migr_lintr	1	Simple interest		foodgrps	seeds	seeds like black or yellow mustard, sesame, linseed, hemp or nuts like peanuts, almonds and cashews or	seeds

		Part I				Part II	
list_name	name	label::en	filter	list_name	name	label::en	filter
						foods containing those seeds and nuts	
migr_lintr	2	Compound		foodgrps	starch	Potatoes,Yams, Ol and similar starchy roots	starch
migr_lintr	3	Don’t know		foodgrps	glv	Green leafy veg	glv
migr_lrpaid	1	Still outstanding and currently not being repaid		foodgrps	yellowveg	Pumpkin, carrots or other yellow veg	yellowveg
migr_lrpaid	2	Currently being repaid		foodgrps	othveg	Other vegetables like onions, garlic, aubergine, tomato, wax gourd, bitter gourd, cabbage, cauliflower, okra, parwal, and any others (all other vegetables not included above)	othveg
migr_lrpaid	3	Repaid in total		foodgrps	sprouts	Sprouted seeds and pulses	sprouts
migr_work	1	Daily paid labour (servant, labour exchange, daily-waged labour, factory labour, band party player, tube well digger)		foodgrps	meat	Meat	meat
migr_work	2	Regular Job (driver, teacher, factory, gov job, ngo job etc.)		foodgrps	fish	Fish and shell fish	fish

		Part I				Part II	
list_name	**name**	**label::en**	**filter**	**list_name**	**name**	**label::en**	**filter**
migr_work	3	Small scale trade (Tela, small market stall, very small shop, tea shop)		foodgrps	eggs	Eggs	eggs
migr_work	4	Medium Scale trade (Small Grocery, Medicine shop/ practitioner, small rice mill, operating a band party)		foodgrps	dairy	Dairy products	dairy
migr_work	5	Large Scale Trade (Larger shop in main bazaar, big grain store or mill, factory, etc)		foodgrps	yellowfruit	Yellow fruits including ripe mango and papaya, money jack, indian date	yellowfruit
migr_work	6	Agricultural work		foodgrps	othfruit	Any others fruits jackfruit, banana, and any others not included in previous list	othfruit
migr_work	7	Keeping/looking after livestock		foodgrps	spices	Spices/salt	spices
migr_work	8	Making things for sale e.g. Bamboo baskets, fans, tailoring etc.		foodgrps	fat	Oil/ghee/veg ghee/ lard and foods containing them	fat
migr_work	9	Selling things gathered from the wild (e.g. fish, snails,		foodgrps	sugar	Sweet foods and drinks	sugar

		Part I				Part II	
list_name	**name**	**label::en**	**filter**	**list_name**	**name**	**label::en**	**filter**
		firewood, bamboo, leaves, sag etc.)					
migr_work	10	Riding rickshaw/operating ox cart/ or push along cart (Thela)		foodgrps	tea	Tea/ coffee	tea
migr_work	11	Doing unpaid work outside the household		foodgrps	nothing	Nothing	
migr_work	12	In school/education		foodgrps	dk	Don’t know, the child was not present.	
migr_work	13	Unemployed		tea	0	No	
migr_work	14	Retired		tea	1	Contained milk only	
migr_work	15	Other		tea	2	Contained sugar only	
agr	1	own home/family		tea	3	Contained both milk and sugar	
agr	2	labour on others’ field		meat	chicken	Chicken	
agr	3	share cropping		meat	goat	Goat	
livestock	1	own home's/family's livestock		meat	organ	Organ meat	

		Part I				Part II	
list_name	name	label::en	filter	list_name	name	label::en	filter
livestock	2	other people's livestock		meat	othmeat	Other meat	
livestock	3	share cropping		childill	1	Yes	
rem_use	rem_food	Purchase of food		childill	0	No	
rem_use	rem_consum	Other everyday consumption (clothing/drinks/tobacco)		childill	3	Don’t know/can’t remember	
rem_use	rem_house	Build or rebuild house		treat	1	Village practioner	
rem_use	rem_toilet	Build toilet		treat	2	Health Post	
rem_use	rem_water	Install waterpump		treat	3	other government hospital	
rem_use	rem_edu	Education of household members		treat	4	Private Clinic or Nursing Home	
rem_use	rem_med	Health and medical expenses		treat	5	Medical College	
rem_use	rem_migrloan	Pay off migration-finance loans		treat	6	Medicine Store	
rem_use	rem_othloan	Pay off other loans		treat	7	Ayurvedic hospitals	
rem_use	rem_migrfin	Financing migration of other family member		treat	8	Primary Health Care Centre	

list_name	name	Part I label::en	filter	list_name	name	Part II label::en	filter
rem_use	rem_fest	Special occasions (e.g. wedding or funeral)		treat	9	Shaman (Dhami/Jhangri)	
rem_use	rem_hh	Purchase household goods		treat	10	Health Camp	
rem_use	rem_elec	Purchase electronic devices (tv, mobiles, laptop)		treat	11	other	
rem_use	rem_agr	Purchase agricultural land		diarr_feed	diapwater	Plain water	
rem_use	rem_homestead	Purchase homestead land		diarr_feed	diaswater	Sugar water	
rem_use	rem_hire	Hire labour		diarr_feed	diaors	a fluid made from a special packet called ORS	
rem_use	rem_save	Savings		diarr_feed	diagruel	Gruel made from rice or other grain	
rem_use	rem_invest	Business investment		diarliquid	1	Much less than usual	
rem_use	rem_bills	Pay utilities bills (phone, electricity, rent, etc.)		diarliquid	2	Somewhat less than usual	
rem_use	rem_jewel	Jewelry		diarliquid	3	About the same as usual	
rem_dec	1	Mother		diarliquid	4	More than usual	

		Part I				Part II	
list_name	**name**	**label::en**	**filter**	**list_name**	**name**	**label::en**	**filter**
rem_dec	2	The interviewee if it is not the mother who is being interviewed		diarliquid	5	Nothing given to drink	
rem_dec	3	The migrant him/herself		diarsolid	1	Much less than usual	
rem_dec	4	The migrant’s father		diarsolid	2	Somewhat less than usual	
rem_dec	5	The migrant’s mother		diarsolid	3	About the same as usual	
rem_dec	6	Other family members living in the household		diarsolid	4	More than usual	
rem_dec	7	Other family members living outside the households		diarsolid	5	Stopped food	
rem_dec	8	Other non family members		bdtest	1	Yes	
rem_gtype	remg_tv	TV		bdtest	0	No	
rem_gtype	remg_cloth	Clothing		bdtest	3	Don’t know/can’t remember	
rem_gtype	remg_jewel	Jewelry		maletreat	1	Yes	
rem_gtype	remg_med	Medicines		maletreat	2	No	
rem_gtype	remg_hh	Household utensils		maletreat	3	Don’t know/can’t remember	
rem_gtype	remg_bed	Bedding		maletreat	4	Didn’t suffer from malaria	

list_name	name	Part I label::en	filter	list_name	name	Part II label::en	filter
rem_gtype	remg_pc	Computer/Laptops		migr_m	1	Much easier	
rem_gtype	remg_mobile	Mobile Phone		migr_m	2	Easier	
rem_gtype	remg_appl	Other electronic appliances		migr_m	3	The same/neither easier nor harder	
rem_gtype	remg_agr	Agricultural inputs		migr_m	4	Harder	
rem_gtype	remg_invest	Items for business		migr_m	5	Much harder	
rem_gtype	remg_relig	Religious gifts		migr_m	6	Some things have become harder, some things have become easier	
rem_gtype	remg_edu	School items		migr_mp	a	Reduced work burden	
rem_pers	rem_relative	Family member who does not live in the household		migr_mp	b	Enhanced purchasing power	
rem_pers	rem_friend	Friend of a household member		migr_mp	c	Increased employment opportunities	
rem_pers	rem_neighbour	Neighbour		migr_mp	d	Increased mobility	
problems	a	Physical/sexual/psychological abuse		migr_mp	e	Better education	
problems	b	Work-related illness or injury		migr_mp	f	Social status enhanced	

list_name	name	Part I label::en	filter	list_name	name	Part II label::en	filter
problems	c	Withholding or delay of payment, lower salary than previously agreed		migr_mp	g	Improved decision-making capacity	
problems	d	poor housing and lodging		migr_mn	a	Increased work burden	
problems	e	overtime work without compensation		migr_mn	b	Financial burden through debt	
problems	f	language barrier		migr_mn	c	Reduction in mobility	
problems	g	Lack of information regarding workers' rights		migr_mn	d	Social status diminished	
problems	h	isolation from other workers and/or difficulty staying in contact with family at home		migr_mn	e	Lack of security due to absence of male member of family	
hh_consum	clothesadult	Clothes and shoes for adults, including any materials or fabric	hh_consum_clothesadult	migr_mn	f	Disruption of family life	
hh_consum	clotheschild	Clothes and shoes for children, including any materials or fabric	hh_consum_clotheschild	migr_mn	g	Social tensions within the household over remittances	

		Part I				Part II	
list_name	**name**	**label::en**	**filter**	**list_name**	**name**	**label::en**	**filter**
hh_consum	school	School expenses (transport, books, fees etc. excluding clothes & shoes)	hh_consum_school	migr_mn	h	Having to raise the child/children alone	
hh_consum	tuition	Private tuition	hh_consum_tuition	migr_mn	i	Being exposed to the gossip in the community	
hh_consum	furnit	Furniture, other floor coverings for the house	hh_consum_furnit	matrem_use	matrem_food	Purchase of food	
hh_consum	medic	Health care (Medication, Laboratory tests & Doctor’s fees)	hh_consum_medic	matrem_use	matrem_consum	Other everyday consumption (clothing/drinks/tobacco)	
hh_consum	festiv	Festival or other celebration (Festivals, wedding, pilgrimage, Arghau Funerals Shraddha, Bratabandha birthday pasani (rice feeding ceremony))	hh_consum_festiv	matrem_use	matrem_med	Health and medical expenses	
hh_consum	agri	Agricultural inputs (seed, fertiliser, insecticide, irrigation, tractor costs, thresher hire, etc)	hh_consum_agri	matrem_use	matrem_hh	Purchase household goods	

list_name	name	Part I label::en	filter	list_name	name	Part II label::en	filter
hh_consum	insurance	life insurance	hh_consum_insurance	matrem_use	matrem_elec	Purchase electronic devices (tv, mobiles, laptop)	
hh_consum	house	Construction or repairing of house	hh_consum_house	matrem_use	matrem_save	Savings	
hh_consum	animal	Farm animals	hh_consum_animal	ghq12_no1	1	No	
hh_consum	cosmetic	Cosmetic/hygiene items	hh_consum_cosmetic	ghq12_no1	0	Yes	
hh_consum	hhitems	Household utensils	hh_consum_hhitems	ghq12_yes1	0	No	
hh_consum	hh_consum_none	None of those listed		ghq12_yes1	1	Yes	
migrinfo	0	No		respwithmother	1	Mother only answered	
migrinfo	1	Safer Migration (SaMi) information centre in District Administration Office		respwithmother	2	Other family member assisted	
hh_pers	child	Child		respwithmother	3	Other family member answered all	
hh_pers	hhhead	Household head		respondent	1	Mother-in-law	

		Part I				Part II	
list_name	**name**	**label::en**	**filter**	**list_name**	**name**	**label::en**	**filter**
hh_pers	othadult	Other adult		respondent	2	Father-in-law	
hh_cope	savings	Used savings		respondent	3	Husband	
hh_cope	loan	Took out a loan		respondent	4	Other women from husband's household	
hh_cope	soldland	Sold land		respondent	5	Father	
hh_cope	soldassets	Sold other assets e.g. jewelry		respondent	6	Mother	
hh_cope	eatless	Reduced food consumption		respondent	7	Other women from the parental household	
hh_cope	consumless	Reduced non-food consumption		respondent	8	Female neighbour /friend	
hh_cope	morework	Took extra work (non-migratory)		respondent	9	Male neighbour	
hh_cope	moremigr	Took extra migratory work overseas		respondent	10	Other Males from Husband's house/Parental house	
hh_cope	nothing	Nothing		respondent	11	Other	
hh_pers_unemploy	1	Main breadwinner		language	1	Maithili	

list_name	name	Part I label::en	filter	list_name	name	Part II label::en	filter
hh_pers_unemploy	2	Other adult		language	2	Nepali	
hhaelectr	1	Yes own or neighbour's		language	3	Other	
hhaelectr	2	Yes but from hooking		stovetype	1	Open fire (e.g. with 3 stones or a trivet)	
hhaelectr	3	Yes from solar panel		stovetype	2	Mud stove with no chimney	
hhaelectr	0	No		stovetype	3	Brick stove with no chimney	
assets	hharadio	Radio		stovetype	4	Closed stove with chimney (improved stove)	
assets	hhamonotv	Black and white TV		stovetype	5	Gas Stove	
assets	hhacolourtv	Colour TV		stovetype	6	Other	
assets	hhabicycle	Bicycle		fuel	1	Combination of firewood together with dried cow dung (goitha)	
assets	hhaownrickshaw	Own rickshaw		fuel	2	Combination of dried cow dung and agricultural residues or leaves	
assets	hhaoxcart	Ox cart		fuel	3	Firewood or sawdust	
assets	hhamotorbike	Motorcycle		fuel	4	Dried cow dung only	

		Part I				Part II	
list_name	**name**	**label::en**	**filter**	**list_name**	**name**	**label::en**	**filter**
assets	hhatractor	Tractor		fuel	5	Straw/Agricultural crops residues/other plant(not firewood)	
assets	hhavehicle	Bus/Truck/Jeep/ car/tempo		fuel	6	Gas	
assets	hhathresher	Thresher		fuel	7	Charcoal	
assets	hhapumpset	Pump		fuel	8	Kerosene	
assets	hhafixedphone	Fixed telephone		fuel	9	Bio gas	
assets	hhabatteryset	Battery set		watersource	1	Piped in to dwelling	
assets	hhasolarset	Solar set		watersource	2	Piped to yard/plot	
assets	hhasewingmach	Sewing Machine		watersource	3	Public tap/standpipe	
assets	hhamobilephone	Mobile Phone		watersource	4	Tubewell (handpump) in your own home	
assets	hhacamera	Camera		watersource	5	Tubewell (handpump) in your yard / near the house	
assets	hhacdplayer	CD player		watersource	6	Neighbor's tubewell (handpump)	
assets	hhavcdplayer	Video/dvd player		watersource	7	Public Handpump	
assets	hhagenerator	generator		watersource	8	Deep borehole	

list_name	name	Part I label::en	filter	list_name	name	Part II label::en	filter
assets	hharicemill	Rice mill		watersource	9	Protected well	
assets	hhapc	Computer / laptop		watersource	10	Unprotected well	
assets	hhafridge	Fridge		watersource	11	Bottle or jar	
assets	hhanone	None of those listed		watersource	12	Other (such as spring, water tanker, or other)	
incomesource	incdaylabour	Daily paid labour (servant, labour exchange, daily-waged labour, factory labour, band party player, tube well digger)		toilet	1	Bushes/Stream/Open Areas	
incomesource	incjob	Regular Job (driver, teacher, factory, gov job, ngo job etc.)		toilet	2	Pit Toilet	
incomesource	incsmalltrade	Small scale trade (Tela, small market stall, very small shop, tea shop)		toilet	3	Pan Toilet	
incomesource	incmedtrade	Medium Scale trade (Small Grocery, Medicine shop/ practitioner, small rice mill, operating a band party)		toilet	4	Flush Toilet	

list_name	name	Part I label::en	filter	list_name	name	Part II label::en	filter
incomesource	inclargetrade	Large Scale Trade (Larger shop in main bazaar, big grain store or mill, factory, etc)		toilet	5	Other Toilet	
incomesource	inccrops	Selling own crop production (Cereal,vegetables)		inlawhouse	1	Yes, living together	
incomesource	incdairy	Selling Milk, yoghurt or ghee from own cattle		inlawhouse	0	No, household partition	
incomesource	incmeat	Selling livestock, fish or meat from own production		decmaker	1	You	
incomesource	incartisaninc	Making things for sale e.g. Bamboo baskets, fans, tailoring etc.		decmaker	2	Your husband only	
incomesource	incwildprod	Selling things gathered from the wild (e.g. fish, snails, firewood, bamboo, leaves, sag etc.)		decmaker	3	You and your husband	
incomesource	incvehiother	Riding rickshaw/ operating oxcart/ or push along cart (tela) ‐ rented		decmaker	4	Mother in law	

		Part I				Part II	
list_name	**name**	**label::en**	**filter**	**list_name**	**name**	**label::en**	**filter**
incomesource	incvehicown	Riding own rickshaw/operating own ox cart/ or push along cart (Tela)		decmaker	5	Father in law	
incomesource	increntvehic	Renting out Rickshaw/ ox cart/ or push cart (Tela)/ Thresher/ Tractor/Pumpset etc.		decmaker	6	Father in law and mother in law together	
incomesource	incbordertrade	Border trade		decmaker	7	You and the whole household	
incomesource	incalcohol	Making and selling alcohol		decmaker	0	Unable to answer, interview is observed by other family members	
incomesource	increm	Remittances		receivemoney	1	You	
incomesource	increnthouse	Renting out house, apartment or room		receivemoney	2	Your husband only	
incomesource	incgiveloan	Give out loans		receivemoney	3	You and your husband	
incomesource	incpension	cash transfers such as widow allowance, disabled pension, old age allowance		receivemoney	4	Mother in law	
mainfood	sfrice	rice		receivemoney	5	Father in law	

		Part I				Part II	
list_name	**name**	**label::en**	**filter**	**list_name**	**name**	**label::en**	**filter**
mainfood	sfwheat	wheat		receivemoney	6	Father in law and mother in law together	
mainfood	sfricewheat	both rice and wheat equally		receivemoney	7	Everyone - money is stored in a pooled location that everyone can access	
mainfood	sfmaize	maize		receivemoney	8	Nobody - money is not pooled, all earners keep money for themselves	
mainfood	sfmillet	millet		receivemoney	0	Unable to answer, interview is observed by other family members	
rank_source	5	1 (most important)		remcollect	1	You	
rank_source	4	2		remcollect	4	Mother in law	
rank_source	3	3		remcollect	5	Father in law	
rank_source	2	4		remcollect	6	Father in law and mother in law together	
rank_source	1	5 (least important)		remcollect	7	You and the whole household	
rank_source	0	not at all		remcollect	8	No money received	
ownland	1	Have land		remcollect	0	Unable to answer, interview is observed by other family members	

list_name	name	Part I label::en	filter	list_name	name	Part II label::en	filter
ownland	2	Have sharecropped land		hhincome	1	All household income	
ownland	3	Have no land		hhincome	2	All household income minus pocket money / koseliya	
stovetype	1	Open fire (e.g. with 3 stones or a trivet)		hhincome	3	Only enough to cover household expenses, earners keep their surplus money	
stovetype	2	Mud with no chimney		hhincome	0	Unable to answer, interview is observed by other family members	
stovetype	3	Brick stove with no chimney		floor	1	Clay	
stovetype	4	Closed stove with chimney (improved stove)		floor	2	Dung and clay	
stovetype	5	Gas Stove		floor	3	Sand	
stovetype	6	Other		floor	4	Cement	
fuel	1	Combination of firewood together with dried cow dung (goitha)		floor	5	Other	

		Part I				Part II	
list_name	**name**	**label::en**	**filter**	**list_name**	**name**	**label::en**	**filter**
fuel	2	Combination of dried cow dung and agricultural residues or leaves		wall	1	Cement and bricks	
fuel	3	Firewood or sawdust		wall	2	Mud and bricks	
fuel	4	Dried cow dung only		wall	3	Mud and stone	
fuel	5	Straw/Agricultural crops residues/other plant(not firewood)		wall	4	Planks of wood	
fuel	6	Gas		wall	5	Grass/straw Thatch	
fuel	7	Charcoal		wall	6	Metal sheets	
fuel	8	Kerosene		wall	7	Cement and woven stems or bamboo	
fuel	9	Bio gas		wall	8	Mud and woven stems or babmoo	
watersource	1	Piped in to dwelling		wall	9	Other	
watersource	2	Piped to yard/plot		roof	1	Cement	
watersource	3	Public tap/standpipe		roof	2	Asbestos sheets	

list_name	name	Part I label::en	filter	list_name	name	Part II label::en	filter
watersource	4	Tubewell (handpump) in your own home		roof	3	Traditional tiles	
watersource	5	Tubewell (handpump) in your yard / near the house		roof	4	Tiles	
watersource	6	Neighbor's tubewell (handpump)		roof	5	Metal sheets	
watersource	7	Public Handpump		roof	6	Grass/straw thatch	
watersource	8	Deep borehole		roof	7	Other	
watersource	9	Protected well					
watersource	10	Unprotected well					
watersource	11	Bottle or jar					
watersource	12	Other (such as spring, water tanker, or other)					
toilet	1	Bushes/Stream/Open Areas					
toilet	2	Pit Toilet					
toilet	3	Pan Toilet					
toilet	4	Flush Toilet					

list_name	name	Part I label::en	filter	list_name	name	Part II label::en	filter
toilet	5	Other Toilet					
serespondent	1	woman herself					
serespondent	2	Mother-in-law					
serespondent	3	Father-in-law					
serespondent	4	Husband					
serespondent	5	Other women from husband's household					
serespondent	6	Father					
serespondent	7	Mother					
serespondent	8	Other women from the parental household					
serespondent	9	Female neighbour /friend					
serespondent	10	Male neighbour					
serespondent	11	Other Males from Husband's house/Parental house					
serespondent	12	Other					

A. 2 Study approvals

Nepal Health Research Council Approval of Research Proposal "Trajectory of growth faltering: A cohort study of infants in Dhanusha, Nepal"

Nepal Health Research Council

Estd. 1991

NHRC

Ref. No. 111

28 July 2013

Prof. Dr. D. S. Manandhar
Principal Investigator
Mother and Infant Research Activities
Thapathali, Kathmandu

Ref: **Approval of Research Proposal** entitled **Trajectory of growth faltering: A cohort study of infants in Dhanusha, Nepal**

Dear Prof. Dr. Manandhar,

It is my pleasure to inform you that the above-mentioned proposal submitted on 7 July 2013 (**Reg. no. 95/2013** please use this Reg. No. during further correspondence) has been approved by NHRC Ethical Review Board on 25 July 2013 (2070-04-10).

As per NHRC rules and regulations, the investigator has to strictly follow the protocol stipulated in the proposal. Any change in objective(s), problem statement, research question or hypothesis, methodology, implementation procedure, data management and budget that may be necessary in course of the implementation of the research proposal can only be made so and implemented after prior approval from this council. Thus, it is compulsory to submit the detail of such changes intended or desired with justification prior to actual change in the protocol.

If the researcher requires transfer of the bio samples to other countries, the investigator should apply to the NHRC for the permission.

Further, the researchers are directed to strictly abide by the National Ethical Guidelines published by NHRC during the implementation of their research proposal and submit progress report and full or summary report upon completion.

As per your research proposal, the total research amount is NRs. 9, 45,158.00 and accordingly the processing fee amounts to NRs. 9,470.00. It is acknowledged that the above-mentioned processing fee has been received at NHRC.

If you have any questions, please contact the research section of NHRC.

Thanking you.

[redacted]

Dr. Shanker Pratap Singh
Member Secretary

Tel.+977-1-4254220, 4227460, Fax: +977-1-4262469, RamShah Path, P.O. Box 7626, Kathmandu, Nepal.
Website: http: www.nhrc.org.np; Email : nhrc@nhrc.org.np

Nepal Health Research Council Approval of Research Proposal "The association of migration for labour with the left-behind child's nutritional status and growth – Evidence from a birth cohort in Dhanusha District, Nepal.

Government of Nepal

Nepal Health Research Council (NHRC)

Estd. 1991

Ref. No.: 2014

13 March 2018

Ms. Laura Katharina Busert
Principal Investigator, Great Ormond Street Institute for Child Health, University College Londan

Prof. Dr. Dharna Sharna Manandhar
Co-Principal Investigator, MIRA, Thapathali

Ref: **Approval of Thesis Proposal** entitled **The association of migration for labour with the left-behind child's nutritional status and growth - Evidence from a birth cohort in Dhanusha District, Nepal**

Dear Ms. Busert and Prof. Dr. Manandhar,

It is my pleasure to inform you that the above-mentioned proposal submitted on **6 January 2018** (**Reg. no. 13/2018)** please use this Reg. No. during further correspondence) has been approved by Nepal Health Research Council (NHRC) Ethical Review Board on **4 March 2018**.

As per NHRC rules and regulations, the investigator has to strictly follow the protocol stipulated in the proposal. Any change in objective(s), problem statement, research question or hypothesis, methodology, implementation procedure, data management and budget that may be necessary in course of the implementation of the research proposal can only be made so and implemented after prior approval from this council. Thus, it is compulsory to submit the detail of such changes intended or desired with justification prior to actual change in the protocol. Expiration date of this proposal is **January 2019.**

If the researcher requires transfer of the bio samples to other countries, the investigator should apply to the NHRC for the permission. The researchers will not be allowed to ship any raw/crude human biomaterial outside the country; only extracted and amplified samples can be taken to labs outside of Nepal for further study, as per the protocol submitted and approved by the NHRC. The remaining samples of the lab should be destroyed as per standard operating procedure, the process documented, and the NHRC informed.

Further, the researchers are directed to strictly abide by the National Ethical Guidelines published by NHRC during the implementation of their project proposal and **submit progress report in between and full or summary report upon completion.**

As per your project proposal, the total research amount is **NRs 9,76,605** and accordingly the processing fee amounts to **NRs 20,000.** It is acknowledged that the above-mentioned processing fee has been received at NHRC.

If you have any questions, please contact the Ethical Review M & E Section at NHRC.

Thanking you,

[redacted]

Prof. Dr. Anjani Kumar Jha
Executive Chairperson

Tel: +977 1 4254220, Fax: +977 1 4262469, Ramshah Path, PO Box: 7626, Kathmandu, Nepal
Website: http://www.nhrc.gov.np, E-mail: nhrc@nhrc.gov.np

UCL Research Ethics Committee Approval of Research Proposal

UCL RESEARCH ETHICS COMMITTEE
ACADEMIC SERVICES

UCL

12th July 2017

Professor Mario Cortina-Borja
Population, Policy and Practice Programme
Institute of Child Health
UCL

Dear Professor Cortina-Borja

Notification of Ethical Approval
Re: Ethics Application 11345/001: The effects of migraine for labour on the left-behind child's nutritional status and growth

I am pleased to confirm in my capacity as interim Chair of the UCL Research Ethics Committee (REC) that your study has been approved by the UCL REC until **28th September 2018.**

Approval is subject to the following conditions:

Notification of Amendments to the Research
You must seek Chair's approval for proposed amendments (to include extensions to the duration of the project) to the research for which this approval has been given. Ethical approval is specific to this project and must not be treated as applicable to research of a similar nature. Each research project is reviewed separately and if there are significant changes to the research protocol you should seek confirmation of continued ethical approval by completing the 'Amendment Approval Request Form': http://ethics.grad.ucl.ac.uk/responsibilities.php

Adverse Event Reporting – Serious and Non-Serious
It is your responsibility to report to the Committee any unanticipated problems or adverse events involving risks to participants or others. The Ethics Committee should be notified of all serious adverse events via the Ethics Committee Administrator (ethics@ucl.ac.uk) immediately the incident occurs. Where the adverse incident is unexpected and serious, the Chair or Vice-Chair will decide whether the study should be terminated pending the opinion of an independent expert. For non-serious adverse events the Chair or Vice-Chair of the Ethics Committee should again be notified via the Ethics Committee Administrator within ten days of the incident occurring and provide a full written report that should include any amendments to the participant information sheet and study protocol. The Chair or Vice-Chair will confirm that the incident is non-serious and report to the Committee at the next meeting. The final view of the Committee will be communicated to you.

Final Report
At the end of the data collection element of your research we ask that you submit a very brief report (1-2 paragraphs will suffice) which includes in particular issues relating to the ethical implications of the research i.e. issues obtaining consent, participants withdrawing from the research, confidentiality, protection of participants from physical and mental harm etc.

Academic Services, 1-19 Torrington Place (9th Floor),
University College London
Tel: +44 (0)20 3108 8216
Email: ethics@ucl.ac.uk
http://ethics.grad.ucl.ac.uk/

With best wishes for the research.

[redacted]

Professor Michael Heinrich
Interim Chair, UCL Research Ethics Committee

Cc: Laura Busert

Example of local approval letter (Kamala Municipality)

कमला नगरपालिका

नगर कार्यपालिकाको कार्यालय

माची [illegible] धनुषा

२ नं. प्रदेश, नेपाल

पत्र संख्या - २०७४/०७५

चलानी नं.:- २२६

मिति 13 APR 2018

विषय:- Permission for research study

श्री Mother and Infant Research Activities (MIRA)
GPO Box 921
Y.B. Bhawan, Thapathali, Kathmandu, Nepal

This is to confirm the approval of the research study titled "The association of migration for labour with the left-behind child's nutritional status and growth - Evidence from a birth cohort in Dhanusha District Nepal" (NHRC Reg. no. 13/2018). This data collection is part of Laura Katharina Busert's PhD project and run in collaboration between Mother and Infant Research Activities (MIRA) and University College London (UCL). The municipal office of Kamla has been informed about all proceedings, gives permission for the work and overall fully supports the project.

Kind regards,

[redacted]

Ram Ud[illegible]
(Mayor) नगर प्रमुख
Kamla Municipality, Dhanusha

A. 3 Protocol main data collection

Growth Monitoring Study (GMS) Follow-up 2018

Protocol for main data collection

Introduction

Background

Good nutrition is essential for survival and healthy development of children. Linear growth is considered a marker of good nutrition and development, because it has been associated with short-term morbidity and mortality in early infancy, cognitive ability and school performance in childhood, and non-communicable disease and income in adulthood (Black et al., 2008; Olofin et al., 2013; Victora et al., 2008).

Growth monitoring helps to visualize the pattern of growth and development of the child, especially detecting the timing and pattern of growth faltering which in turn helps to design interventions which are most likely to have impact in preventing child malnutrition. In order to identify local growth limiting factors and most feasible health interventions in Dhanusha district, University College London and Mother and Infant Research Activities (MIRA) conducted a growth monitoring study between June 2012 and August 2014.

A framework developed by UNICEF (UNICEF, 1990) on the causes and consequences of child malnutrition emphasizes the importance of poverty, both at the household as well as at the community and national level, as the underlying determinant. Sending a family member to work abroad has become a frequent poverty alleviation strategy for households in low-and middle-income countries and remittances are an important source of income for these economies. In fact, the earnings that labour migrants from low- and middle-income countries send back to their families are three times the volumes of official aid flows (World Bank Group, 2016). Lokshin, Bontch-Osmolovski, and Glinskaya (2010) found that around one fifth of the poverty reduction occurring in

Nepal between 1995 and 2004 can be attributed to remittances. Since then, the share of remittances received as proportion of GDP has increased dramatically, from 11.3% in 2004 to 31.4% in 2016, the highest share worldwide (World Bank Group, 2017). Dhanusha disctrict has the highest number of labour migrants (Ministry of Labour and Employment, 2018) .

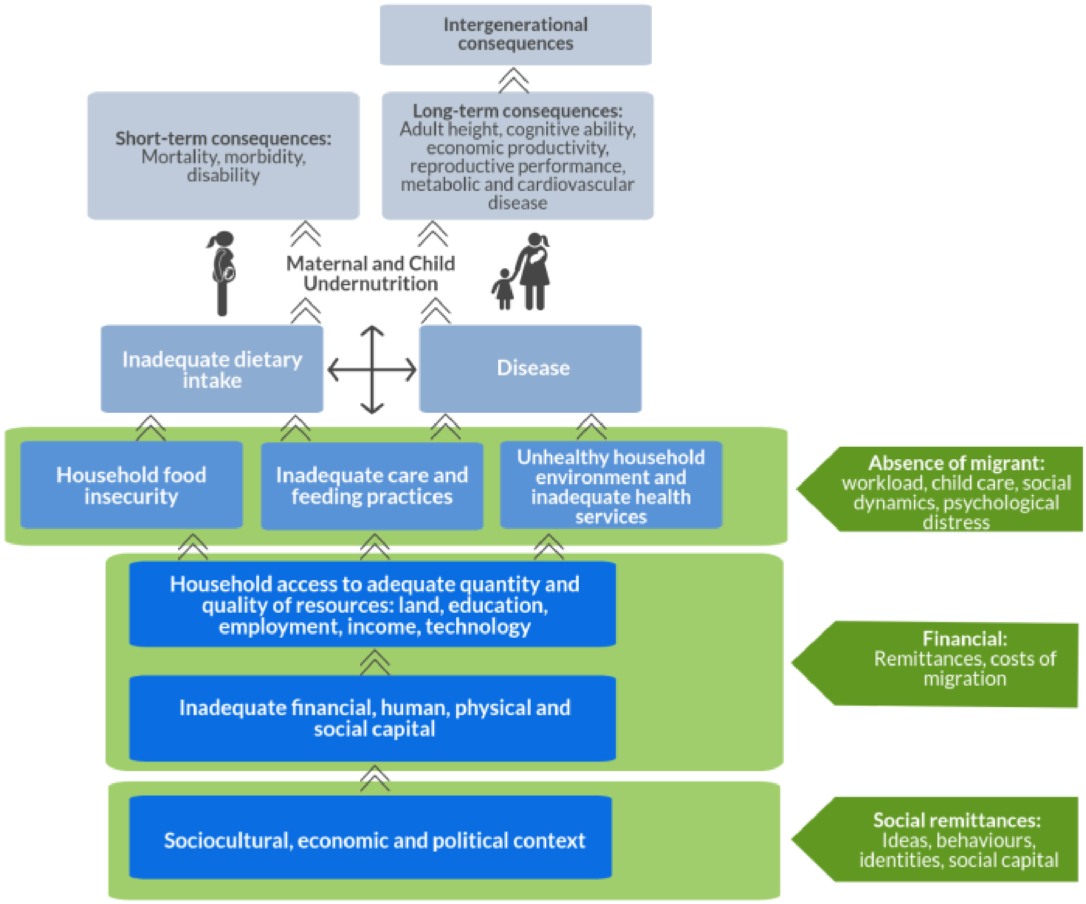
As the number of labour migrants rises, so does the number of left-behind families and children. We are not aware of any official statistics for Nepal or Dhanusha, but in the GMS cohort the prevalence of left behind-children was 47% when the children were 2 years old. While it has been argued that remittances and their impacts on livelihoods have a positive impact on children's welfare, there is also much concern about the social costs of migration and it is uncertain whether they are offset by the income generated abroad (Cortes, 2007).

Aim and objective

Overall study aim: To assess the effect of international labour migration on child growth in rural Nepal.

Specific objective for the data collection: To follow-up the children of the GMS cohort within 4 months of data collection and to collect accurate information on migration and remittances in their households.

Conceptual Framework



Conceptual framework of the pathways between labour migration and child nutrition, using the UNICEF framework of the determinants of child undernutrition.

Questionnaire

The questionnaire consists of two parts:

Part I: Household composition, migration history, loans for migration, remittances, household assets.

The respondent should be the household member that knows best about these things.

- Age, sex, and education of household members who have NOT migrated for work in the past seven years (since Falgun 2067)
- Members of the household who migrated for work abroad in the past seven years; details of each cycle of migration: timing of migration, destination of

migration, costs of migration, loans taken, remittances, use and recipient of of remittances, goods received from migrant

- Remittances from people outside the household
- Good and services acquired by the household in the past 12 months
- Household economic shocks: death, illness, loss of employment, bad harvest, loss of contact with person abroad
- Household assets and whether they were purchased through remittances
- Household source of income
- Sources of staple food
- Indoor air pollution
- Water and sanitation
- House that they live in: Roof, wall, floor

Part II: Household food situation, child and maternal wellbeing

The respondent should be the mother of the child

- 1d and 7d household food consumption
- Household food security
- Child 1d food consumption
- Child workload
- Child morbidity (diarrhea, cough, fever) and healthcare
- Effects of migration on mother at home
- GHQ12: Mother's mental health
- Maternal workload

The position of the household is also recorded using the ODK programme.

Benefits for participants

Referral of children

Children in our cohort who (1) are severely thin, defined as BMIZ < -3, or (2) have bilateral pitting oedema, are referred to the Nutrition Rehabilitation Centre at Janakpur Zonal Hospital using the referral form (Appendix).

(1) Assessement of BMIZ: The child's BMI will be calculated by the electronic questionnaire. Check the WHO tables (Appendix) whether the child's BMI is below the value indicated in the "-3 SD" column.

    Example: A boy aged 5 years and 7 months (67 months) with a BMI of less than 12.1 has to be referred.

(2) Assessment of bilateral pitting oedema: Apply normal thumb pressure on both feet for three seconds (count the numbers 101, 102, 103 in order to estimate three seconds without using a watch). If a shallow print persists on both feet, then the child has nutritional oedema (pitting oedema).

If the child fulfills one of the two criteria, fill in the referral form and give it to the parent or guardian of the child. Ask them to bring the referral form with them when they visit the Nutrition Rehabilitation Centre, and to obtain proof of consultation from the staff at the centre. If they can show proof of consultation to a member of the research team, we will contribute 500 rupees to the travel expenses to Janakpur for the child and one accompanying adult.

Children who present with persistent illness in terms of either cough, fever, and/or diarrhea, the data collector will advise the parent/guardian to seek medical treatment.

Gesture of thanks

Participating children will be given a small gift to thank them for their participation.

Physical measurements

Overview

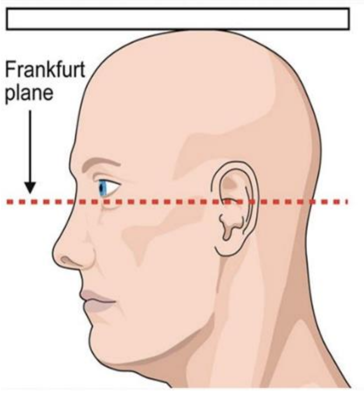
	Child	Mother	HH member knowledgeable about migration
Height	X	X	
Weight	X	X	
Body circumferences	X		
Skinfold thickness	X		
Lower leg length	X		
BIA	X		
Grip strength	X		
Questionnaires		X	X

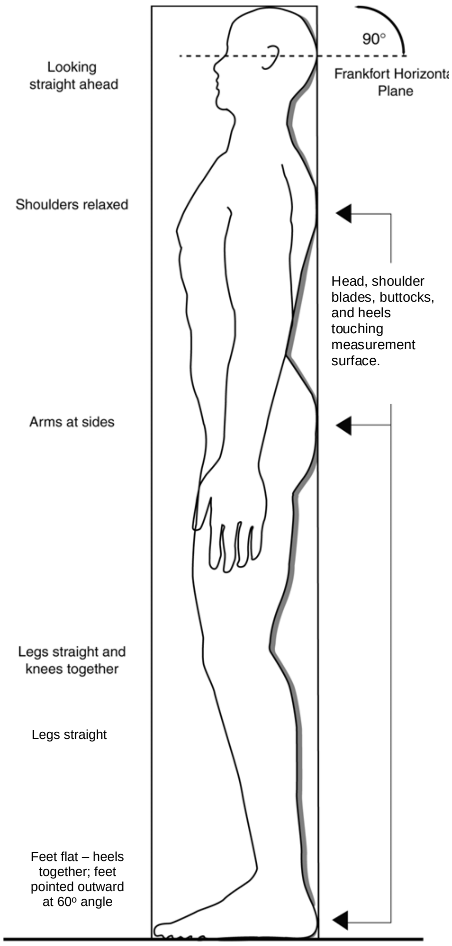
Weight

1. Weight is measured using the Seca baby scale for children under 20 kg and the Tanita adult scale for mothers and children ≥20kg.
2. The participant is asked to change into the standard set of clothes, pass urine and wash hands and feet.
3. Observer checks that scales are placed on level floor, away from any objects and tared to zero.
4. Participant stands on centre of scales, keeping still, facing forwards and hands at sides.
5. Measurement is recorded to the nearest 0.1 kg (for Tanita adult scale) and 0.01 kg for the Seca baby scale.
6. The measurement is repeated and recorded twice after excluding any erroneous values.

Height

1. Height is measured using the Shorr Board stadiometer
2. Remove shoes and any hair ornaments that will interfere with the measurement.
3. Participant stands straight with:
   - Feet flat on floor,
   - Back, shoulders, head, buttocks against back-board of stadiometer,
   - Heels against heel plate
   - Head in horizontal Frankfurt (orbito-meatal) plane passing through upper margins of the external acoustic meatuses and the lower margin of the left orbit.
   - NB: If it is not possible to have all the head, back and buttocks in contact with the backboard make sure the subject is standing with an upright spine.

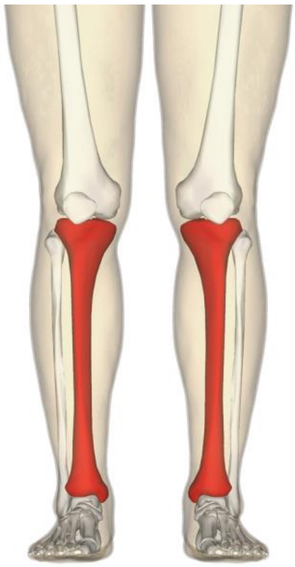




1. Participant takes a breath in and on expiration the headboard is moved down gently onto the head compressing the hair and the measurement recorded. Doing the measurement on expiration helps to dissuade overstretching and/or lifting the heels.
2. Check that the participant is still correctly positioned and record the measurement to the nearest 0.1 cm.
3. The measurement is repeated and recorded twice after excluding any erroneous values.

Tibia length

1. The participant should be sitting on a stool or on the ground.
2. Ask the participant to bend the left leg and lay the left foot on the right knee.
3. Palpate the ends of the tibia at the knee joints and the ankle joints (below the protruding bones). Mark the ends of the tibia.
4. Use the caliper to measure the distance between the two marks.
5. The measurement is repeated and recorded twice after excluding any erroneous values.
6. For the second measurement use the caliper with the display facing downwards (towards the leg), so that the numbers cannot be seen while performing the measurement. Only turn the caliper around when you think that the measurement is correct. This way one can avoid to unintentionally try to repeat the previous measurement.



Circumferences

Measurement of circumferences should not be over clothing unless it is light and close fitting.

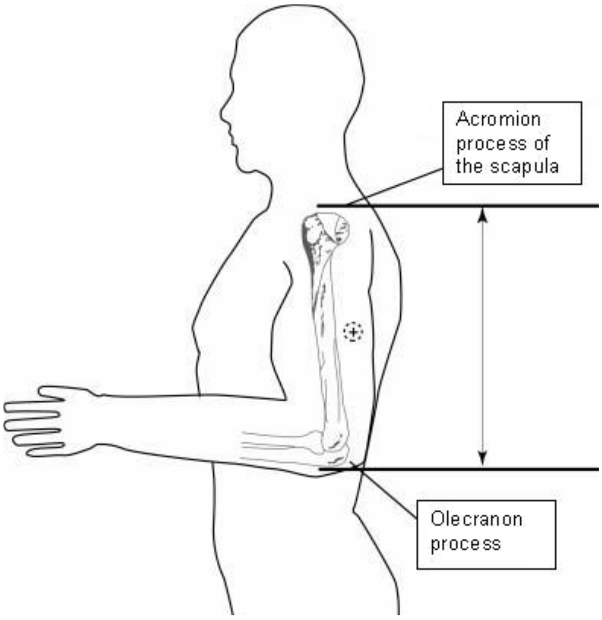
Head circumference

1. Remove hair ornaments so that hair can be compressed close to the skull.
2. Participant stands straight with head in Frankfurt plane.
3. Operator places insertion tape horizontally around widest point of occipital bones and forehead perpendicular to the long axis of the face.
4. Operator records measurement at point on tape indicated after compressing hair by pulling tape tight.
5. The measurement is recorded to the nearest 0.1 cm
6. The measurement is repeated and recorded twice after excluding any erroneous values.

Mid-upper arm circumference (MUAC)

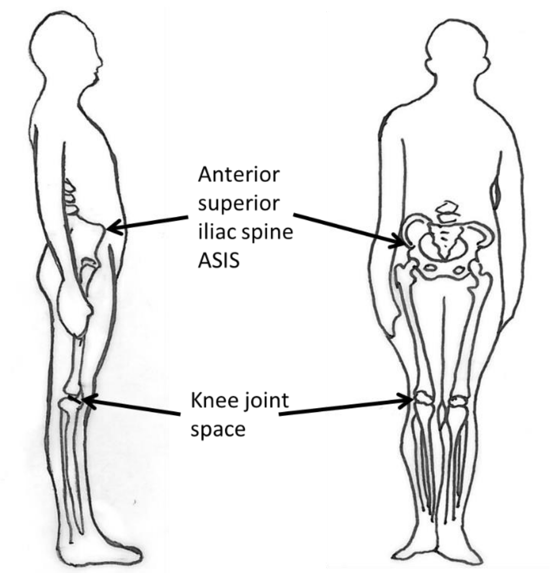
1. Participant stands straight with left arm at side and elbow bent at an angle of 90 degrees.
2. Operator finds the depression at the end of the acromion process and locates the lateral tip of the acromion process.
3. Operator finds the point of the olecranon process (elbow).
4. Operator measures the distance between acromion tip and point of elbow.
5. Operator marks a point halfway between these anatomical landmarks.
6. Participant lets arm hang loosely at the side. If also measuring bicep and tricep skinfolds, extend this line horizontally to the anterior and posterior of the upper arm. Ensure that the arm is relaxed and hanging at the side whist taking the measurement.
7. The operator measures, and records, mid-upper arm circumference at this point, with the tape perpendicular to the long axis of the arm and pulled tight so that it is in contact with the skin without compression.
8. The measurement is recorded to the nearest 0.1 cm.

The measurement is repeated and recorded twice after excluding any erroneous values.


Acromion process of the scapula
Olecranon process

Mid-thigh circumference

1. Subject stands straight with legs slightly apart with weight evenly distributed over both legs.
2. Measurement is taken on the subject's left side
3. Operator finds the anterior superior iliac spine (ASIS), the bony prominence on the front of the hip bone just below the iliac crest.
4. Operator finds the knee joint space, by bending the knee if necessary.
5. Operator measures the distance between ASIS and knee joint space.
6. Operator marks a point halfway between these anatomical landmarks.
7. Operator measures, and records, mid-thigh circumference at this point, with the tape horizontal. Ensure the tape is in contact with the skin but not compressing the thigh.
8. The measurement is recorded to the nearest 0.1 cm
9. The measurement is repeated and recorded twice after excluding any erroneous values.



Calf circumference

1. Subject stands straight with legs slightly apart and weight evenly distributed over both legs.
2. Measurement is taken on the subject's left side.
3. Operator measures, and records, the calf circumference at its widest girth, with the tape perpendicular to the long axis of the calf and tight enough to be in contact with the skin but not compressing the calf.
4. The measurement is recorded to the nearest 0.1 cm.
5. The measurement is repeated and recorded twice after excluding any erroneous values.

Waist circumference

1. Subject stands straight with abdomen relaxed and arms hanging at the sides and feet together.
2. Operator marks the point 4 cm above the umbilicus20 and places the tape around that
3. At the end of normal expiration, measure and record the waist circumference at this point with the tape horizontal and in contact with the skin without compressing the waist.
4. The measurement is recorded to the nearest 0.1 cm

[20] This measuring technique is a divergence from the GOS ICH protocol, which describes the WHO/Lohman method of placing the tape around the narrowest girth as seen from the front. In the trainings it became apparent that it was difficult to reliably locate this landmark as many children in this population do not have a discernible waist. It was found that the method endorsed in (Rudolf, Walker, & Cole, 2007) resulted in a better technical error of measurement and was comfortable for participants.

5. The measurement is repeated and recorded twice after excluding any erroneous values.

Hip circumference

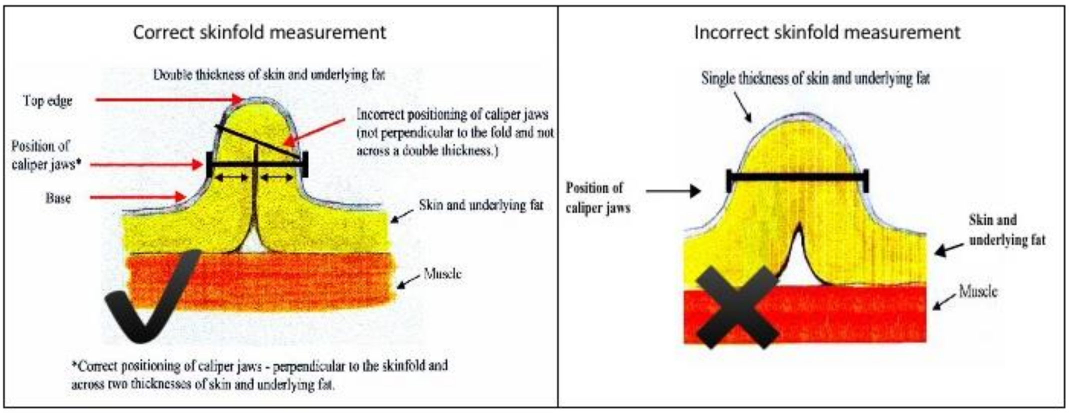
1. Subject stands straight with arms at the sides and feet together.
2. Whilst squatting at the side of the subject the operator finds the widest girth of the hips, usually at the maximum protruding point of the buttocks around the greater trochanters of the femur.
3. The tape is passed around the widest point and the operator checks this is horizontal and in close contact without compression.
4. The measurement is recorded to the nearest 0.1 cm.
5. The measurement is repeated and recorded twice after excluding any erroneous values.

Skinfold thickness

General technique

1. Always check the dial of the calipers start at zero and adjust if necessary.
2. All measurements are taken on the subject's left side.
3. Assuming the operator is right handed, then once the site has been located and marked the thumb and forefinger of the left hand are used to elevate a fold of skin and subcutaneous fat about 1cm away from the measurement point. If necessary, the skin can be lifted using both hands and then held by the left hand whilst measuring with the right.
4. The thumb and finger must be far enough away from the point of measurement so that the fingers are not compressing the point of measurement and the skinfold is pulled away from the musculature in order to form a fold with almost parallel skin surfaces. It may not be possible to achieve parallel sides when the skinfold is large. Care must be taken to only grasp skin and subcutaneous fat.
5. The right hand is used to open the calipers and place them over the skinfold perpendicular to the long axis of the fold approximately half way between the crest of the fold and the body surface.
6. The calipers are released whilst continuing to hold the skinfold with the left hand.
7. A reading is taken once the dial first slows to almost a stop. This should be around 3 secs but never more than 4 secs because if the calipers are left in position too long, particularly in obese subjects, they will start to compress the skinfold and give an inaccurate measurement.
8. Once a reading is taken release the calipers FIRST before releasing the fold held by the left hand. In young children there is a danger that they may suddenly pull away and there is a risk of damage to the skin. The operator should be aware and release the calipers quickly.
9. Whilst taking a reading the operator's head should be positioned so as to avoid errors due to parallax.
10. A measurement is recorded to the nearest 0.2 cm.

11. The measurement is repeated and recorded three times after excluding any erroneous values



Biceps

1. Subject stands straight with arm held loosely at the side.

2. Operator finds the level of the mid-upper arm circumference measurement (see MUAC above) and locates the point on the anterior aspect of the arm. Using the previous mark for MUAC, a line is drawn perpendicular to that line and directly over the humerus.

3. The skinfold measurement is taken by the operator gently pinching the skin and adipose tissue immediately above this site and pulling it away from the underlying muscle.

4. The caliper is then used for the measurement at the exact level on the mid-upper arm plane

5. The measurement is repeated and recorded three times after excluding any erroneous values

Triceps

1. Subject stands straight with arm held loosely at the side.

2. The operator finds the level of the mid-upper arm circumference measurement (see MUAC above) and locates the point on the posterior aspect of the arm. Using the previous mark for MUAC, a line is drawn perpendicular to that line and directly over the humerus

3. The skinfold measurement is taken by the operator gently pinching the skin and adipose tissue immediately above this site and pulling it away from the underlying muscle.

4. The caliper is then placed at the exact level on the mid-upper arm plane.

5. The measurement is repeated and recorded three times after excluding any erroneous values

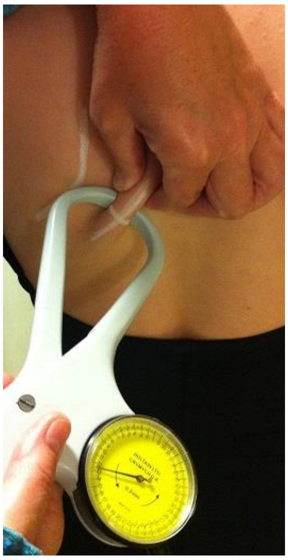
Subscapular

1. Subject stands straight with arms held loosely at the side.

2. The operator finds the inferior angle at the lower margin of the scapula. If this is difficult to locate then gently take the left forearm and place behind the back, mark the scapular angle and then release the arm.

Mark a cross below the inferior angle of the scapula. Make the first line at 45 degrees to the spine and cross this with a line that bisects the inferior angle of the scapula.

3. The skinfold is grasped diagonally so that the point of measurement is just inferior to this point and the fold is inclined infero-laterally at approximately 45 ^{0} to the horizontal and in the natural cleavage line of the skin.



4. The caliper is placed approximately 1 cm from the fingers of the left hand, perpendicular to the long axis of the skinfold.

The measurement is repeated and recorded three times after excluding any erroneous values

Suprailiac

1. Subject stands straight with arms held slightly abducted to aid access to the measurement site.

2. The operator palpates the top of the iliac crest and marks a cross aligned with the mid-axillar.

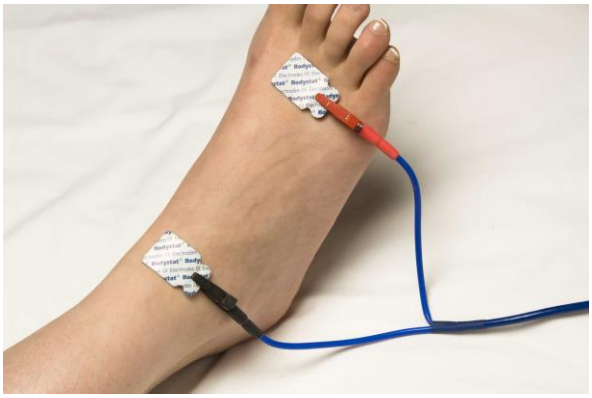
3. An oblique skinfold is grasped just above the centre of the marked cross (see 2 above) and following the natural cleavage line of the skin so that the fold is approximately 1cm above the iliac crest at the mid-axillary point. It should be aligned inferomedially at approximately 45 ^{0} to the horizontal. Two hands may be used to grasp the skinfold initially and then the right hand removed to use the caliper.

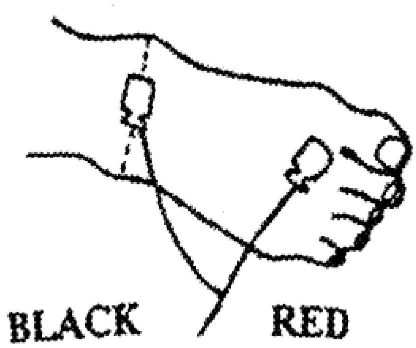
4. The caliper is placed on the fold at the mid-axillar point.

5. The measurement is repeated and recorded three times after excluding any erroneous values

Bioelectrical impedance analysis (BIA)

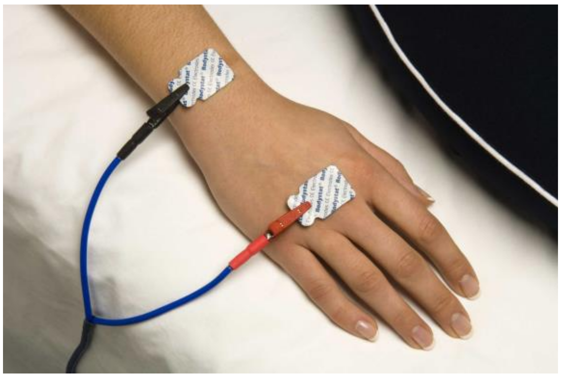
1. BIA measurements are taken using the Bodystat 500.
2. Ask the participant to pass urine and to wash hands and feet.
3. Measurements are done on the participant's left side.
4. Instruct the participant to remove their shoe and sock from their left foot.
5. Remove any watches or bracelets on the left wrist which may impede the correct placing of electrodes.
6. Lie participant in the supine position (on his/her back) for 3-4 minutes before taking the measurements. This is to ensure that the fluid levels have stabilized in the body before a measurement is performed.
7. Thoroughly wipe (using alcohol wipes/sterettes) the area of the skin where the electrodes are to be attached as products such as body moisturiser, can affect the results
8. Try to minimise sources of electrical disturbances (no power sources in participant's pockets, mobile phones etc.)
9. Placing Foot electrodes
    - Electrodes are placed sideways so that the non-stick electrode connector point is facing the researcher.
    - One electrode is placed behind the 2nd toe next to the big toe
    - Place the second electrode on the ankle at the level of and between the medial and lateral malleoli (the large protruding bones on the sides of the ankle). Correct placement of the BLACK INNER electrode on the wrist and the ankle is critical.
    - Another easy way to find the correct position of the black inner electrodes is to draw an imaginary straight line between the protruding bones on the wrist and ankle as illustrated in the diagram. Then place each electrode in the centre of that line with the line also passing through the centre of the electrode tab.
    - Attach two alligator clips to the electrodes (red to the electrode nearest the toes)

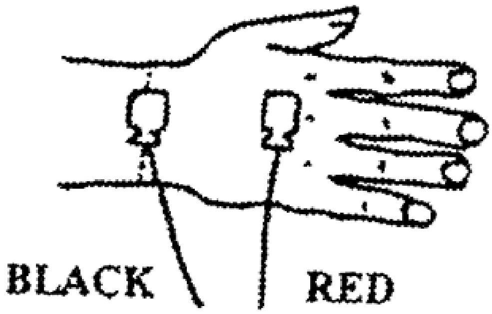



BLACK
RED

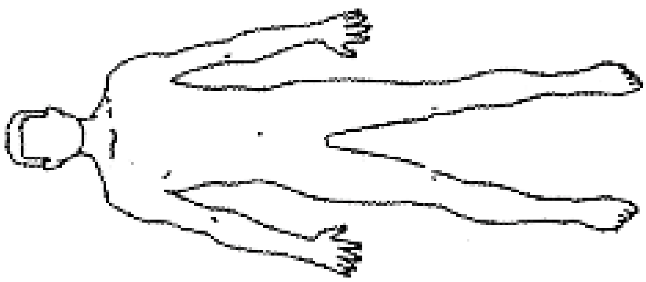
10. Placing hand electrodes

- Electrodes are placed sideways so that the non- stick electrode connector point is facing the researcher.
- One electrode is placed behind the knuckle of the middle finger.
- The second electrode is placed on the wrist next to the ulna head. Correct placement of the BLACK INNER electrode on the wrist and the ankle is critical.
- Another easy way to find the correct position of the black inner electrodes is to draw an imaginary straight line between the protruding bones on the wrist and ankle as illustrated in the diagram. Then place each electrode in the centre of that line with the line also passing through the centre of the electrode tab.
- Attach two alligator clips to the electrodes (red to the electrode nearest the fingers)





11. Ensure that the legs and arms are spread out so they are not in contact with any other part of the body.



12. Record resistance, reactance, impedance, phase angle
13. Repeat measurements three times. Do not change electrodes between measurements unless they were placed incorrectly before

Use of electrodes

- The electrodes may be repositioned if necessary but should not be used on another subject since they may dry out thereby artificially increasing the Impedance values.
- Keep unused electrodes in the sealed plastic bag to ensure freshness.

In case of an error message, check the following:

- Ensure that the electrodes are correctly positioned and firmly in place.
- Electrodes should not be used more than once and should not be cut in half.
- If the electrode is not firmly positioned due to cream on the skin, then remove the electrode and wipe the skin with an alcoholic wipe. Replace with fresh electrodes.
- Ensure that the clips are attached correctly.
- The black clip must be connected to the wrist and ankle and the red clip must be connected to the electrode nearest to the fingers and toes.
- Ensure that the patient is lying in the correct position and remains still during the testing process.
- Ensure that there is no static nearby, e.g. the carpet.

If the device remains with a faulty electrode connection:

- Check the calibration
- Check to ensure that the leadwires are not being wrapped around the unit

Grip strength

1. Grip strength is measured using the Takei 540.
2. Ask the participant to remove hand and wrist jewelry.
3. To loosen up the hands and fingers, the participant will complete two warm-up exercises. The warmup exercises include shaking both hands three times and bending and stretching all fingers three times. Demonstrate each exercise and ask the participant to do the exercise.
4. Adjust the grip size of the dynamometer until the second joint of the index finger is at a 90˚ angle on the handle (90˚ flexion between proximal and middle phalangeal joint). When adjusting the grip size, the hand should be in line with the wrist and forearm.
5. Perform the exam with the participant standing up, arm down the side of the body
6. Ask the participant to squeeze as hard as possible. Support the participant by saying “Squeeze, squeeze, squeeze!” during the exam.
7. The test is performed three times.

Equipment checklist

- Information Sheets
- Consent Forms
- Referral Forms
- Charged(!) mobile phones
- Stadiometer
- Scales
- Batteries for back up
- Circumference tapes
- Callipers
- BIA machine
- Electrodes
- Dynamometer

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A. 4 R function to calculate the technical error of measurements (TEM), relative TEM, and coefficient of reliability

```
TEM.df<-function(data1,   NObs,   NSubj,   NRep,   names.obs,
names.subj, print.it=FALSE)
{
  ### from Ulijaszek & Kerr, 1999 and Perini et al 2005
  ### data1 is a matrix; nrow(data1) = NSubj; ncol(data1) =
NObs*K
  ### There are NObs observers on NSubj each repeated NRep
times
  ### assume that data1 has dimnames assigned
  ### MCB & LKB 06.06.18
  ### MCB, LKB, 09.07.19


  tem<-function(M) ### function to compute TEM; M is a matrix
  {
    sqrt(sum(apply(M,1,function(x)       {sum(x^2)         -
sum(x)^2/ncol(M)})) / (nrow(M)*(ncol(M)-1))
         )
  }

  ### Create a data.frame with elements
  ### elements are: Obs, Subj, Rep, Y in vertical format
  ### assume there are no missing data
```

```
Y<- as.vector(t(data1))
Subj<- rep(names.subj, rep(NObs*NRep, NSubj))
Obs<- rep(rep(names.obs,  rep(NRep, NObs)), NSubj)
Rep<- rep(1:NRep, NObs*NSubj)

df<-data.frame(Obs=Obs, Subj=Subj, Rep=Rep, Y=Y) ### puts matrix data1 in long format


###  intra-observer TEM
intra.tem<- intra.mean<- intra.sd<- rep(NA, NObs) ### initialises
k0<-0 ###  initialises counter

for(i in unique(df$Obs))
{
  k0<- k0+1
  aux<-   matrix(   df[df$Obs==i,"Y"],   ncol=NRep, byrow=TRUE)
  intra.tem[k0]<- tem(aux)
  intra.mean[k0]<- mean(as.vector(aux))
  intra.sd[k0]<- sd(as.vector(aux))
}

intra.pctem<- intra.tem*100/intra.mean
intra.res<- round(rbind(intra.tem, intra.pctem),6) ## row binds intra.tem and intra.pctem;  6=#decimal pts
```

```
    dimnames(intra.res)<-  list(c('Intra  TEM','%  Intra
TEM'), names.obs)

    ### inter-observer TEM
    inter.mat<- with(df, tapply(Y, list(Subj, Obs), mean))
## mean slicing by Subj and Obs
    inter.tem<- tem(inter.mat)
    inter.pctem<- inter.tem*100/mean(inter.mat)

    ### total TEM & R

    total.tem<- sqrt( sum(intra.tem^2)/NObs + inter.tem^2)
    total.mean<- total.tem*100/mean(as.vector(data1))
    total.sd<- sd(inter.mat)
    R<- 1 - (total.tem/total.sd)^2

    total.res<-  round(cbind(  c(inter.tem,  total.tem),
c(inter.pctem, total.mean)),6)
    dimnames(total.res)<-   list(c('Inter',   'Total'),
c('TEM','% TEM'))

    ### report

    if(print.it)
    {
      cat(c(paste( rep('-',40),sep='',collapse='')))
      cat(paste("\n",  deparse(substitute(data1)),"\n"))
## get the name of object passed as data1
```

```
            cat('\nIntra-observer TEMs\n')
            print(intra.res, quote=FALSE)

            cat('\nInter-observer TEM\n')
            print(total.res, quote=FALSE)
            cat('\n')
            cat(paste('R', round(R, 6), sep=' = '))
            cat('\n')
            cat(c(paste( rep('-',40),sep='', collapse='')))
        }

        invisible(list(   intra=intra.res,   total=total.res,
R=R) )
}### end TEM.df
```

A. 5 Protocol for isotope calibration sub-study

1. Preparations in the office

a) Calibration of laboratory scale:

- To ensure accuracy, the scale is calibrated every day.
- The following weights (in g) are used for calibration: 0.02, 0.05, 0.2, 0.25, 0.5, 0.75, 1.00, 2.00, 5.00, 10.00, 15.00, 20.00, 24.5, 24.75, 25.00, 25.25, 25.50, 40.00, 50.00, 73.00, 73.50, 74.00, 74.50, 75.00, 76.00, 80.00, 90.00, 100.00.
- Each day's measurements are recorded in the designated excel spreadsheet.

b) Labelling:

- Colour label all components before starting using indelible marker pens.
- Label (1) participant ID, (2) nature of the sample in question ('dose', 'pre', post') and (3) date of preparation on all parts: lid and body of dosing bottles, cap and body of salivettes, body of sample tubes, sealable plastic bag.
- Use the following colour coding:
  - Dose and dosing bottles (GREEN)
  - Pre-dose salivettes and tubes (RED)
  - Post-dose salivettes and tubes (BLUE)

c) Preparation of doses

- Wash hands before preparing each dose.
- Deuterium: 0.07g stock deuterium oxide (~ 99.9%) per kg body weight is used. (For example: 1.19g deuterium oxide for a child weighing 17 kg.)
- Water: 50g of bottled drinking water is used for every child.
- Place dosing bottle on laboratory scale, zero scale. Draw deuterium into the syringe and filter the deuterium dosing solution using the 0.25 micropore filter into the dosing bottle.
- Add the water into the dosing bottle. Shake bottle for one minute.
- Before opening the dosing bottle, tap the lid to make drops of the dose fall from the lid into the bottle.
- Using a *clean* pipette, obtain a sample (approx 1.5mls) from the middle of the bottle and place in the pre-marked (in Green) 2ml sample tube.
- Dry any drops of dose from the rim of the dosing bottle.
- Close the dosing bottle and put it into a resealable plastic (pre-marked) bag together with a plastic straw.
- Weigh the bag with bottle and straw. Record measurement in the Isotope Log Book.
- Open the salivettes and cut the cotton buds in half with a clean pair of scissors. Put the two halfs back into the salivettes. This is done because the children are quite small and find it difficult to roll the rather large cotton buds in their mouth.

- List of items per test:

    - Salivettes x2
    - Freezer tubes x3
    - Dosing bottle
    - Straw
    - Re-sealable plastic bag
    - Bottled drinking water (50ml)
    - Deuterium
    - Pipettes x3
    - One bottle of weighed drinking water
    - Disposable plastic gloves x2
    - Juice container (200ml)
- Generic items: Marker pens (Red, Green, Blue), filter, 5ml syringes.

2. Sample collection

a) Taking informed consent

- Read out the Information Sheet to the mother/guardian.
- Ask whether s/he has any questions. Answer all questions.
- Fill in the Consent Form, ask mother/guardian to sign it. If s/he cannot write, take the consent by thumbprint.
- Take a picture of the signed Consent Form and leave it with the mother/guardian.

b) Anthropometric measurements

- Take the child's height, weight and bioelectrical impedance (BIA) according to the measurement technique described in the SOPs of the main data collection.
- Record the measurement on the Isotope Data Sheet.

c) Pre-dose saliva collection

- Make sure that the child did not eat or drink anything within 30 minutes of collecting the sample.
- Explain the procedure to the child, showing the cotton bud and the dosing bottle.
- Ask the child to build up saliva in the mouth, and to then take the cotton bud and roll it in the mouth with the tongue to allow the saliva to collect. *The bud must not be chewed*.
- After 1 to 2 minutes ask the child to open the mouth to show the soaked bud. It is critical to collect an adequate amount of saliva, ideally 2ml. If the cotton bud has doubled or tripled in size it contains enough saliva.
- Put on a plastic glove and take the soaked bud from the child's mouth and place it into the salivette.
- Repeat the procedure with the other half of the cotton bud.

d) Give deuterium drink

- The accuracy of the total body water test relies on knowing the precise amount of deuterium that has been consumed. Spillage of the prepared drink should be avoided at all costs.
- Shake the bag with the bottle.
- Open the bag, undo lid and insert straw.
- Keep the bottle with the straw inside the bag to catch possible spillage.
- Hold the straw and bottle, tilt the bottle slightly so that the straw is in the deep end of the bottle.
- Ask the child to drink from the straw while you hold the bottle, straw and bag.
- When the child has drunk all the water, fold the straw into the bottle, close the lid and seal the bag.
- Record the time the dose was given on the Isotope Data Sheet.
- Calculate the time to take the "post-dose" sample, four hours later.

e) **Waiting Period**

- Offer the 200ml juice carton to the child. Record on the Isotope Data Sheet whether s/he drank it.
- Hand the measured water bottle to the mother/guardian or the child. Explain that the child must only drink from this bottle until we come back for the second sample. No one else is allowed to drink from the bottle.
- Explain what time we come back.
- Tell them that the child must stop eating and drinking 30 minutes before we come back to take the second sample.

f) **Post-dose saliva sample**

- Make sure that the child did not eat or drink anything within 30 minutes of collecting the sample.
- Collect the drinking bottle and weigh it on the baby scale (accurate to two decimal readings). Record the measurement on the Isotope Data Sheet.
- Collect the second saliva sample following the same procedure as with the first sample.
- Thank the participant and hand of the gift to the child.

3. **Sample processing in the office**

- Re-weigh bag with dose bottle and straw. Record the measurement on the Isotope Data Sheet.
- If freezer and centrifuge available: Centrifuge salivettes, use clean pipette to fill saliva into labelled sample tubes, and store in freezer.
- If centrifuge a/o freezer are not available at that time, store salivettes in the fridge.
- Make sure that all information is recorded in the Isotope Log and Isotope Data Sheet
- Enter all data in the ODK questionnaire.

Details to be recorded in the **Isotope Log**: Babyid, date the dose was prepared, date the dose was used, estimated child weight, approx. deuterium dose, weight of bag+FULL bottle+straw, weight of bag+EMPTY bottle+straw, comments.

Isotope calibration

Date: ___ ___ / ___ ___/ ___ ___ ___ ___ Anthropometrist: ________________

Baby ID: ___ ___ ___ Childname: _________________________

MW name: _________________ HH name: __________________________

Municipality: ______________________________ Ward: _____

VDC: ___________________________________ Ward: _____

Time dose administered: _______________________

Time post sample taken: _______________________

	Measurement 1	Measurement 2	Measurement 3
height	cm	cm	
weight	kg	kg	
BIA			
Impedance Z	Ω	Ω	Ω
Resistance R	Ω	Ω	Ω
Reactance Xc	Ω	Ω	Ω
Phase Angle PA	°	°	°

Was the child measured with bangles/anklets? O Yes O No

If possible, take the BIA measurements both with and without bracelets/anklets. Record the measurements *without bangles/anklets in this table*, and the measurements *with bangles/anklets on the backside of this sheet*.

Bilateral pitting oedema O Yes O No

Isotope bottle O Red O Clear

Stadiometer No _______

Baby scale No _______

Adult scale No _______

BIA machine No _______

Weight water bottle BEFORE __________ AFTER: ___________ → CONSUMED: __________

Child drank Frooti (200ml) : O Yes O No

Comments:

A. 6 Information sheet and consent form (Nepali) for main data collection

Information Sheet

आमा वा अभिभावकहरुको लागि जानकारी पत्र (Nepali)

परियोजनाको नामः श्रमिक कामको लागि विदेश जादा स्वदेशमा रहेका उनीहरुका बच्चाको पोषण अवस्था तथा वृद्धिमा पार्ने असरहरु।

यो जानकारी पत्रको एक प्रति तपाईलाई उपलब्ध गराइनेछ जुन तपाईलाई पढेर सुनाइनेछ र आवश्यक परेमा विस्तृतमा भनिनेछ

हाम्रो अध्ययनको परिचय

नमस्कार. मेरो नाम __________ हो

म युनीभरशिटी कलेज लण्डन (युके) सँग काम गरिरहेको छु, जसले यहाँ (धनुषामा) अध्ययन अनुसन्धान संचालन गरिरहेको छ।

हाम्रो परियोजनाको कार्यालय जनकपुरमा छ।

सन २०१२ मा जव तपाईको बच्चा जन्मियो तव धनुषा जिल्लाको ६०० महिलाहरु मध्ये तपाई एक हुनुहुन्थ्यो, जसले आमा र नवजात शिशु स्याहार कृयाकलाप (मिरा) द्वारा संचालित अध्ययनमा आफ्नो इच्छा अनुसार सहभागी हुन अनुमती दिनुभएको थियो।

हरेक चार हप्तामा हाम्रो एकजना तथ्याङ्क संकलनकर्ता तपाईको घरमा तपाइको बच्चाको नापतौल गर्न र तपाईको बच्चाको स्वास्थ्य र उसले खाएको खाना, उनीहरुको स्वास्थ्य वृद्धिविकास कसरी भईरहेको भन्ने बारे केही प्रश्नवलीहरु सोध्न आउनुभएको थियो

तपाईको बच्चा २ वर्षको हुँदा अन्तिम पटक नाप तौल गरेदेखि अहिलेसम्मको अवस्थामा हामी तपाईको बच्चाको वृद्धि र सामान्य स्वास्थ्य अवस्थाको बारेमा जान्न चाहन्छौ।

त्यसकारण हामी तपाईँलाई यो सानो अध्ययनमा सहभागीहुन अनुरोध गर्दछौ र तपाईँको र तपाईँको बच्चाको नापजोख सम्वन्धि केही प्रश्नहरु सोध्न अनुमती माग्दछौ।

तपाइको इच्छा छ भने मात्र यस अध्यानमा भाग लिनुहोला, यदी भागलिन चहानुहुन्न भने तपाईँलाई यसले कुनै किसिमको वेफाइदा हुने छैन

तपाईं सहभागी हुने निर्णय लिनु भन्दा अगाडी तलको जानकारी राम्रोसंग सुन्नु महत्त्वपूर्ण छ र इच्छा भएमा तपाई अरुसंग छलफल गर्न सक्नुहुनेछ। कुनै कुरा स्पस्ट नभएमा वा थप जानकारी चाहीएमा सोध्नुहोला।

अनुसन्धानको उद्देश्य

हामी यस समुदायमा बच्चाको वृद्धि र विकासमा प्रभाव पार्ने तत्वहरुको बारेमा जान्न चाहन्छौं।

त्यसमध्येका घरमुलीको अनुपस्थिति पछिको अवस्थामा बच्चालाई प्रभावपार्ने तत्वको बारेमा हामी जान्न चाहन्छौ

सहभागीको छनौट

सन् २०१२ देखि २०१४ को पछिल्लो तथ्याङ्क संकलनमा सहभागी हुनुभएका सम्पूर्ण आमा र बच्चालाई यस अध्ययनमा सहभागीहुन अनुरोध गर्दछौ।

विधी

यदि तपाई सहभागी हुन इच्छुक हुनुहुन्छ भने मात्र म तपाईँसँग अन्तर्वाता लिन चाहन्छु र तपाइ र तपाइको बच्चाको नापतौल लिन चाहन्छु।

म तपाईं, तपाईँको बच्चा र घरमूलीको बारेमा प्रश्न सोध्नेछु।

गत चार वर्ष अघिको भेटघाटमा सोधिएका प्रश्नहरु जस्तै प्रश्नहरु हुनेछन् तर कामकोलागि बैदेशिक रोजगारमा जाने पारिवारिक पृष्ठभूमिमा केही नयाँ प्रश्नहरुपनि सोधिने छन्।

हामी तपाईँको बच्चाको नापतौल लिन चाहन्छौं, जस्तै उचाई, तौल, शरिरमा बोसोको प्रतिशत, शरिरको गोलाई, खुट्टाको लम्बाई, छालाको तह (बिस्तारै पाखुरा, कुम र पेटमा दवाएर)

हामी तपाईँको पनि उँचाई र तौल लिन चाहन्छौं.

नाप तौलको बारेमा तपाईँलाई केही सल्लाह सुझाव दिनेछौ र त्यसको अर्थ भन्नेछौ

यस अध्ययनममा भएका सम्पूर्ण तथ्याङ्क संकलनकर्ताहरु तालिम प्राप्त र यस किसिमको नापतौललिन अनुभवि छन्।

यस नापतौलबाट कुनै किसिमको हानी हुदैन

सम्पूर्ण जाँचहरु तपाईँको घरमा नै गरिने छ.

अन्तर्वाता र नाप तौल एक पछि अर्को गरी एक देखि साडे एक घण्टाभित्रमा गरिने छ।

जव हामी तपाइको बच्चाको नाप लिन्छौं, त्यतिबेला यदि बच्चा उमेर अनुसार धेरै नै दुब्लो देखीएमा केही थप सहयोग पाउन सक्नुहुने छ।

यो अबस्थामा हामी तपाईँलाई उपयुक्त उपचारको लागि जनकपुर अञ्चल अस्पतालको पोषण पुनःस्थापनाकेन्द्रमा पठाउने छौं।

यदि तपाईँको बच्चालाई चिकित्सककोमा पठाउनु पर्ने भएमा सुपरभाईजरले प्रमाणित गरेको यातायातको प्रमाण र डाक्टरी रिपोर्टको आधारमा हामी एकजना अभिभावक र बच्चाको लागि यातायात खर्च बापत बढीमा रु. ५००।– सहयोग गर्ने छौं।

हामीले संकलन गरेको केही जानकारीले तपाईं यस अध्ययनमा सहभागीसरह तुल्याउने सम्भावना छ।

परियोजनामा काम गर्ने मुख्य अनुसन्धान कर्ताबाहेक अध्ययनका नतिजाहरु सार्वजनिक गर्ने क्रममा तपाइको व्यक्तिगत चिनारी दिने खालको नतिजालाई हटाइने छ। तपाइले दिएको सूचनाहरु कम्प्यूटरमा सुरक्षित साथ राखिने छ।

सहभागीताको सम्भावित जोखिमहरू

यहाँ सहभागी हुँदा तपाईं र तपाईको बच्चालाई कुनै किसिमको हानी हुन्छ जस्तो लाग्दैन। यसमध्येको कुनैपनि नाप तौल हानीकारक छैनन्

सबै प्रश्न र नाप जोख तपाईँको घरमा गरिने छ

हामीले सोधेको कुनै प्रश्नको जानकारी दिन तपाईँलाई केही असजिलो महसूस हुनसक्छ, तपाइले उत्तर दिन मन नभए नदिन पनि सक्नुहुन्छ

जानकारीको गोपनियता

तपाइले मिराको गणक वा अन्तर्वाताकारलाई दिनुभएको सबै सूचनाहरु गोप्य राखिने छ । यसको अर्थ तपाईले भनेका वा दिएका सुचनाहरु कसैलाई भनिने छैन

जानकारीहरु रजिष्टर वा कम्प्यूटरमा दर्ता गरि राखिने छ तर ती जानकारीहरु सुरक्षित राखिने छ र जिम्मेवार व्यक्तिलाई मात्र हेर्न अनुमती दिइने छ

स्वेच्छिक सहभागीता

तपाइको सहभागीता स्वच्छिक हो । याद राख्नुहोस्, यसमा सहभागी हुने वा नहुने कुरा तपाईको निर्णयमा भरपर्ने छ । सहभागी नहुने कुराले तपाईंलाई कुनै किसिमको वेफाइदा हुने छैन । यदि सहभागी हुने निर्णय गर्नु भए पनि जति वेला पनि विनाकारण तपाईं आफ्नो नाम फिर्ता लिन सक्नुहुन छ

यदि नाम फिर्ता लिने निर्णय गर्नु भएमा तपाईंलाई कुनै प्रकारको जरिवाना वा घाटा हुने छैन ।

थप नाजनकारी

यदि तपाईंको केही प्रश्नहरु छ भने हामीलाई सम्पर्क गर्न सक्नुहुने छ ।

सम्पर्क गर्ने व्यक्तिको नाम र सम्पर्क नम्वर यस जानकारी पत्रमा उल्लेख गरिएको छ ।

सम्पर्क जानकारी

श्याम शुन्दर यादव, अनुसन्धान सहायक, 9801642281, 9815853585

युकेको डाटा सुरक्षा ऐन १९९८ अनुसार तथ्याङ्क संकलन र भण्डारण गरिने छ ।

नैतिक अनुमोदन

नेपाल स्वास्थ्य अनुसनधान परिषद् (परियोजना आइ दि नम्वर 13/2018 बाट अनुमति प्राप्त) र युनिभरसिटी कलेज लण्डनको नैतिक अनुसन्धान समितिबाट (परियोजना आइ दि नम्वर: 11345/001) स्वीकृति प्राप्त परियोजना हो

Consent form

आमा वा अभिभावकहरुको लागि सहमति पत्र

परियोजनाको नामः श्रमिक कामको लागि विदेश जादा स्वदेशमा रहेका उनीहरुका बच्चाको पोषण अवस्था तथा वृद्धिमा पार्ने असरहरु।

यस अध्ययन मा सहभागी हुन इच्छुक हुनु भएकोमा धेरै धन्यवाद। सहभागी हुन सहमति जनाउनु भन्दा अगाडी, मैले अध्ययन को बारेमा तपाईलाई बताउन अनिवार्य हुन्छ। अध्ययन सम्वन्धि बिषयमा सुचना सामग्रीमा राखिएका कुराहरु सुन्नु भएपछी कृपया मैले सोधेका प्रश्नहरु सुन्नुहोस्। मैले पढेर यी कुराहरु भने कि भनिन भन्ने बारेमा मलाई बताउनुहोस्। तपाई संग फर्म भरि सके पछी तपाईले यो फर्म पढ्न र सच्याउन सक्नुहुन्छ।

यदि तपाईलाई सूचना सामग्री वा तपाईलाई बताएको कुराहरुमा कुनै प्रश्नहरु भएमा कृपया तपाइले भाग लिने निर्णय गर्नु भन्दा अगाडी नै सोध्नुहोस। तपाईँलाई एक प्रति अनुमति पत्र र सुचना सामग्री राख्नको लागि दिइने छ जुन कुनै पनि बेलामा प्रेषण गर्नको लागि हुनेछ र अंतरवार्ताकारले तपाइको हस्ताक्षर वा औठाको छापको फोटो लिने छन्।

सहभागीको भनाइ

______________________________ कृपया नाम लेख्नुहोस्

- माथि लेखिएको नोट र सूचना सामग्री पढेर मलाई सुनाइएको छ र अध्ययनमा के कुराहरु समाबेस गरीएका छन भन्ने कुरा बुझेको छु

  छ □ / छैन □

- माथि उल्लेखित नामको अध्ययनको बारेमा मलाई सन्तुष्ट हुने गरि बताइएको छ र म यस अध्ययनमा स्वयम सेवक को रुपमा भाग लिन सहमत छु

  छ □ / छैन □

- यस अध्ययनको उद्देश्यको लागि मेरो व्यक्तिगत सूचना लिने प्रकृयाको लागि अनुमति छ

  छ □ / छैन □

- प्रश्नावली र नाप जोखको लागि मिराको कर्मचारीहरु संग भेट गर्नको लागि सहमति छ

  छ □ / छैन □

- सुचनाहरु गोप्य राख्न कडा सावधानी अपनाइने छ, लन्डनमा प्रयोग गर्दा यु के डाटा प्रोटेक्सन ऐन १९९८ को प्रावधान अनुसार गरिने छ भन्ने बुझेको छु

  छ □ / छैन □

- मेरो व्यक्तिगत विवरण नभएको अध्ययन सम्वन्धित तथ्यांकहरु भबिश्यमा अन्य कसैले प्रयोग गर्ने छन भन्ने कुरामा सहमत छु। म बुझ्छु कि मेरो व्यतिगत तथ्यांक नाम र ठेगाना हटाएर प्रयोग गरिने छ

  छ □ / छैन □

- मैले दिएका जानकारीहरु प्रकासंनको लागि प्रयोग हुने कुरा बुझेको छु तर गोप्यता र व्यक्तिगत विवरणहरु नखुल्ने कुरालाई उचित तरीकाले मिलाइएको हुन्छ र कुनै पनि प्रकासनहरुमा मेरो परिचय खुल्ने कुनै व्यक्तिगत विवरण रहने सम्भावना छैन

  छ □ / छैन □

- अनुशंधांनकर्ता ले भविष्यमा गर्ने फलोअप (पुन: कुराकानी अगाडि बढाउन) अध्ययनहरुको लागि बोलाउन चाहेमा सम्पर्क गर्नको लागि सहमति छ

  छ □ / छैन □

- मैले बुझेको छु कि यदि यो परियोजनामा सहभागी हुन नसक्ने कुराको निर्णय कुनै पनि समयमा म गर्न सक्छु। म अनुशंधान मा सहभागी हुने र तुरुन्तै नहुने कुराको जानकारी दिन सक्छु र यस कुराले म वा मेरो बच्चालाई कुनै किसिमको नकारात्मक असर हुनेछैन

  छ □ / छैन □

- मेरो व्यक्तिगत विवरण नभएको अनुशन्धानका तथ्यांकहरु भविष्यमा अन्य कसैले प्रयोग गर्न सक्ने कुरामा मेरो सहमति छ

  छ □ / छैन □

तथ्याक संकलनको क्रममा अनुशन्धान टिमको लागि मेरो, मेरो बच्चाको फोटो लिन सहमति छ।

□ (सहमति छ) अध्ययनमा प्रयोग गर्न को लागि फोटो दिन मेरो सहमति छ (प्रकासन तथा वेव पेजको प्रयोजनको लागि)

□ म फोटोको लागि सहमत छु तर प्रकासन तथा वेव पेजको प्रयोजनको लागि फोटोहरु प्रयोग गर्न चाहन्न

□ सहमति छैन, फोटो लिनको लागि म चाहदिन

सहभागीको हस्ताक्षर /औठाछाप ______________________________

मिति ______________________

अनुशन्धानकर्ताको नाम (कृपया लेख्नुहोस): ______________________________

मिति ______________________

अनुशन्धानकर्ताको हस्ताक्षर ______________________________

नेपाल स्वास्थ्य अनुसनधान परिषद् (परियोजना आइ दि नम्बर 13/2018 बाट अनुमति प्राप्त) र युनिभरसिटी कलेज लण्डनको नैतिक अनुसन्धान समितिबाट (परियोजना आइ दि नम्बर: ११३४५/००१) स्वीकृति प्राप्त परियोजना हो

Appendix B Determinants of infant growth (Chapter 6)

B. 1 Initial analytical approach using an infant and young child feeding index

In an initial analytical approach, I attempted to use a feeding index that summarises the adherence to recommended feeding practices in a score. I calculated an infant and young child feeding (IYCF) score following the method described by Ruel and Menon (2002) and adapted it to the available data (see Table S 1). The longitudinal data posed a further problem because the scale of the score changes over the age of the child, e.g., at age three months the maximum score is two points, whereas at nine months it is six points. I solved this problem by dividing the achieved score at each time point by the respective highest possible score at that age, so that at each time point the score ranged between 0 and 1. At the model development stage, I found that the score was not a relevant determinant of infant growth, which was surprising as feeding practices are regarded on of the immediate risk factors for childhood stunting. One possible explanation was that while some components of the score are relevant, other may not be and that they “dilute” the validity of the score. I therefore decided not to use the score but the single feeding indicators and to separate the dataset by the two feeding phases exclusive breastfeeding period (birth to six months) and complementary feeding period (7 to 24 months).

Table S 1: Variables and scoring system to create the infant and young child feeding index for children 0-24 months old by age group

Corresponding WHO IYCF indicator	Birth	1-5 months	6-8 months	9-11 months	12-24 months
IYCF 1: Early initiation of breastfeeding	Child put to the breast within one hour of birth: 1	-	-	-	-
First feeds (additional non-IYCF indicators)	Colostrum not discarded: 1 First feed: own milk: 2; other mother's milk: 1; pre-lacteal feed: 0	-	-	-	-
IYCF 2: Exclusive breastfeeding under 6 months	-	Child exclusively breastfed: 2 Predominant breastfeeding: 1	-	-	-
IYCF 3: Continued breastfeeding at 1 year	-	-	Continued breastfeeding: 2	Continued breastfeeding: 2	Continued breastfeeding: 1
IYCF 5: Minimum dietary diversity	-	-	Dietary diversity score (0-7) 0=0, 1-3=1, 4+=2	Dietary diversity score (0-7) 0=0, 1-3=1, 4+=2	Dietary diversity score (0-7) 0=0, 1-3=1, 4+=2

IYCF 6: Minimum meal frequency		-	Times fed solid/semisolid/soft foods per day Breastfed children 6–8 months: 0=0, 1=1, 2=2 times Non-breastfed children 6–23 months: 0/1=0 2/3=1 4=2	Times fed solid/semisolid/soft foods per day Breastfed children 9-24 months: 0/1=0, 2=1, 3=2 times Non-breastfed children 6–23 months: 0/1=0 2/3=1 4=2	Times fed solid/semisolid/soft foods per day Breastfed children 9-24 months: 0/1=0, 2=1, 3=2 times Non-breastfed children 6–23 months: 0/1=0 2/3=1 4=2
Theoretical max. score at each age	4	2	6	6	5

B. 2 Random effects models diagnostic plots

Figure S 1 to Figure S 4 to show the model diagnostics plots used in Models 2 (final models using the datasets with complete observations). Figure S 1 (model birth to six months) and Figure S 3 (model 7 to 24 months) show that fixed effects (FE) and random (RE) were close to normally distributed. Homoscedasticity, the homogeneity of variance in FE residuals, is visualized in Figure S 2 (model birth to six months) and Figure S 4 (model 7 to 24 months).

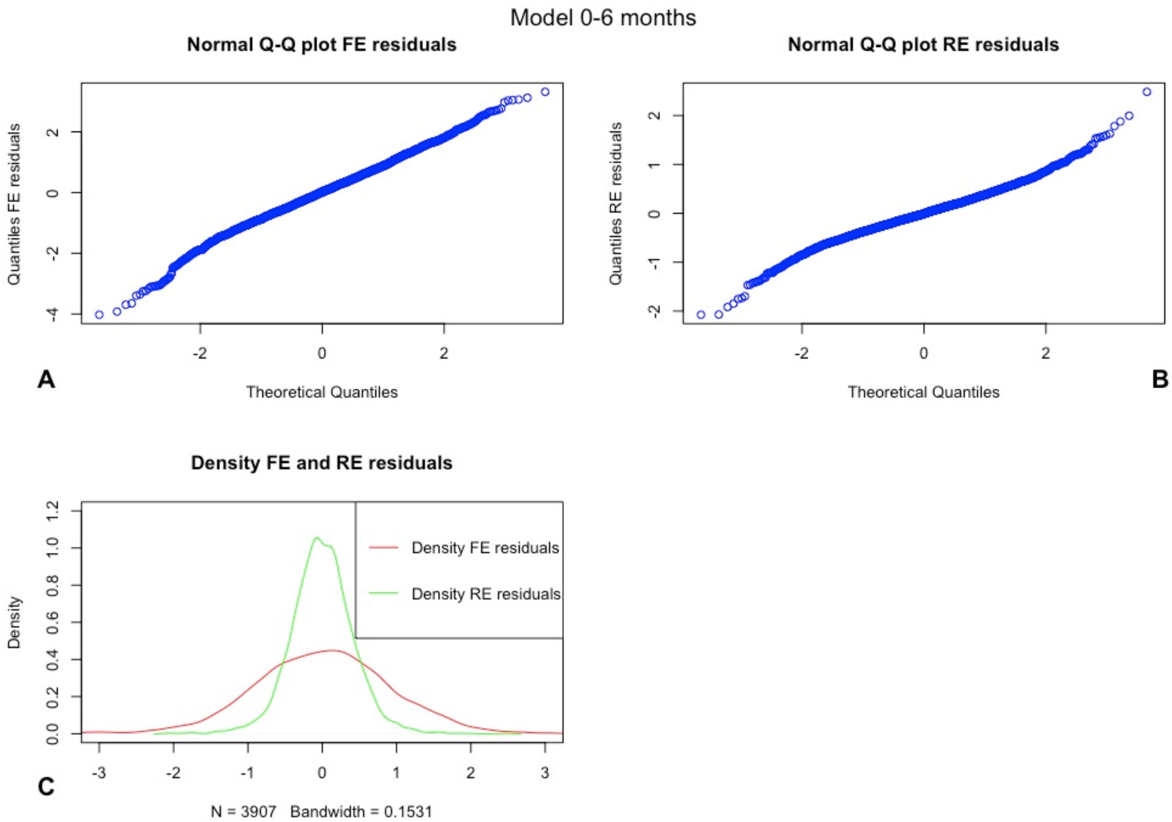


Figure S 1: Assessment of normality of fixed effects (FE) and random effects (RE) residuals in the birth to six months age-period using Q-Q plots (A and B) and density (C).

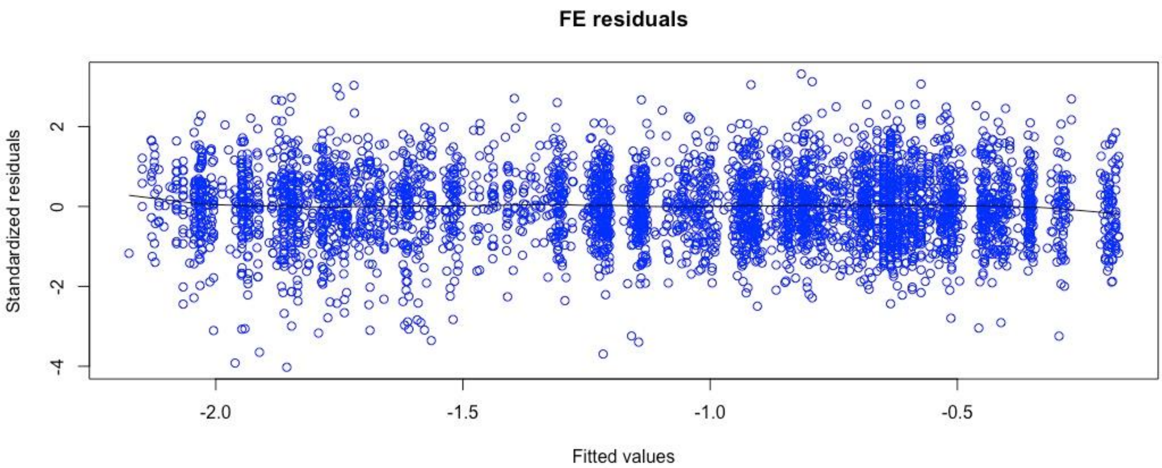


Figure S 2: Assessment of homoscedasticity of fixed effects (FE) residuals in the birth to six months age-period.

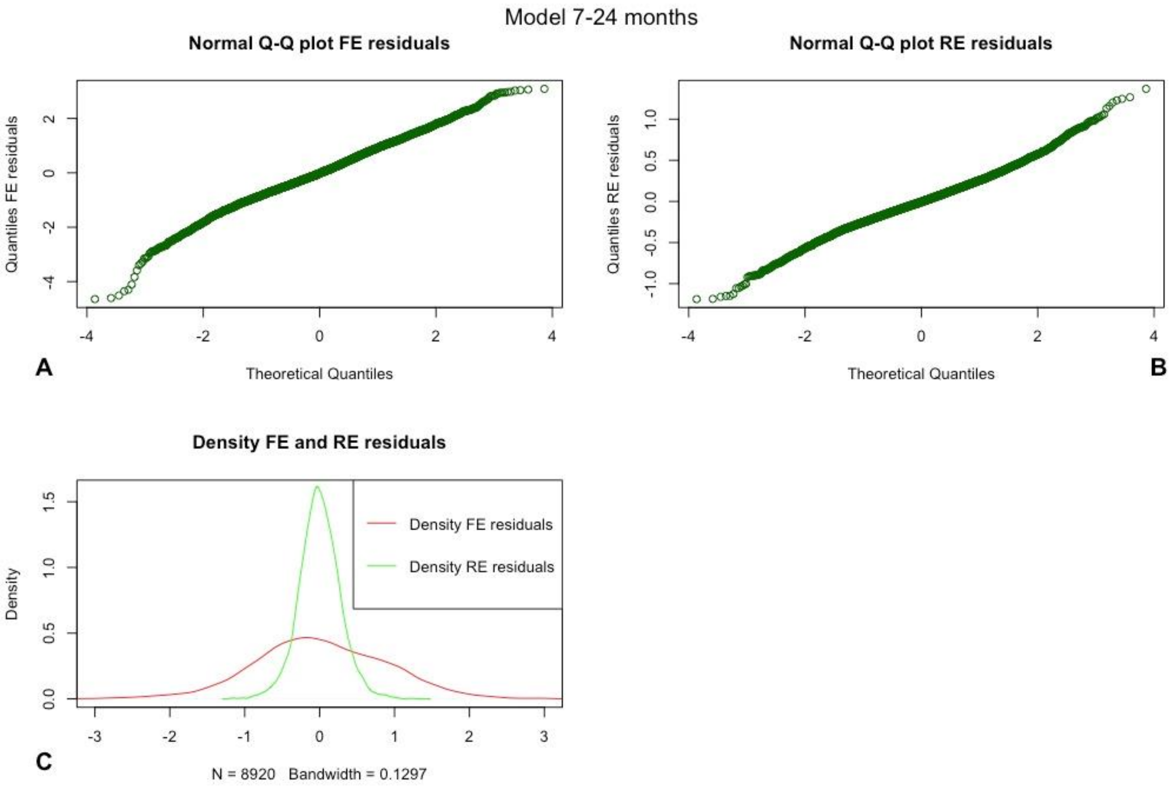


Figure S 3: Assessment of normality of fixed effects (FE) and random effects (RE) residuals in the 7 to 24 months age-period using Q-Q plots (A and B) and density (C).

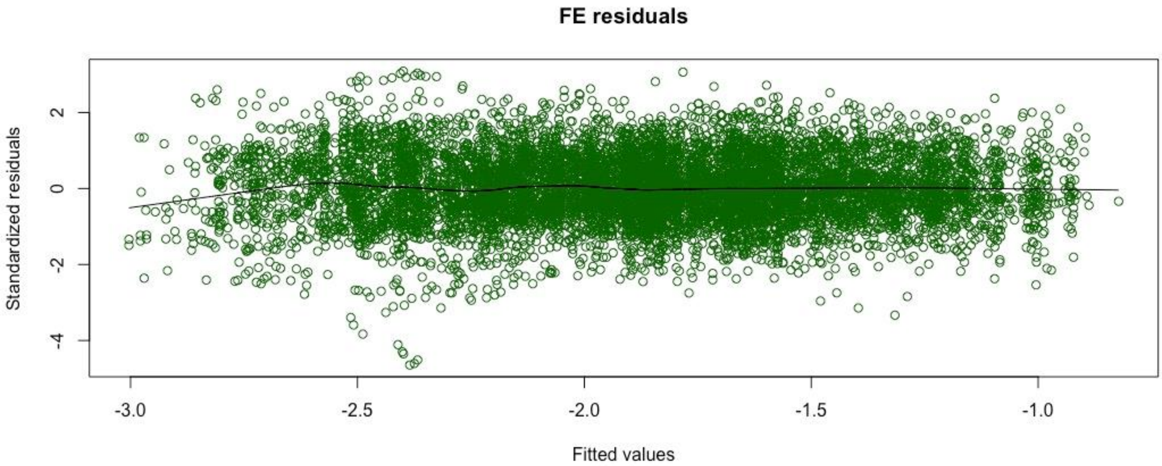


Figure S 4: Assessment of homoscedasticity of fixed effects (FE) residuals in the 7 to 24 months age-period.

B. 3 Regression results determinants of infant growth analysis

Table S 2: Crude and adjusted coefficients for length-for-age *z*-score from birth to six months, from random effect models.

	Model 1[1]		Model 2[2]		Model 3[3]	
Factor	Coeff (95% CI)	*p*	Coeff (95% CI)	*p*	Coeff (95% CI)	*p*
Intercept	-1.06 (-1.14, -0.97)	0.00	-0.74 (-0.92, -0.57)	0.00	6.86 (4.96, 8.76)	0.00
Season of measurement						
Spring	Ref		Ref		Ref	
Monsoon	0.12 (-0.03, 0.27)	0.12	0.08 (-0.06, 0.23)	0.27	0.08 (-0.06, 0.23)	0.13
Autumn	0.03 (-0.14, 0.20)	0.74	-0.02 (-0.18, 0.15)	0.86	-0.01 (-0.18, 0.15)	0.45
Winter	-0.12 (-0.31, 0.07)	0.22	-0.16 (-0.34, 0.03)	0.10	-0.15 (-0.34, 0.03)	0.05
Child age						
spline(age in months)_1	-0.14 (-0.21, -0.07)	0.00	-0.22 (-0.35, -0.10)	0.00	-0.22 (-0.34, -0.09)	0.00
spline(age in months)_2	0.16 (0.07, 0.26)	0.00	0.15 (-0.02, 0.31)	0.08	0.14 (-0.03, 0.30)	0.05
spline(age in months)_3	-0.56 (-0.61, -0.52)	0.00	-0.53 (-0.65, -0.40)	0.00	-0.53 (-0.65, -0.40)	0.00
Child sex						
boy	Ref					
girl	0.01 (-0.15, 0.16)	0.95	-			
<u>Home environment</u>						
Asset quartile						
Asset quartile 1 (worse off)	Ref					
Asset quartile 2	0.11 (-0.11, 0.33)	0.32	-		-	
Asset quartile 3	0.30 (0.09, 0.51)	0.01	-		-	
Asset quartile 4 (better off)	0.31 (0.09, 0.52)	0.01	-		-	
Household food insecurity						

Some level of household food insecurity	Ref					
Household is food secure	0.21 (0.04, 0.38)	0.01	-		-	
Water source						
Own pump/well/tap/borehole	Ref					
Public/neighbours well, pump or tap	-0.09 (-0.26, 0.08)	0.31	-		-	
Toilet use						
No open defecation	Ref					
Open defecation	-0.23 (-0.42, -0.05)	0.01	-		-	
Number of older siblings						
None	Ref					
One	-0.46 (-0.71, -0.22)	0.00	-		-	
Two or more	0.08 (-0.11, 0.27)	0.41	-		-	
Interaction Age : Number of older siblings						
spline(age in months)_1:One	-0.14 (-0.34, 0.06)	0.18	-		-	
spline(age in months)_2:One	0.26 (-0.01, 0.53)	0.06	-		-	
spline(age in months)_3:One	0.37 (0.24, 0.51)	0.00	-		-	
spline(age in months)_1:Two or more	-0.43 (-0.59, -0.27)	0.00	-		-	
spline(age in months)_2:Two or more	-0.18 (-0.39, 0.03)	0.10	-		-	
spline(age in months)_3:Two or more	-0.06 (-0.17, 0.04)	0.22	-		-	
<u>Maternal factors</u>						
Birthweight						
Normal birthweight (≥ 2500g)	Ref		Ref		Ref	
Low birthweight (<2500g)	-1.24 (-1.40, -1.08)	0.00	-1.21 (-1.38, -1.05)	0.00	-1.13 (-1.29, -0.96)	0.00
Interaction Age : low birthweight						

spline(age in months)_1:low birthweight	0.27 (0.12, 0.42)	0.00	0.25 (0.11, 0.40)	0.00	0.25 (0.10, 0.40)	0.00
spline(age in months)_2:low birthweight	0.44 (0.24, 0.63)	0.00	0.43 (0.23, 0.62)	0.00	0.42 (0.22, 0.62)	0.00
spline(age in months)_3:low birthweight	0.51 (0.41, 0.60)	0.00	0.48 (0.38, 0.58)	0.00	0.47 (0.38, 0.57)	0.00
Maternal education						
No education	Ref		Ref		Ref	
Some level of education	0.07 (-0.11, 0.25)	0.48	0.05 (-0.11, 0.21)	0.51	0.01 (-0.14, 0.17)	0.44
Interaction Age : Mat. education	0.00 (0.00, 0.00)					
spline(age in months)_1: Some level of education	0.23 (0.08, 0.38)	0.00	0.24 (0.10, 0.38)	0.00	0.23 (0.09, 0.38)	0.00
spline(age in months)_2: Some level of education	0.38 (0.18, 0.58)	0.00	0.36 (0.16, 0.55)	0.00	0.36 (0.17, 0.56)	0.00
spline(age in months)_3: Some level of education	0.18 (0.08, 0.28)	0.00	0.16 (0.07, 0.26)	0.00	0.16 (0.07, 0.26)	0.00
Birth-to-pregnancy interval						
≥24 months	Ref					
<24 months	0.21 (0.00, 0.43)	0.05	-		-	
End date of previous pregnancy unknown	-0.25 (-0.52, 0.03)	0.08	-		-	
Primigravida	-0.41 (-0.63, -0.18)	0.00	-		-	
Interaction Age : Birth-to-pregnancy interval						
spline(age in months)_1:<24 mths	-0.16 (-0.33, 0.01)	0.07	-		-	
spline(age in months)_2:<24 mths	-0.27 (-0.50, -0.04)	0.02	-		-	
spline(age in months)_3:<24 mths	-0.28 (-0.39, -0.16)	0.00	-		-	

spline(age in months)_1: End date of previous pregnancy unknown	-0.06 (-0.29, 0.17)	0.60	-		-	
spline(age in months)_2: End date of previous pregnancy unknown	-0.17 (-0.48, 0.14)	0.27	-		-	
spline(age in months)_3: End date of previous pregnancy unknown	0.11 (-0.04, 0.26)	0.14	-		-	
spline(age in months)_1:Primigravida	0.19 (0.01, 0.38)	0.04	-		-	
spline(age in months)_2:Primigravida	0.37 (0.12, 0.61)	0.00	-		-	
spline(age in months)_3:Primigravida	0.31 (0.19, 0.44)	0.00	-		-	
Maternal age at birth						
Mother is >19 years	Ref		Ref		Ref	
Adolescent mother (≤19y)	-0.45 (-0.67, -0.24)	0.00	-0.22 (-0.41, -0.03)	0.03	-0.26 (-0.44, -0.07)	0.00
Interaction Age : Adolescent mother						
spline(age in months)_1: Adolescent mother	0.21 (0.03, 0.39)	0.02	0.13 (-0.05, 0.30)	0.16	0.13 (-0.05, 0.30)	0.08
spline(age in months)_2: Adolescent mother	0.23 (0.00, 0.47)	0.05	0.08 (-0.15, 0.32)	0.47	0.10 (-0.13, 0.33)	0.21
spline(age in months)_3: Adolescent mother	0.28 (0.16, 0.40)	0.00	0.15 (0.04, 0.27)	0.01	0.15 (0.04, 0.27)	0.00
Maternal absence and feeding arrangement *						
Doesn't work outside, takes break to feed the baby or takes baby with her	Ref					
Baby is with another carer	-0.27 (-2.96, 2.41)	0.84	-		-	

No feeding arrangement	0.46 (-1.36, 2.28)	0.62	-	-	
Interaction Age : Maternal absence and feeding arrangement					
spline(age in months)_1: Baby is with another carer	-0.07 (-1.35, 1.22)	0.92	-	-	
spline(age in months)_2: Baby is with another carer	0.67 (-4.66, 6.00)	0.81	-	-	
spline(age in months)_3: Baby is with another carer	0.01 (-1.33, 1.34)	0.99	-	-	
spline(age in months)_1: No feeding arrangement	-0.31 (-1.19, 0.57)	0.48	-	-	
spline(age in months)_2: No feeding arrangement	-0.73 (-4.33, 2.87)	0.69	-	-	
spline(age in months)_3: No feeding arrangement	-0.34 (-1.24, 0.56)	0.46	-	-	
Mother ate less, same, or more in the last trimester of pregnancy					
Ate less	Ref				
Ate the same	0.14 (-0.02, 0.30)	0.10	-	-	
Ate more	0.29 (-0.03, 0.61)	0.07	-	-	
Maternal height (in cm)				0.04 (0.02, 0.05)	0.00
<u>Infection</u>					
Diarrhoea					
No diarrhoea in the previous two weeks	Ref				
Child had diarrhoea in the previous two weeks	-0.05 (-0.12, 0.02)	0.19	-	-	

Symptom of chest infection**						
No cough with rapid breathing	Ref		Ref		Ref	
Cough and rapid breathing	-0.10 (-0.15, -0.05)	0.00	-0.10 (-0.14, -0.05)	0.00	-0.10 (-0.15, -0.05)	0.00
<u>Breastfeeding practices</u>						
Breastfeeding within the first hour after birth						
Child was breastfed more than one hour after birth	Ref					
Child was breastfed within one hour after birth	0.23 (0.06, 0.40)	0.01	-		-	
Exclusive breastfeeding						
Child was not exclusively breastfed in the first six months	Ref					
Child was exclusively breastfed in the first six months	0.02 (-0.03, 0.07)	0.49	-		-	
Discard colostrum						
Colostrum was not discarded	Ref					
Colostrum was discarded	0.01 (-0.18, 0.19)	0.93	-			

[1] Unadjusted (univariable) mixed-effects linear regression models between the respective potential determinant and the outcome length-for-age *z*-score, with a random effect on the intercept. The dataset contains all observations with complete data in those variables that were selected as potential determinants of infant growth (*n*=3829).

[2] Multivariable mixed-effects linear regression model adjusted for those factors that were identified as relevant in Models 1, using BIC as criterion for goodness of fit. The final model contains child age, low birthweight, maternal education, maternal age at birth, chest infection, and season of measurement as fixed effects, and a random effect on the intercept (*n*=3907).

[3] Multivariable mixed-effects linear regression models using the dataset with imputed covariates, adjusted for the same factors as Model 2 and additionally for maternal height (*n*=4216).

*In the three months preceding the interview. **In the two weeks preceding the interview.

Table S 3: Crude and adjusted coefficients for length-for-age *z*-score from 7 to 24 months, from random effect models.

	Model 1[1]		Model 2[2]		Model 3[3]	
Factor	Coeff (95% CI)	*p*	Coeff (95% CI)	*p*	Coeff (95% CI)	*p*
Intercept	-1.35 (-1.43, -1.27)	0.00	-1.33 (-1.49, -1.17)	0.00	10.03 (8.14, 11.92)	0.00
Season of measurement						
Spring	Ref		Ref		Ref	
Monsoon	0.03 (0.01, 0.06)	0.00	0.03 (0.01, 0.06)	0.00	0.03 (0.01, 0.06)	0.00
Autumn	0.00 (-0.02, 0.03)	0.73	0.01 (-0.02, 0.04)	0.48	0.01 (-0.02, 0.03)	0.28
Winter	-0.07 (-0.09, -0.05)	0.00	-0.06 (-0.08, -0.04)	0.00	-0.06 (-0.08, -0.04)	0.00
Child age						
spline(age in months)_1	-0.80 (-0.82, -0.77)	0.00	-0.76 (-0.80, -0.72)	0.00	-0.75 (-0.80, -0.71)	0.00
spline(age in months)_2	-0.39 (-0.42, -0.36)	0.00	-0.41 (-0.46, -0.36)	0.00	-0.41 (-0.46, -0.36)	0.00
spline(age in months)_3	-1.22 (-1.28, -1.16)	0.00	-1.41 (-1.52, -1.31)	0.00	-1.41 (-1.51, -1.30)	0.00
spline(age in months)_4	-0.45 (-0.48, -0.41)	0.00	-0.52 (-0.57, -0.47)	0.00	-0.52 (-0.57, -0.47)	0.00
Child sex						
boy	Ref		-			
girl	0.02 (-0.13, 0.18)	0.76	-		-	
<u>Home environment</u>						
Asset quartile						
Asset quartile 1 (worse off)	Ref					
Asset quartile 2	0.22 (0.01, 0.44)	0.04	-		-	
Asset quartile 3	0.32 (0.10, 0.53)	0.00	-		-	
Asset quartile 4 (better off)	0.32 (0.11, 0.53)	0.00	-		-	
Household food insecurity						
Some level of household food insecurity	Ref		Ref		Ref	
Household is food secure	0.29 (0.12, 0.45)	0.00	0.23 (0.07, 0.39)	0.00	0.16 (0.01, 0.31)	0.02

Water source						
Own pump/well/tap/borehole	Ref		Ref		Ref	
Public/neighbours well, pump or tap	-0.14 (-0.31, 0.04)	0.12	-0.02 (-0.19, 0.14)	0.79	-0.01 (-0.16, 0.15)	0.47
Interaction Age : Water source						
spline(age in months)_1: Public/neighbours well, pump or tap	-0.08 (-0.13, -0.02)	0.01	-0.06 (-0.12, -0.01)	0.02	-0.07 (-0.12, -0.02)	0.01
spline(age in months)_2: Public/neighbours well, pump or tap	-0.15 (-0.22, -0.08)	0.00	-0.14 (-0.21, -0.07)	0.00	-0.14 (-0.21, -0.07)	0.00
spline(age in months)_3: Public/neighbours well, pump or tap	-0.09 (-0.22, 0.04)	0.18	-0.09 (-0.22, 0.04)	0.19	-0.10 (-0.23, 0.03)	0.06
spline(age in months)_4: Public/neighbours well, pump or tap	-0.07 (-0.15, 0.00)	0.05	-0.08 (-0.16, -0.01)	0.02	-0.09 (-0.16, -0.01)	0.01
Toilet use						
No open defecation	Ref					
Open defecation	-0.21 (-0.39, -0.02)	0.03	-		-	
Any older siblings						
No older siblings	Ref					
Has older siblings	0.10 (-0.07, 0.27)	0.26	-		-	
Interaction Age : Older siblings						
spline(age in months)_1: Has older siblings	-0.16 (-0.21, -0.10)	0.00	-		-	
spline(age in months)_2: Has older siblings	0.05 (-0.02, 0.12)	0.14	-		-	
spline(age in months)_3: Has older siblings	-0.34 (-0.47, -0.21)	0.00	-		-	
spline(age in months)_4: Has older siblings	-0.04 (-0.12, 0.03)	0.25	-		-	

<u>Maternal factors</u>						
Birthweight						
Normal birthweight (≥ 2500g)	Ref		Ref		Ref	
Low birthweight (<2500g)	-0.75 (-0.91, -0.58)	0.00	-0.75 (-0.91, -0.59)	0.00	-0.63 (-0.78, -0.48)	0.00
Interaction Age : low birthweight						
spline(age in months)_1: low birthweight	0.20 (0.14, 0.25)	0.00	0.18 (0.13, 0.24)	0.00	0.18 (0.13, 0.23)	0.00
spline(age in months)_2: low birthweight	0.16 (0.08, 0.23)	0.00	0.16 (0.09, 0.23)	0.00	0.15 (0.09, 0.22)	0.00
spline(age in months)_3: low birthweight	0.23 (0.10, 0.36)	0.00	0.22 (0.09, 0.35)	0.00	0.22 (0.09, 0.35)	0.00
spline(age in months)_4: low birthweight	0.29 (0.22, 0.36)	0.00	0.29 (0.22, 0.36)	0.00	0.28 (0.21, 0.36)	0.00
Maternal education						
No education	Ref		Ref		Ref	
Some level of education	0.30 (0.13, 0.46)	0.00	0.22 (0.07, 0.38)	0.00	0.18 (0.03, 0.32)	0.01
Birth-to -pregnancy interval						
≥24 months	Ref					
<24 months	-0.16 (-0.36, 0.04)	0.12	-		-	
End date of previous pregnancy unknown	-0.27 (-0.52, -0.02)	0.04	-		-	
Primigravida	0.05 (-0.16, 0.25)	0.64	-		-	
Maternal age at birth						
Mother is >19 years	Ref					
Adolescent mother (≤19y)	-0.02 (-0.21, 0.18)	0.85	-		-	
Maternal absence and feeding arrangement *						

Doesn't work outside, takes break to feed the baby or takes baby with her	Ref		Ref		Ref	
Baby is with another carer	0.12 (0.01, 0.22)	0.03	0.09 (-0.02, 0.19)	0.10	0.09 (-0.01, 0.19)	0.04
No feeding arrangement	0.13 (0.05, 0.20)	0.00	0.11 (0.03, 0.18)	0.00	0.11 (0.03, 0.18)	0.00
Interaction Age : Maternal absence and feeding arrangement						
spline(age in months)_1: Baby is with another carer	-0.18 (-0.29, -0.07)	0.00	-0.14 (-0.24, -0.04)	0.01	-0.14 (-0.24, -0.03)	0.00
spline(age in months)_2: Baby is with another carer	-0.12 (-0.23, -0.01)	0.03	-0.11 (-0.22, 0.00)	0.04	-0.11 (-0.22, 0.00)	0.02
spline(age in months)_3: Baby is with another carer	-0.29 (-0.56, -0.01)	0.04	-0.22 (-0.48, 0.05)	0.11	-0.22 (-0.48, 0.05)	0.05
spline(age in months)_4: Baby is with another carer	0.01 (-0.09, 0.11)	0.88	0.04 (-0.06, 0.14)	0.46	0.04 (-0.06, 0.14)	0.21
spline(age in months)_1: No feeding arrangement	-0.36 (-0.45, -0.28)	0.00	-0.34 (-0.42, -0.25)	0.00	-0.33 (-0.42, -0.25)	0.00
spline(age in months)_2: No feeding arrangement	-0.13 (-0.23, -0.02)	0.02	-0.08 (-0.19, 0.02)	0.12	-0.08 (-0.18, 0.02)	0.06
spline(age in months)_3: No feeding arrangement	-0.35 (-0.56, -0.14)	0.00	-0.25 (-0.46, -0.05)	0.01	-0.25 (-0.45, -0.04)	0.01
spline(age in months)_4: No feeding arrangement	-0.22 (-0.33, -0.11)	0.00	-0.17 (-0.28, -0.06)	0.00	-0.17 (-0.28, -0.06)	0.00
Mother ate less, same, or more in the last trimester of pregnancy						
Ate less	Ref					
Ate the same	-0.07 (-0.24, 0.09)	0.38	-		-	
Ate more	-0.06 (-0.39, 0.26)	0.70	-		-	

Maternal height (in cm)	-		-		0.06 (0.05, 0.07)	0.00
<u>Infection</u>						
Diarrhoea **						
No diarrhoea	Ref					
Child had diarrhoea	-0.01 (-0.03, 0.00)	0.10	-		-	
Symptom of chest infection **			-			
No cough with rapid breathing	Ref					
Cough and rapid breathing	-0.02 (-0.04, 0.00)	0.08	-		-	
<u>Breastfeeding practices</u>						
Breastfeeding within the first hour after birth						
Child was breastfed more than one hour after birth						
Child was breastfed within one hour after birth	-		-		-	
Exclusive breastfeeding						
Child was not exclusively breastfed in the first six months						
Child was exclusively breastfed in the first six months	-		-		-	
Discard colostrum						
Colostrum was not discarded	Ref					
Colostrum was discarded	0.04 (-0.15, 0.22)	0.69	-		-	
<u>Complementary feeding practices</u>						
Child dietary diversity ***						
No minimum dietary diversity (<4 of 7 food groups)	Ref		Ref		Ref	

Minimum dietary diversity (≥4 of 7 food groups)	0.04 (0.02, 0.06)	0.00	0.03 (0.01, 0.05)	0.00	0.03 (0.01, 0.05)	0.00
Meal frequency ***						
No minimum meal frequency	Ref					
Minimum meal frequency	-0.02 (-0.03, 0.00)	0.05	-		-	
Continued breastfeeding						
Child is not breastfed anymore	Ref					
Child is still breastfed	0.05 (0.01, 0.08)	0.02	-		-	

[1] Unadjusted (univariable) mixed-effects linear regression models between the respective potential determinant and the outcome length-for-age *z*-score, with a random effect on the intercept. The dataset contains all observations with complete data in those variables that were selected as potential determinants of infant growth (*n*=8411).

[2] Multivariable mixed effects linear regression model adjusted for those factors that were identified as relevant in Models 1, using BIC as criterion for goodness of fit. The final model contains child age, low birthweight, maternal education, maternal age at birth, chest infection, and season of measurement as fixed effects, and a random effect on the intercept (*n*=8920).

[3] Multivariable mixed effects linear regression models using the dataset with imputed covariates, adjusted for the same factors as Model 2 and additionally for maternal height (*n*=9511).

*In the three months preceding the interview. **In the two weeks preceding the interview. ***In the 24 hours preceding the interview

Appendix C Association between paternal labour migration and growth of the left-behind children (Chapter 7)

C. 1 Random effects model diagnostic plots

Figure S 8.5 and Figure S8.6 are examples of model diagnostics plots that I used to assess mixed-effects models. Figure S 8.5 shows that random effects were close to normally distributed. In Figure S8.6 we see that fixed effect residuals had constant variance (A) and were normally distributed (B).

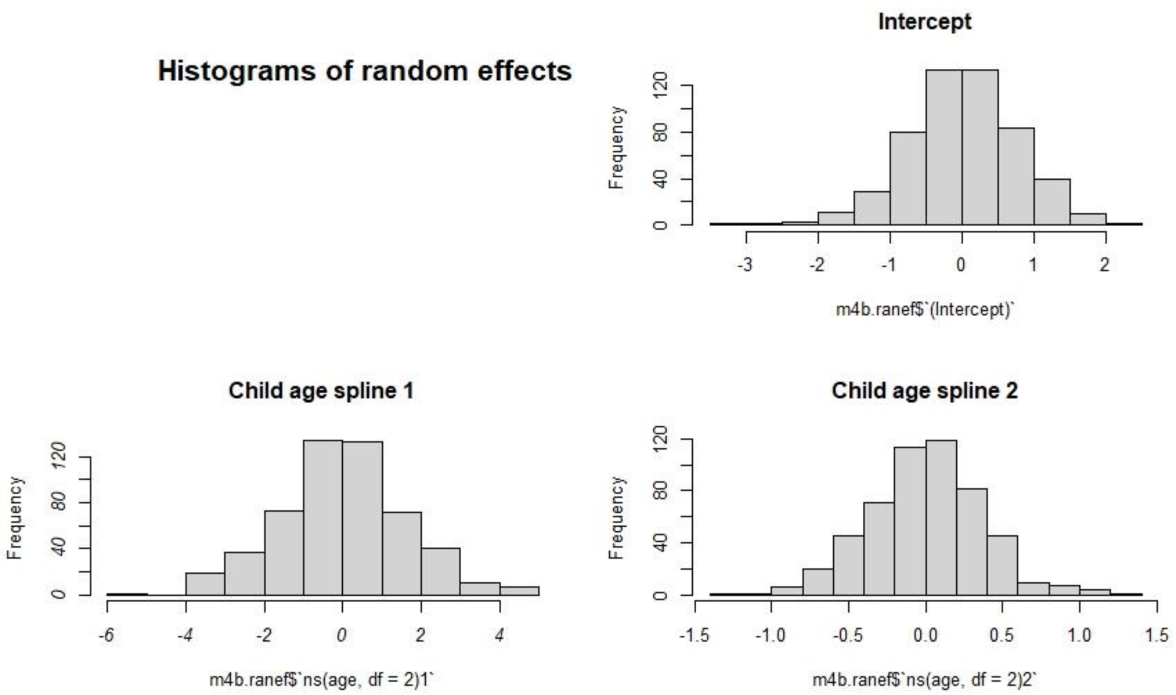
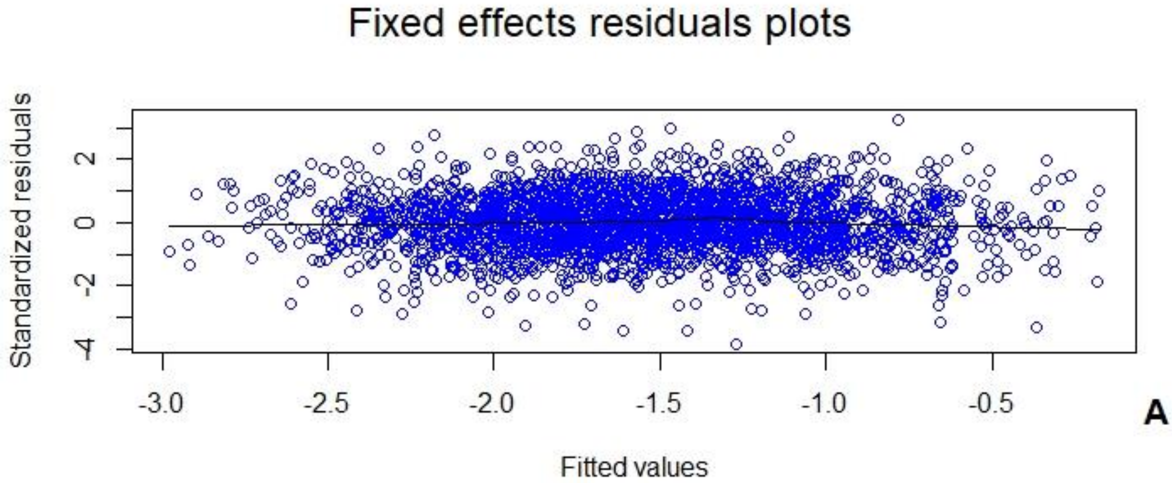


Figure S 8.5: Histograms of random effects (Model 0-72 months, short- vs. longer term migrant fathers)



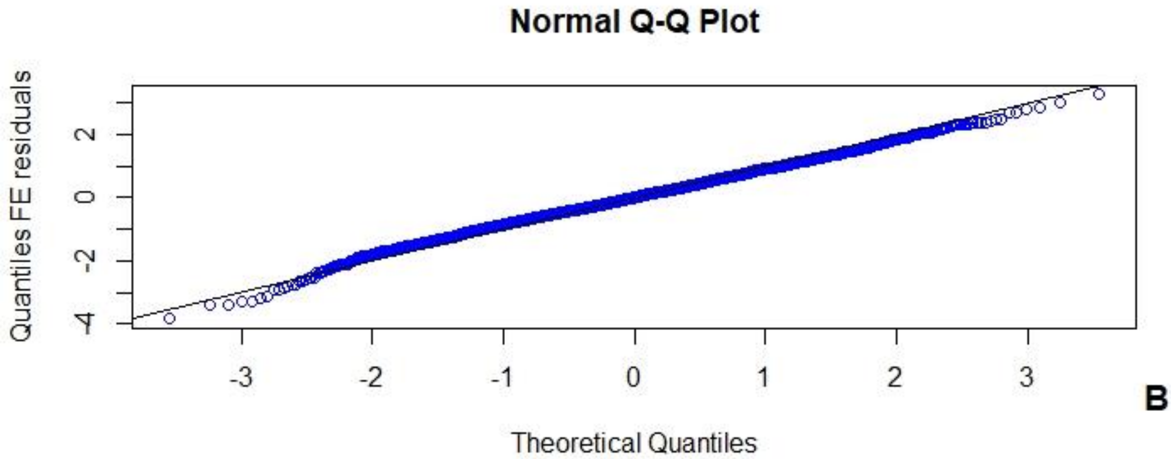


Figure S8.6: Residuals plots of fixed effects residuals (Model 0-72 months, short- vs. longer term migrant fathers).

C. 2 Results tables on the association between fathers' migration and other measures of child growth at six years

Table S 8.4: Association between fatherss migration for work and left-behind children' body circumferences at six years. Results from linear regressions.

	Head			**MUAC**			**Waist**			**Hip**			**Calf**		
	Coef	SE	*p*	Coef	SE	*p*	Coef	SE	*p*	Coef	SE	*p*	Coef	SE	*p*
Father never migrated	Ref			Ref			Ref			Ref			Ref		
Migration at any time in child's life	-0.22	0.12	0.06	-0.21	0.11	0.05	-0.58	0.26	0.03	-0.40	0.29	0.17	-0.29	0.13	0.03
Father did not migrate before childbirth	Ref			Ref			Ref			Ref			Ref		
Migration before birth	-0.30	0.12	0.01	-0.13	0.11	0.23	-0.22	0.26	0.39	-0.35	0.28	0.22	-0.14	0.13	0.28
Father did not migrate at age birth to 6mths	Ref			Ref			Ref			Ref			Ref		
Migration at birth to 6mths	-0.33	0.11	0.00	-0.12	0.11	0.24	-0.39	0.25	0.13	-0.54	0.28	0.06	-0.31	0.13	0.02
Father did not migrate age 6mths to 1y	Ref			Ref			Ref			Ref			Ref		
Migration at 6mths to 1y	-0.24	0.11	0.03	-0.18	0.10	0.08	-0.47	0.24	0.06	-0.55	0.27	0.04	-0.31	0.12	0.01
Father did not migrate age 1-2y	Ref			Ref			Ref			Ref			Ref		
Migration at 1-2y	-0.13	0.11	0.22	-0.06	0.10	0.57	-0.42	0.24	0.08	-0.31	0.27	0.24	-0.21	0.12	0.09
Father did not migrate age 2-6y	Ref			Ref			Ref			Ref			Ref		
Migration at 2-6y	-0.23	0.12	0.05	-0.20	0.11	0.06	-0.53	0.25	0.03	-0.34	0.28	0.23	-0.27	0.13	0.03
n	524			525			525			525			525		

Table S 8.5: Association between fathers' migration for work and left-behind children' skinfold thickness at six years. Results from linear regressions.

	Biceps			Triceps			Subscapular			Suprailiac		
	Coef	SE	*p*	Coef	SE	*p*	Coef	SE	*p*	Coef	SE	*p*
Father never migrated	Ref			Ref			Ref			Ref		
Migration at any time in child's life	-0.13	0.10	0.20	-0.25	0.14	0.09	-0.25	0.09	0.01	-0.35	0.16	0.03
Father did not migrate before childbirth	Ref			Ref			Ref			Ref		
Migration before birth	-0.09	0.10	0.35	-0.11	0.14	0.43	-0.08	0.09	0.38	-0.21	0.16	0.17
Father did not migrate at age birth to 6mths	Ref			Ref			Ref			Ref		
Migration at birth to 6mths	-0.04	0.10	0.66	0.02	0.14	0.88	-0.08	0.09	0.36	-0.16	0.15	0.30
Father did not migrate age 6mths to 1y	Ref			Ref			Ref			Ref		
Migration at 6mths to 1y	-0.06	0.10	0.53	-0.01	0.14	0.94	-0.05	0.08	0.53	-0.16	0.15	0.29
Father did not migrate age 1-2y	Ref			Ref			Ref			Ref		
Migration at 1-2y	-0.03	0.09	0.76	-0.08	0.13	0.54	-0.07	0.08	0.43	-0.12	0.15	0.43
Father did not migrate age 2-6y	Ref			Ref			Ref			Ref		
Migration at 2-6y	-0.14	0.10	0.16	-0.19	0.14	0.18	-0.26	0.09	0.00	-0.29	0.15	0.06
n	524			523			521			524		

Table S 8.6: Association between fathers' migration for work and left-behind children's lean mass at six years. Results from linear regressions.

	Lean mass			Lean mass index			Lean mass z-score		
	Coef	SE	*p*	Coef	SE	*p*	Coef	SE	*p*
Father never migrated	Ref			Ref			Ref		
Migration at any time in child's life	-0.39	0.16	0.02	-0.16	0.09	0.09	-0.15	0.09	0.08
Father did not migrate before childbirth	Ref			Ref			Ref		
Migration before birth	-0.09	0.16	0.57	0.00	0.09	0.98	-0.04	0.09	0.63
Father did not migrate at age birth to 6mths	Ref			Ref			Ref		
Migration at birth to 6mths	-0.38	0.16	0.02	-0.17	0.09	0.08	-0.22	0.09	0.01
Father did not migrate age 6mths to 1y	Ref			Ref			Ref		
Migration at 6mths to 1y	-0.40	0.15	0.01	-0.19	0.09	0.04	-0.20	0.08	0.01
Father did not migrate age 1-2y	Ref			Ref			Ref		
Migration at 1-2y	-0.25	0.15	0.10	-0.16	0.09	0.07	-0.13	0.08	0.12
Father did not migrate age 2-6y	Ref			Ref			Ref		
Migration at 2-6y	-0.34	0.16	0.03	-0.14	0.09	0.14	-0.13	0.09	0.12
n	472			472			472		

Table S 8.7: Association between fathers' migration for work and left-behind children's fat mass at six years. Results from linear regressions.

	Fat mass			Fat mass index			Fat mass z-score		
	Coef	SE	*p*	Coef	SE	*p*	Coef	SE	*p*
Father never migrated	Ref			Ref			Ref		
Migration at any time in child's life	-0.10	0.11	0.33	-0.06	0.08	0.50	-0.07	0.12	0.60
Father did not migrate before childbirth	Ref			Ref			Ref		
Migration before birth	-0.22	0.11	0.03	-0.18	0.08	0.03	-0.20	0.12	0.10
Father did not migrate at age birth to 6mths	Ref			Ref			Ref		
Migration at birth to 6mths	-0.09	0.10	0.38	-0.05	0.08	0.54	-0.02	0.12	0.88
Father did not migrate age 6mths to 1y	Ref			Ref			Ref		
Migration at 6mths to 1y	-0.06	0.10	0.56	-0.02	0.08	0.76	0.01	0.12	0.93
Father did not migrate age 1-2y	Ref			Ref			Ref		
Migration at 1-2y	-0.03	0.10	0.78	-0.02	0.08	0.80	0.01	0.12	0.93
Father did not migrate age 2-6y	Ref			Ref			Ref		
Migration at 2-6y	-0.11	0.10	0.29	-0.07	0.08	0.42	-0.08	0.12	0.48
n	472			472			472		

Table S 8.8: Association between fathers' migration for work and left-behind children's tibia length and grip strength categories at six years. Results from linear regressions and ordinal logistic regression.

	Tibia length			Grip strength category	
	Coef	SE	*p*	OR	95% CI
Father never migrated	Ref			Ref	
Migration at any time in child's life	-1.02	1.28	0.43	1.11	0.79
Father did not migrate before childbirth	Ref			Ref	
Migration before birth	0.84	1.27	0.51	1.08	0.77
Father did not migrate at age birth to 6mths	Ref			Ref	
Migration at birth to 6mths	-0.04	1.25	0.97	1.14	0.81
Father did not migrate age 6mths to 1y	Ref			Ref	
Migration at 6mths to 1y	-0.04	1.21	0.97	1.17	0.84
Father did not migrate age 1-2y	Ref			Ref	
Migration at 1-2y	0.64	1.20	0.60	1.29	0.94
Father did not migrate age 2-6y	Ref			Ref	
Migration at 2-6y	-1.06	1.25	0.39	1.11	0.79
n	515			524	