Nutrition Causal Analysis

In Chars Livelihoods of

Gaibandha and Lalmonirhat districts,

-Bangladesh-

Final Report – Jan 2012

Forewords

Action Against Hunger (ACF) *is developing a standardized method for analysing the causes of malnutrition*, as a starting point for improving the appropriateness/relevance and effectiveness of the organization's programming in a given context. The nutrition causal analysis (NCA) is also intended to be useful as a platform for informing the broader stakeholder response, and for ensuring that this response reflects an appropriate contextualized understanding of malnutrition's complex multi-causality.

While there are a number of documented approaches to conducting NCAs, ACF is conducting this research project because methodologies used for conducting NCA are typically constrained in four main ways:

1) They often yield only a *static picture of the causes of malnutrition* failing to consider seasonality, shocks and trends.
2) NCAs often *focus on a single type of malnutrition* (e.g. stunting vs. wasting), rather than considering the different aetiologies of different malnutrition outcomes, affecting different age groups.
3) They *fail to prioritize causes*, rendering the results less actionable and operationally useful.
4) They are often *based on large samples, at national levels* typically based on Demographics and Health Surveys. Understanding specific causes of undernutrition in a local context, using limited resources to conduct the survey and taking into account the broad spectrum of causes described in the UNICEF framework is more useful for stakeholders to trigger specific actions.

What is needed is an NCA method that can
a) define the key pathways of undernourishment in a particular context, including key behavioural or attitudinal constraints,
b) define the relative priority of these causes in terms of both their contribution to malnutrition and their prospects for modification
c) that can help to fine-tune our understanding of the causality of different syndromes of malnutrition to facilitate a better-tailored and, more effective response.

Though this is a demanding set of criteria, ACF, in collaboration with TUFTS University, has risen to meet this challenge by investing in the development of a standardized method for nutrition causal analysis that can incorporate the elements describe above and be applied across the various contexts in which it works.

The following document represents a first attempt to propose such a method. The lessons learned from these field tests will be used to strengthen the validity and feasibility of the method. The development of any type of 'standardized method' requires a long evolutionary/ iterative process.

This report presents the results of the field study done in Bangladesh from November 2010 to May 2011.

For any information related to this report, please contact:
Julien chalimbaud,
nca@actioncontrelafaim.org or cmn@bd.missions-acf.org

Acknowledgements

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- The ACF team and in particular the NCA team for their continuous efforts and rigor.
- All the participants of the study for enthusiastically giving us some time for this study
- All the organisations and people who are doing a great job in this difficult environment. Very special thanks to OVA, RDRS, CLP for their continuous support during this study.

This NCA was implemented by Julien Chalimbaud (head of NCA research project) and Tamana Ferdous (Deputy Nutrition Coordinator).

This report is organised as follows:

1. *Presentation of the objectives of the survey, the methodology used and its limits*, as it's still under development. This methodology has been used in other contexts (Zimbabwe, South Sudan, Refugee Camps in Cox's Bazzar…) and is available from this address: nca@actioncontrelafaim.org.

2. A presentation of the *main potential causes of undernutrition* or 'hypothesis of causality' identified.

3. A *description of the area studied* (geographic, social, economical groups).

4. An overview of the *nutrition outcomes* measured.

5. A presentation of the *results for each hypothesis identified* and *its links with undernutrition.*

6. A review of the *dynamic aspects of causes of undernutrition.*

7. A presentation of the *ranking exercise* which attempt to classify causes of undernutrition based on their relative contribution.

8. Finally some *recommendation* for actions based on the main findings.

Table of content:

1. Objectives of the study

Undernutrition levels in Bangladesh are high (43% stunting; 17.4% GAM)[1] and given the particular difficulties faced by inhabitants of the chars, it is expected that undernutrition levels in the chars are especially high and are driven by specific causes.

ACF therefore decided to undertake a Nutrition Causal Analysis in order to:

1. Identify factors that are significantly associated with stunting or wasting among children in this population?

2. Identify the main causal 'pathways of undernourishment' by which certain children in this population have become stunted and/or wasted?

3. Understand the dynamics (seasonality, shocks and trends) of undernutrition in this population?

4. Rank the main factors and pathways explaining most of the undernutrition observed in this population?

The study will focus on children from 6 to 59 months.
The study will be undertaken in the Chars of Gaibandha and Lalmonirhat districts.
The study will focus on causes of wasting (without ignoring causes of stunting) as wasting levels are high and related to mortality risks.
The study will follow the new methodology designed by ACF in collaboration with TUFTS University which has participated and controlled the data analysis phase in particular.

2. Methodology

Forewords on causal framework:
The NCA is based upon UNICEF causal framework[2] of malnutrition. While this framework is valuable, there are some limits that need to be addressed when undertaking an NCA:

- Undernutrition includes underweight, stunting and acute undernutrition for which causes are different. The framework remains valid for all of them but is specific to each type.

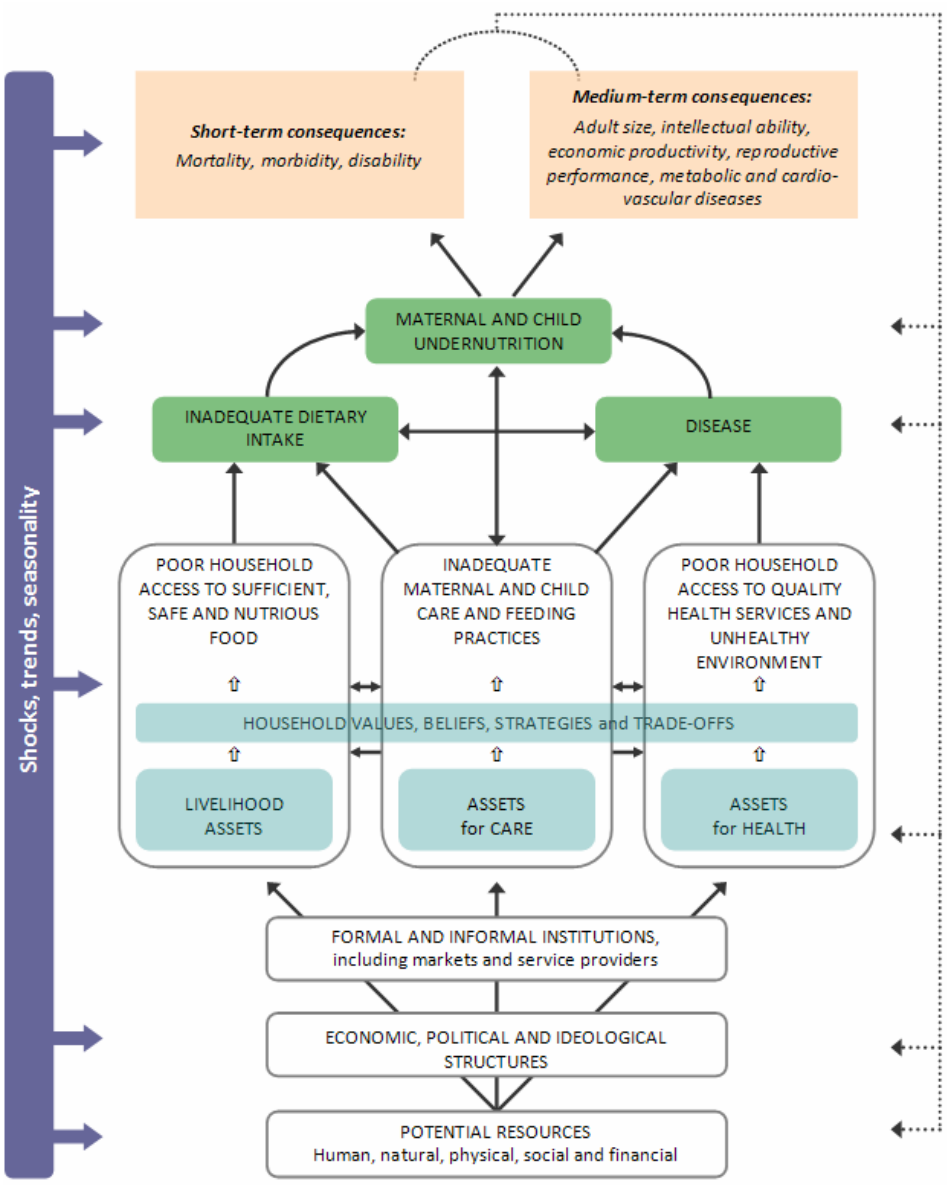
- Undernutrition episodes on children have short-term (mortality; morbidity; disability) and long-term consequences (adult size; intellectual ability, economic productivity, reproductive performance, metabolic and cardiovascular disease)[3] leading to cycles that are not well described in the framework. The nutrition life cycle is important to consider: undernutrition of women can lead to low birth weight and undernutrition of children.

[1] Bangladesh Demographic and Health Survey 2007. National Institute of Population Research and Training.
[2] http://www.ceecis.org/iodine/01_global/01_pl/01_01_other_1992_unicef.pdf

[3] Black RE and Al, 2008. "Maternal and child undernutrition: Global and regional exposures and health consequences"

- The conceptual framework remains valid at all time but for methodological purpose, it is important to emphasize that each risk factor and undernutrition prevalence can dramatically change with
  - Seasonality: refers to seasonal predictable variations (hunger gap period; malaria season…)
  - Shocks: refers to crisis situations having a large impact (drought; malaria outbreak…)
  - Trends: refers to medium-term and long-term changes (climate change; health services development…)

To take into consideration these aspects for field assessments ACF prefers to use the following framework, based on the UNICEF structure:



Looking at all the potential causes of undernutrition is not an easy task but is essential to avoid missing any important information. The methodology acknowledges that not all causes can be realistically detected in a snapshot survey. It would require a very long research process (for example blood sample to measure micronutrient deficiencies; medical examination; measuring children weight at birth…).

Instead, the NCA method tries to overcome these difficulties by:

- Gathering and analysing the existing knowledge and expertise on local causes of undernutrition: we will explore only causes that are known to be important (step 2).
- Gathering information from different sources: from a cross sectional quantitative survey; from context analysis; from exploration of the undernutrition dynamics; from interviews with experts and communities (Step 3).

The interpretation of the analysis is therefore a team exercise whereby information gathered is discussed, analysed, and weighted based on objectives criteria, to reach a consensus on the ranking of causes.

The main steps of the NCA methodology:

STEP 1: Define objectives and describe the context
STEP 2: Develop main hypothesis of causality
STEP 3: Conduct field survey
STEP 4: Analysis of information collected
STEP 5: Ranking causes of undernutrition

In the context of the NCA in the Chars this translated into the following methodological details.

2.1. STEP 1 - Define objectives and describe the context.

Objectives of the survey (geographic coverage, age of children targeted, undernutrition types) have been discussed within ACF and with major partner of the survey (IPHN). The NCA project manager gathered secondary data on undernutrition at national and local level.

2.2. STEP 2 – Develop main hypothesis of causality

The objective is to reduce the scope of the study to the most important causes, based on existing knowledge. This process is iterative:

- *Extensive review of secondary data information* at national and regional levels
- *1 day Workshop* with main national stakeholders. This workshop was held on 9th of December 2010 and included experts from complementary fields of expertise (refer to annexe 4)
- *1 week field work from 19th to 24th of December 2010*. The analyst undertook detailed interviews with key informants (District Commissioner, RDRS, OVA, CLP, TMSS, Jivita, SKS, Hospitals, community clinics…). 4 FGD and detailed interviews with some members of communities (village leaders / women …) were realised.
- *Final review of hypothesis with technical expert of ACF*. The final hypotheses were re-discussed and validated.

After these different steps, we reached a consensus on the following main hypotheses of causes of malnutrition to be evaluated. There is no order of importance at this stage.

Hypothesis 1: ‘Limited household food production’

Hypothesis 2: ‘Poor access to food’

Hypothesis 3: ‘Unequal intra-household food distribution’

Hypothesis 4: ‘Poor diet diversity’

Hypothesis 5: ‘Breastfeeding practices’

Hypothesis 6: ‘Complementary feeding practices’

Hypothesis 7: ‘Low birth Weight (LBW)’

Hypothesis 8: ‘Poor psychological care’

Hypothesis 9: ‘Limited social services available’

Hypothesis 10: ‘Immunization coverage’

Hypotheses 11: ‘Poor health seeking behaviour’

Hypothesis 12: ‘Unhygienic cooking practices’

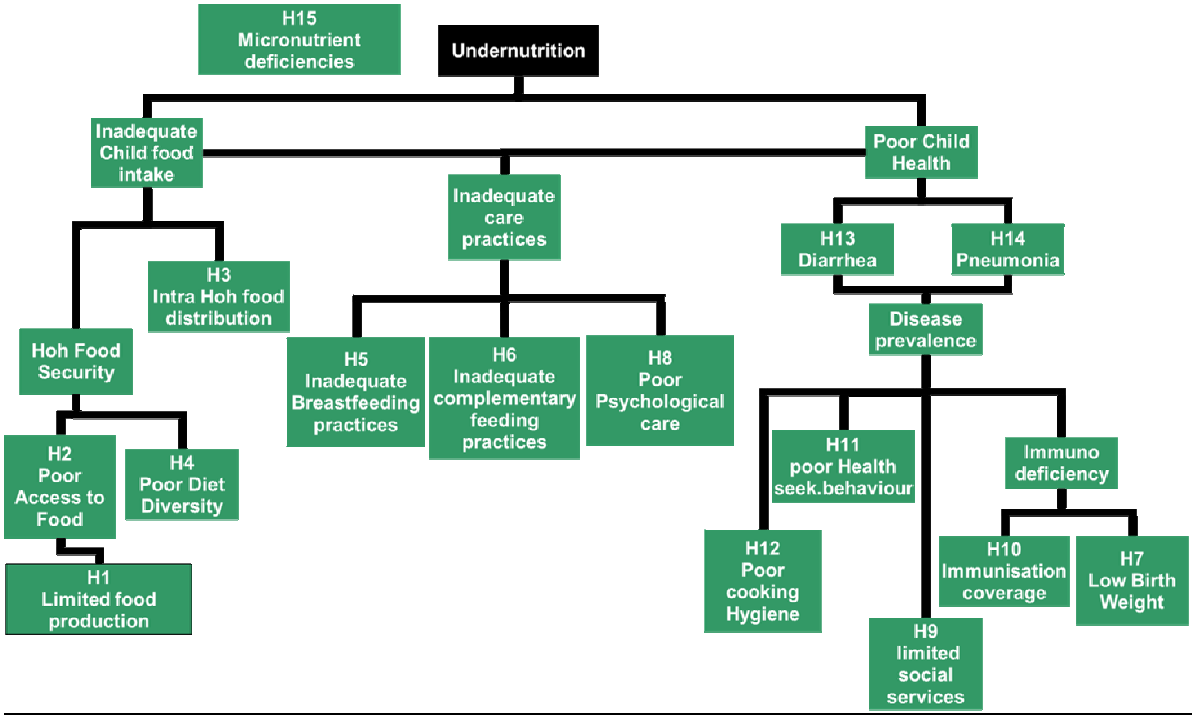
Hypothesis 13: ‘High prevalence of diarrhoea’

Hypothesis 14: ‘High prevalence of Pneumonia’

Hypothesis 15: ‘Micronutrient deficiencies’

Each hypothesis will be detailed in their respective section.

In the form of a causal pathway tree they can be presented as below:



2.3. STEP 3 – Conduct Field Survey

First, a review of existing information helps précising the hypothesis and main causes related. Once all causal factors are identified, we estimate those that can be effectively be measured through the cross sectional survey and those for which qualitative work is more adapted. Field data collection took place from 22/01 to 27/02/2011.

The cross sectional survey included a comprehensive questionnaire and observations as well as anthropometric measurements of one child aged from 6 to 59 months in the household (taken randomly if necessary). The Anthropometric measurements were conducted following SMART[4] methodology. This method ensures that each household/individual in the area will have the same chance to be chosen.
The qualitative data collection was done through Focus Group Discussions (FGD); observations, transect walks, key informants interviews (KI) and observation at household level.

a. Sample size and selection

The **cross sectional survey** used population census established by the Char Livelihood Programme to select randomly 390 households in 19 clusters (see annexe 6) using ENA software. Sample size was calculated using Magnani sampling guide (refer to annexe 5 for further details).
A household was included in the survey only if at least one child aged 6-59 months was present and only if the head of household agreed on the oral consent form that was clearly

[4] Standardized Monitoring and Assessment of Relief and Transitions

spelled out by the field teams. This study received the approbation of the IPHN and the ethical committee of TUFTS University (International Review Board).

In parallel, the **qualitative data collection** was done through:
- 51 Key informants' interviews
- 15 FGD involving around 150 persons.

b. Questionnaires and forms

Information collected in the **household questionnaire** was grouped in the following sections:

- Composition of the family
- Food security (status, crop production, HDDS, IDDS…)
- Household expenditure and assets
- Food utilization (cooking and storage…)
- Care practices including IYCF practices
- Water, sanitation and hygiene (sanitation practices, source of water…)
- Health status (main diseases, vaccination, health seeking behaviour…)

The questionnaire included a section based on **observations** during the interview on:

- Child hygiene
- Latrine hygiene
- Household hygiene
- Type of housing
- Mother and child relationship

Nutritional status was measured through: height, weight, age (using local calendar) and MUAC following SMART guidelines. Mortality rates were not estimated.

A complementary questionnaire, **at village level**, informed about the social services available in the area (government and non-governmental services on health care, nutrition, education…), distance to main market, and access to mainland…

The complete questionnaire can be found in annexe 1.

c. Training

A total of 9 people (a data entry officer, 4 team leaders and 4 surveyors) were recruited and trained during 10 days including theory and field practice especially on anthropometric measurements (following SMART guidelines). 4 teams were composed of one surveyor and one team leader. Management and training was handled by the analyst and deputy nutrition coordinator.

d. Data Entry and supervision

Anthropometric data collected were transferred to the ENA software delta version. This allowed checking of the work and its quality. A meeting was held every evening between the team and the supervisors to comment on results and making readjustments if/when necessary. Data entry on SPSS software was double checked for typing errors.

2.4. STEP 4 – Analysis of information collected

Data analysis is a process of combining statistical analysis of the cross sectional survey with the qualitative data collected through the observations and FGD. As a lot of information is collected, we used the quantitative analysis as a confirmatory analysis: hypothesis of associations are established by the qualitative analysis and is tested using the quantitative information available.

Main steps in data analysis:

- *Database Cleaning*: Exclusion of incomplete or inconsistent data from analysis.
- *Creating Variables*
- *Descriptive Analysis:* Including nutrition anthropometric usual measurements (wasting rates; by age groups; clusters; sex)
- *Classify variables into basic / underlying / immediate levels*
- *Regression Analysis (linear and logistic) by basic/underlying/immediate levels*: to test the relative importance of combined causal factors.
- *Cluster Analysis:* Identification and characterisation of groups at highest risk of malnutrition

Data analysis was implemented using SPSS software and the AMOS extension was used for path analysis. Malnutrition rates were assessed by entering the data in the software ENA (version May 2011).

2.5. STEP 5 – Ranking causes of undernutrition

This final exercise is using information from different sources to classify causes of undernutrition based of their relative importance in explaining undernutrition levels. The process is detailed in the result section 22.

2.6. Limits of the NCA methodology:

The NCA methodology used for this survey is gathering evidence from different sources of information in order to reach a consensus on main causes of undernutrition.
One could argue that the only reliable source of information would be to statistically demonstrate the association between undernutrition and causal factors. This would be satisfying but looking deeper into the UNICEF framework will acknowledge the limitations of a pure 'statistical' approach to detect some causal factors as:

- Some causes are very difficult or impossible to capture with a quantitative cross-sectional approach.
- Other factors might also be difficult to measure in some contexts. For example, we know from our analysis that answers to questions like "when do you wash your hands" will lead to biased answers as respondents will tend to answer "correctly" but not corresponding to the reality. This is true for every survey and needs to be taken into consideration during the analysis stage.
- The cross sectional survey of the NCA is a snapshot and conclusions are really only valid for the time / month the survey has been done.

Given the scope of an NCA study one has to acknowledge these limitations of a pure statistical approach. A good example of this limitation is given by the analysis of some Demographic and Health Surveys which are using large national samples of children across the country and well defined indicators. Typically, DHS are able to explain only 15 to 20% of undernutrition.

The NCA methodology is trying to overcome these issues by collecting context specific indicators and information from various sources to triangulate the analysis. Qualitative information gathered has its own limitation as it is based on existing knowledge (academics, experts, review, and community) and information available.
An NCA is not attempting to provide statistically exact relative importance of causes but rather to reach a consensus to classify causes between categories (major causes / important causes / low priority causes / un-tested causes/rejected causes) based on evidence gathered from multiple sources of information (quantitative AND qualitative).

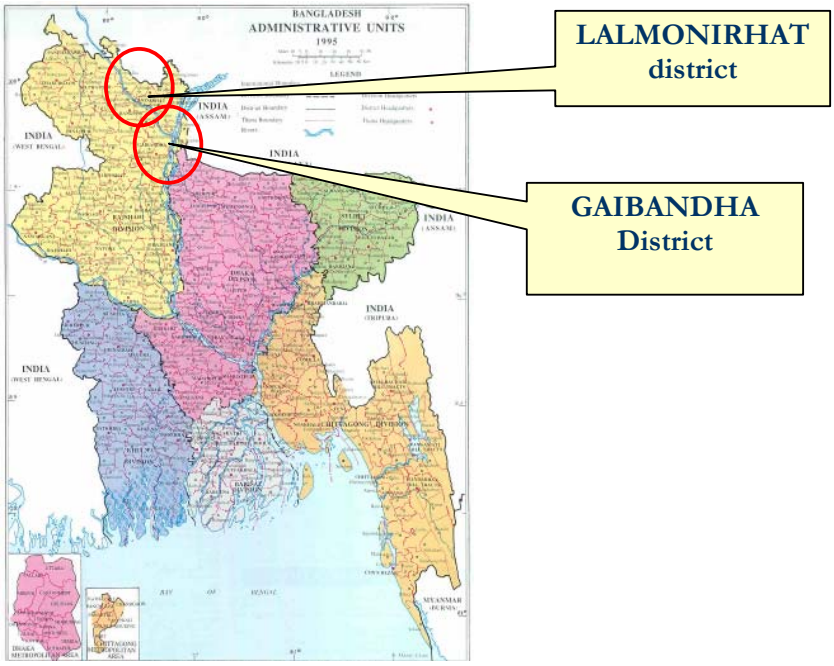
3. Description of households surveyed

3.1.Natural environment

The area studied can be divided into geographic groups (district, rivers, and types of char) and types of land accessible.

a. Geographic groups:

By district:
Gaibandha and Lalmonirhat are two districts of the northern area of Bangladesh and have typical chars area.

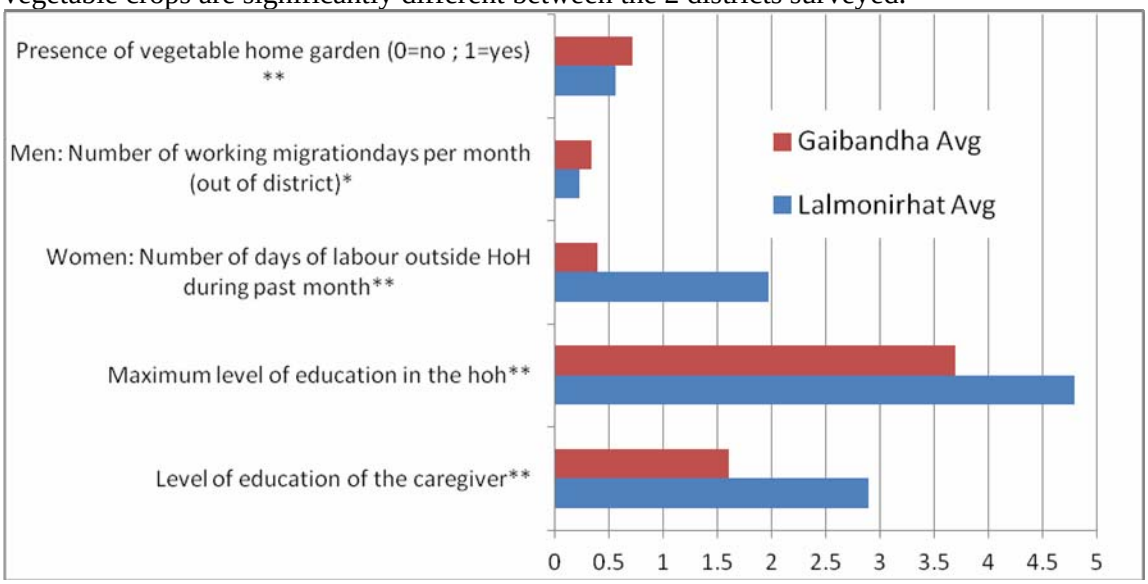


Gaibandha is more populated than in Lalmonirhat, so is our sample. Almost 65% of household in our sample are living in Gaibandha (251 Hoh / 390 in total).

There are some notable differences between the two districts in terms of livelihoods and habits (see table):

Gaibandha	Lalmonirhat
- More migration labour - women are more constrained in their houses and have limited opportunities to move - crops are more diverse - Lower education levels - Traditions and customs are more prevalent	- More job opportunities (highway to India; tobacco industry, agriculture labour…) - Women have more job opportunities especially tobacco activities: more labour constraints but better empowerment. - Crops are concentrated mainly on tobacco and maize. - Higher education levels. - Better market opportunities.

This is confirmed when looking at the results of the questionnaire where education levels (especially of caregiver), migration labour, women working outside households, and vegetable crops are significantly different between the 2 districts surveyed.



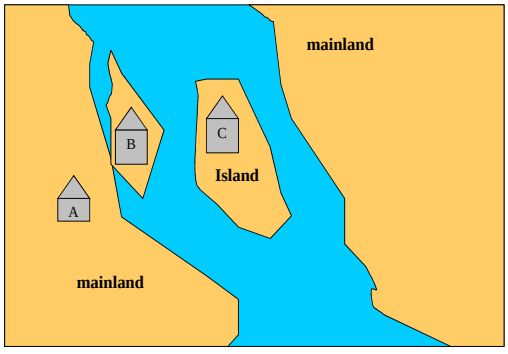
By rivers:

The chars visited are spread along 4 main rivers: Jamuna (31% of sample), Brahmapoutra (22% of sample), Tista (37%) and Dhola River (10%).

Tista and Dhola rivers (mainly lalmonirhat district)	Jamuna and Brahmapoutra rivers (mainly gaibandha district)
- Less soil erosion - Water not very deep - Recurrent issue of flash floods that can have devastating effects on households. - Lower population density - According to CLP surveys: 10 to 15% of population of chars from these rivers are classified as “hard core poor”.	- Intense soil erosion - Deep waters - Natural and controlled floods last longer and are more massive. - Higher population density - More migration labour due to less job opportunities. - According to CLP surveys: 20 to 25% of population of chars from these rivers are classified as “hard core poor”.

By type of chars:

Chars are defined as areas affected by river erosion and silt deposition. Following the classification of the CLP (Chars Livelihood Programme), we distinguish 2 main types of chars:



Island Chars (like village C) are islands where you need the boat to reach the mainland **in any season** (47% of our sample). They are more associated with isolation, lack of access to services, domestic violence, costly transports, limited women empowerment, more early marriage, limited use of vegetable gardens, low soil fertility, difficulties to sell their product at reasonable price. An important aspect of

services is education: levels of education are often more limited in island chars due to limited and costly access to high schools.

Connected chars are villages bordering rivers but on the side of the mainland (like village A in next drawing) or are villages in island chars but that are connected to mainland through bridge or small path (like village B). They constitute 53% of our sample and have more access to services but also to job opportunities and transport facilities.
It is worth noting however that during flooding season, access for island chars is mentioned as much easier than during dry season: with boat they can have access directly to markets from the doorstep of their houses while during the dry season they might have to walk long distances in sandy soils.

Geographic Groups:
Compiling these different geographic borders, we have classified households in 5 groups:

Geographic groups	District	River	Char
Group 1: 100 hoh (26%)	Lalmonirhat	Dhola or Tista	Connected
Group 2: 39 hoh (10%)	Lalmonirhat	Dhola or Tista	Island
Group 3: 44 hoh (11%)	Gaibandha	Tista	Connected
Group 4: 144 hoh (37%)	Gaibandha	Jamuna/Bramahpoutro	Island
Group 5: 63 hoh (16%)	Gaibandha	Jamuna/Bramahpoutro	Connected

Groups 2 and 3 have too few hoh to be able to characterise them.

b. Different types of land:

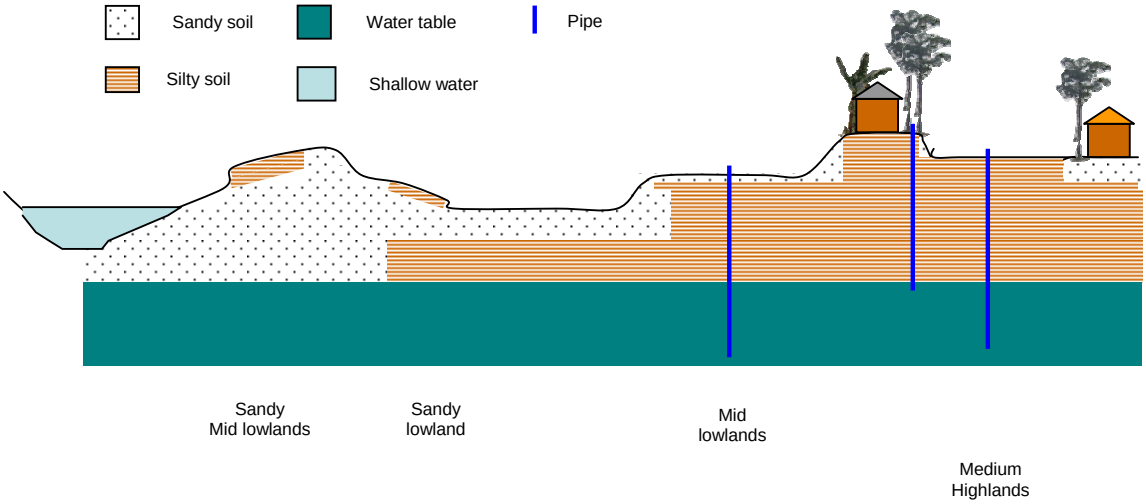
Another important aspect is the "altitude" level of their farm land. It is critical everywhere in Bangladesh and particularly in the chars area.
The altitude levels of land determine the time it remains flooded; the types of crop that can be cultivated and often the soil quality.
As shown in the following simple transect schemes of chars villages in flooded and non-flooded seasons, farm lands are classified in 3 groups:

- **Sandy lowlands**: flooded, 3 to 4 months a year where mainly only Jute can be cultivated (from April to August) and sometimes some vegetables are cultivated from November to February (onions, maize, chilis, daal..). In some chars these lands can be quite extensive and ownership is not very strict. Vegetables grown have often low yields and it is a bit a desperate type of farming when no irrigation is practiced (rare).
- **Medium Lowlands** are also flooded a good part of the year. Depending on their situation / char they can be very sandy or silty. With irrigation, agricultural activities can be diversified. Maize and other vegetables are commonly cultivated. Rice is also an option, depending on soil quality and irrigation available.
- **Medium Highlands** are usually the richest lands available in the chars. When irrigated 2 or 3 harvests can be done in a year. Rice can be cultivated.

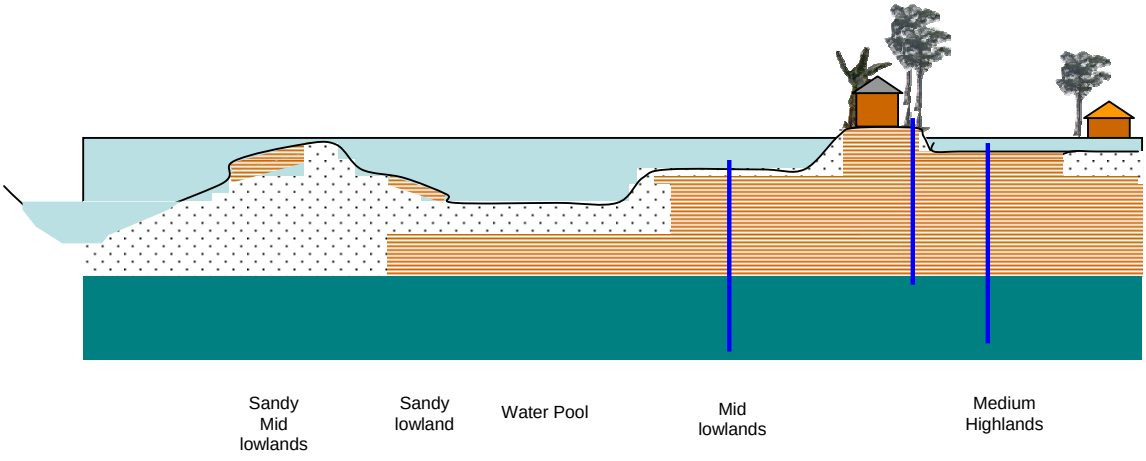
Cropping systems are detailed for each type of land in annexe 3. The type of land cultivated is important for farmers as better soil increase the number of possibilities for the farmers and allow farmers to grow rice or not. Irrigation is also critical to have more than one harvest per year. With poor soil irrigation costs are higher. It is often easy to install an irrigation pump.

The issues are related to the costs of installation and the floods. Irrigation system can be rented.
Floods are also affecting a lot daily life in terms of latrines flooded and destroyed every year as well as water pumps that can be flooded as well. In our survey, we will not be able to identify the type of land cultivated by each household but we know if the house is flooded every year or not.

Winter season:



Flooding season:



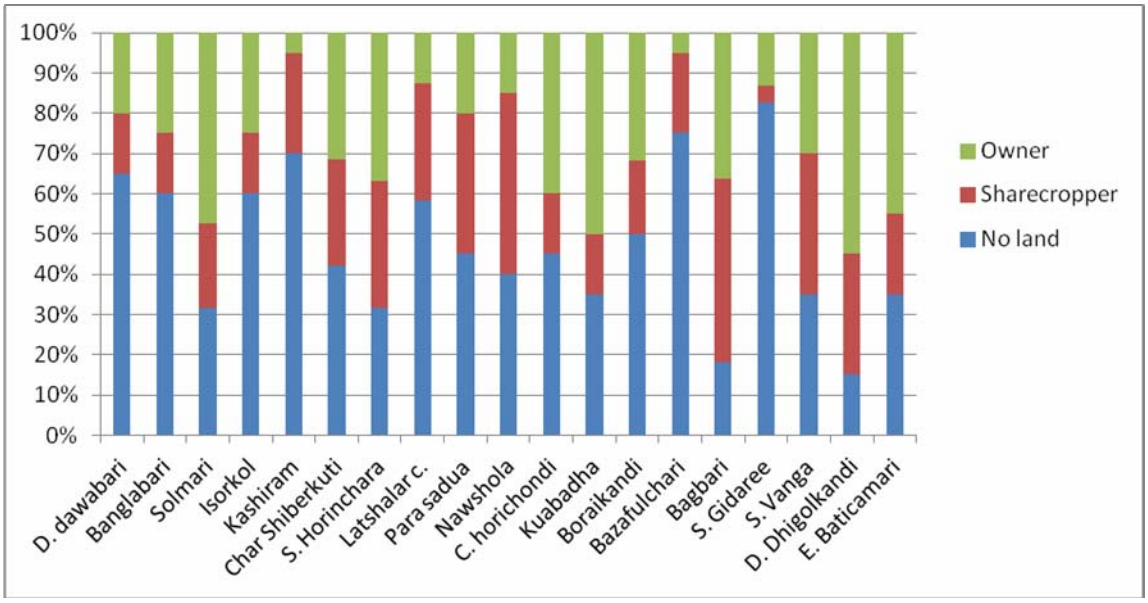
3.2. Economic and social groups

Land access is the priority issue for people living in the char. Land ownership determines economic and social groups.

Land ownership:
It is very complex in the chars as river erosion creates and destroys land. The life expectancy of an island char is around 30 to 40 years so households are used to move from one land to another. What is changing is that finding a new land becomes increasingly difficult. Families

at the border of the rivers are often blocked in their houses, waiting for the river to eat their land day after day, forcing them to pack in a rush and roam for another piece of land.

Land 'owners (28% of our sample):
Chars have very specific land regulations and are managed by public authorities who give the right of access to the land for a given period of time. So there is no properly saying land ownership but large families with political influence have better access to land and have almost a secure access. Land ownership, social and political influence and history of the family are very interlinked. These relationships have been described elsewhere and are not the focus of the present study. One should however keep in mind that land owners usually have significant social influence. They are also able to decide the type of crops to be cultivated in their land. Psychologically it is also a critical asset: in this area where natural environment is constantly evolving, being owner of land provides security and stability.
In the sample of this survey, 28% of respondents are owner of at least a part of their land. This figure can vary significantly from one village to another as shown in the following graph.



Households with no land access can represent from 15% of the total village population in D.Dhigolkandi up to 83% in S.Gidaree. Local history of each village can partly explain these figures. For example, in one village, most of its inhabitants were resettled after their land disappeared: they all came along one roadside and have no official access to land.
In another village, few families came at the beginning of the creation of one char and had access to large pieces of land. They kept sharing the land among relatives.

Another important distinction in land access is the ownership of the land for the homestead. In our sample 56% where owner of homestead land; 32% were renting it to private owners and 11% where settled on government's land (specific resettlement programme or illegally on the roadside). Homestead land ownership is more common in connected chars.

Sharecroppers (24% of our sample):
They are cultivating someone else's land, usually on a yearly basis. Relationship with the land owner is vital. Land owner choose the farmer based on their techniques, their connections,

and their ability to work hard for the land. Sharecroppers have social connections but these are precarious.

No land (47% of the sample):
They have no access to land for cultivation and depend on economic activities. Main economic activities are farming labour during intensive agriculture season in the district or outside the district. Small economic activities include trading, rickshaw puller, government employee…
This group spend significantly ($p<0.001$**) much more time on migration economic activities outside the district: 13 days in last month on average as compared to 4.6 days for land owners.

Based on this description, we can identify 4 main economic groups in our sample (representing 75% of the households surveyed):

Economic groups	Name	Main activities
Group 1: 70 hoh (18%)	Other economic activity group	No farm land with other economic activity
Group 2: 100 hoh (26%)	Farming labour group	No farm land and depending on farming daily labour
Group 3: 86 hoh (22%)	Small farmers group	They cultivate 50 to 250 decimals[5] with no other activity except farming labour
Group 4: 65 hoh (17%)	Marginal farmers group	They cultivate 5 to 49 decimals with no other economic activity except farming labour

4. Nutrition Results

Important note:

This is not a nutrition survey; rates are indicated as descriptive information but cannot be interpreted as nutritional prevalence as methodology and sample is different from a standard nutrition survey:
Sample size was not calculated based on SMART methodology.
One random child (6-59 months) per hoh was measured whereas in SMART survey, all the children in one hoh are measured.

The anthropometric results are based on **WHO growth standards 2006** and using ENA software.
4 children were excluded from the analysis for being out of plausible range (SMART flag).

Sample description based on sex and age of children:

[5] One decimal is the official land unit in Bangladesh and is equivalent to 0.01 acre.

	Boys		Girls		Total		Ratio
	no.	%	no.	%	no.	%	Boy:girl
6-17 months	42	50,6	41	49,4	83	21,4	1,0
18-29 months	49	57,0	37	43,0	86	22,2	1,3
30-41 months	67	53,2	59	46,8	126	32,5	1,1
42-53 months	37	53,6	32	46,4	69	17,8	1,2
54-59 months	12	50,0	12	50,0	24	6,2	1,0
Total	207	53,4	181	46,6	388	100,0	1,1

Sex Ration M/F = 1.14

a. Acute malnutrition

Acute undernutrition based on Weight for height z-scores by sex. Chars area of Bangladesh, February 2011.

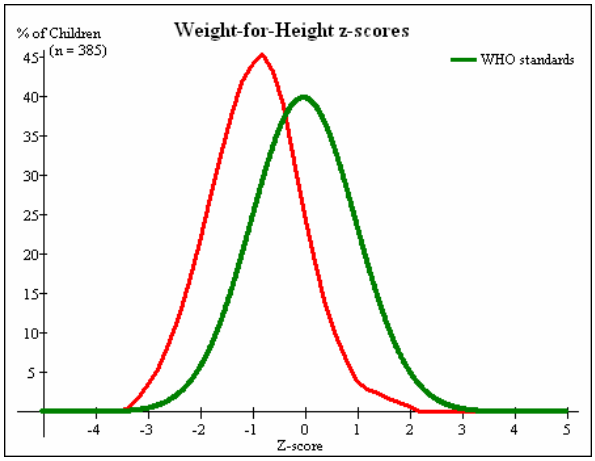
	All n = 385	**Boys n = 205**	**Girls n = 180**
Prevalence of global malnutrition (<-2 z-score and/or oedema)	(41) **10,6 %** (6,5 - 14,8 95% C.I.)	(22) **10,7 %** (5,9 - 15,6 95% C.I.)	(19) **10,6 %** (4,6 - 16,5 95% C.I.)
Prevalence of moderate malnutrition (<-2 z-score and >=-3 z-score, no oedema)	(40) **10,4 %** (6,1 - 14,6 95% C.I.)	(22) **10,7 %** (5,9 - 15,6 95% C.I.)	(18) **10,0 %** (3,9 - 16,1 95% C.I.)
Prevalence of severe malnutrition (<-3 z-score and/or oedema)	(1) **0,3 %** (0 - 0,8 95% C.I.)	(0) **0,0 %** (0,0 - 0,0 95% C.I.)	(1) **0,6 %** (-0,6 - 1,7 95% C.I.)

Prevalence of oedema : 0,0% (n=0)
mean ± SD of WHZ : -0,91±0,87
Design effect of WHZ < -2 : 1,79

The design effect is a bit high (1,79 while the ideal is 1) but remains below 2 which is acceptable.

Acute undernutrition based on Weight for height z-scores by age. Chars area of Bangladesh, February 2011.

		Severe wasting (<-3 z-score)		**Moderate wasting (>= -3 and <-2 z-score)**		**Normal (> = -2 z score)**		**Oedema**	
Age (mths)	Total no.	No.	%	No.	%	No.	%	No.	%
6-17	82	0	0,0	8	9,8	74	90,2	0	0,0
18-29	84	1	1,2	12	14,3	71	84,5	0	0,0
30-41	126	0	0,0	11	8,7	115	91,3	0	0,0
42-53	69	0	0,0	4	5,8	65	94,2	0	0,0
54-59	24	0	0,0	5	20,8	19	79,2	0	0,0
Total	385	1	0,3	40	10,4	344	89,4	0	0,0



"Distribution of Weight for Height indexes in Z-score", Chars area of Bangladesh (feb 2011). WHO standards.

Skewness of WHZ: 0,175 => **probably not skewed** (value < 2*(6/n)½)
(Skewness characterizes the degree of asymmetry around the mean, positive skewness indicates a long right tail, negative skewness a long left tail)
Kurtosis of WHZ: 0,101 => **probably no kurtosis problem** (value < 2*(24/n)½)

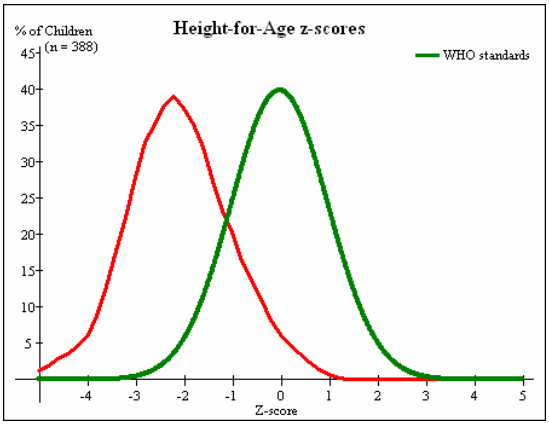
The curve is showing a normal distribution: the complete population situation is affected. Malnourished children are more malnourished as compared to WHO standards. Also, there are les well-nourished children.

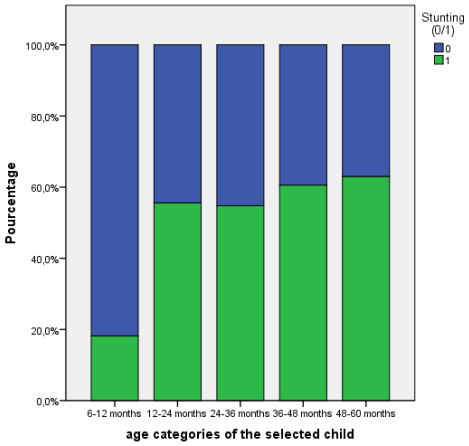
b. Chronic malnutrition

Chronic undernutrition based on Height for Age z-scores by sex. Chars area of Bangladesh, February 2011.

	All n = 388	**Boys n = 207**	**Girls n = 181**
Prevalence of stunting (<-2 z-score)	(212) **54,6%** (49,3-60,0 C.I.)	(112) **54,1%** (46,7-61,5 C.I.)	**55,2%** (47,6-62,9 C.I.)
Prevalence of moderate stunting (<-2 z-score and >=-3 z-score)	(140) 36,1% (31,8-40,3 C.I.)	(79) 38,2% (31,8-44,5 C.I.)	(61) 33,7% (26,6-40,8 C.I.)
Prevalence of severe stunting (<-3 z-score)	(72) 18,6% (15,3-21,8 C.I.)	(33) 15,9% (10,7-21,2 C.I.)	(39) 21.5% (16,1-27,0 C.I.)

mean ± SD of HAZ : -2,09±1,03
Design effect of HAZ < -2 : 1,10
C.I. => 95% Confidence Interval assuming cluster sampling





As expected, stunting is higher for children aged more than 24 months.

c. Results for MUAC

Using MUAC cut off of 115mm for severe acute malnutrition and of 125mm for moderate acute malnutrition, we obtain the following prevalence:

	Based on MUAC **n = 388**	Based on WHZ **N=385**
Prevalence of global malnutrition	(21) **5.4%**	(41) **10,6 %** (6,5 - 14,8 95% C.I.)
Prevalence of moderate malnutrition	(21) **5.4%**	(40) **10,4 %** (6,1 - 14,6 95% C.I.)
Prevalence of severe malnutrition	(0) **0%**	(1) **0,3 %** (0 - 0,8 95% C.I.)

As expected, children identified by MUAC as malnourished are mainly found at younger age:

Age categories of child			N	Valid %
6 to 23 months	Valid	MUAC>= 125mm	97	85.1%
		MUAC<125mm	17	14.9%
		Total	114	100.0%
	Missing value		1	
	Total		115	
24 to 59 months	Valid	MUAC>= 125mm	268	98.5%
		MUAC<125mm	4	1.5%
		Total	272	100.0%
	Missing value		1	
	Total		273	

17 of the 21 children identified by a MUAC<125mm are younger than 24months.

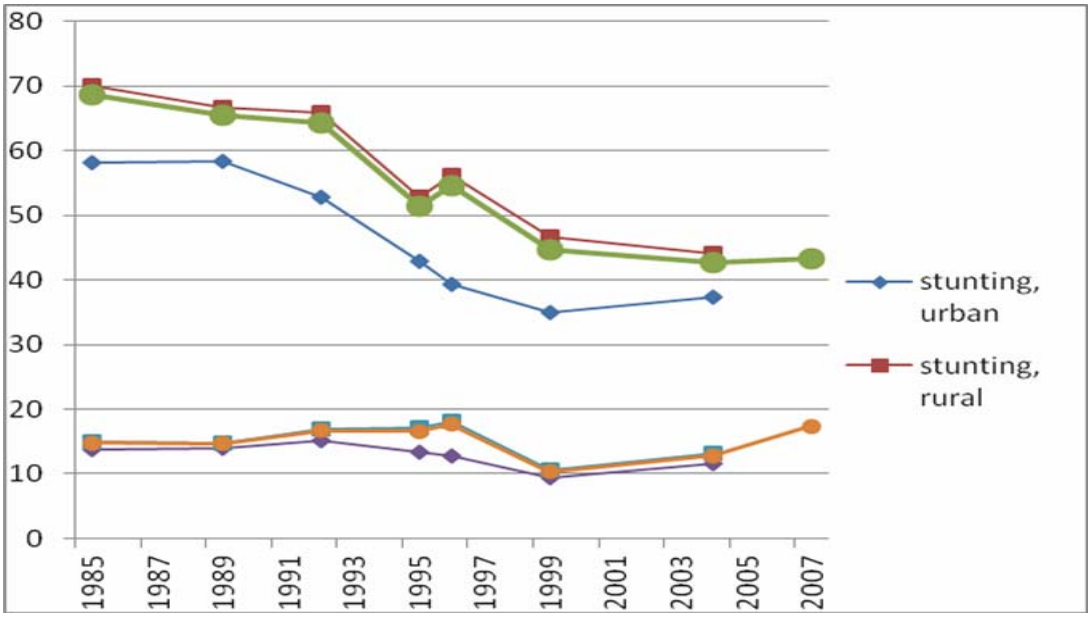
d. Categories of children by type of undernutrition

It is interesting to look at the different categories of children based on the different types of undernutrition as depicted in the table below:

Stunted (<-2HAZ)	Wasted (<-2 WHZ)	Underweight (<-2WAZ)	N	%
No	No	No	152	39,0
No	Yes	No	14	3,6
Yes	No	No	69	17,7
Yes	No	Yes	114	29,2
Yes	Yes	Yes	29	7,4
54,3%	11,0%	39,7%	390	100,0

Of the 11% of children identified as wasted by WHZ, 7.4% are also stunted.

e. Historical trends of undernutrition



Historical trends of undernutrition in Bangladesh.
Sources: BDHS 2004 and 2007 and "Levels and Trends in Child Malnutrition in Bangladesh". Sumonkanti Das, Md. Zakir Hossain and Mossamet Kamrun Nesa.

Wasting has different trends at national level over different periods:
From 85 to 96, rates remain stable and even increase in 95-96.

From 96 to 2000, rates declined sharply (-8%)

From 2000 to 2007, rates are increasing again to reach even higher levels as compared to 1985.

During that period, wasting remained consistently at levels above 10%.

The national trend is quite different for stunting where a rapid and steady decline is observed from 85 to 2007 although it seems to remain more stable over the last years.

5. Hypothesis 1: 'limited hoh food production'

Farming practices are very specific to the chars area to adapt to the natural environment. Crop production levels depend mainly on access to land, soil quality, vulnerability to soil erosion and agricultural technics (choice of seeds, irrigation, and fertilisation).

From left to right: 1)groundnut crop in sandy lowland soil 2)irrigated potatoes in medium lowlands 3) irrigated rice in medium highlands.

Access to land:

Please refer to section 3.2 on social groups for description of types of land access.

The status of land ownership is critical for farming practice and decision making process. Owners of land decide the type of crops to be cultivated. Their strategy is, once their staple food needs are fulfilled, to get the best economic outcomes from their farmlands. Sharecroppers are then often cultivating only cash crops (tobacco, maize) which are demanding in terms of fertilisers and water irrigation and therefore cash. They share usually 50/50 of the harvest and the costs but every type of arrangements are possible and are often precarious for sharecroppers. Sharecroppers have to maintain good social connections with the owner. Sharecroppers sale cash crops and purchase staple crops, often in small quantities, spending a lot of time back and forth to commercial markets. They need to access medium size markets to find middle men to purchase their production.

Land inequalities:

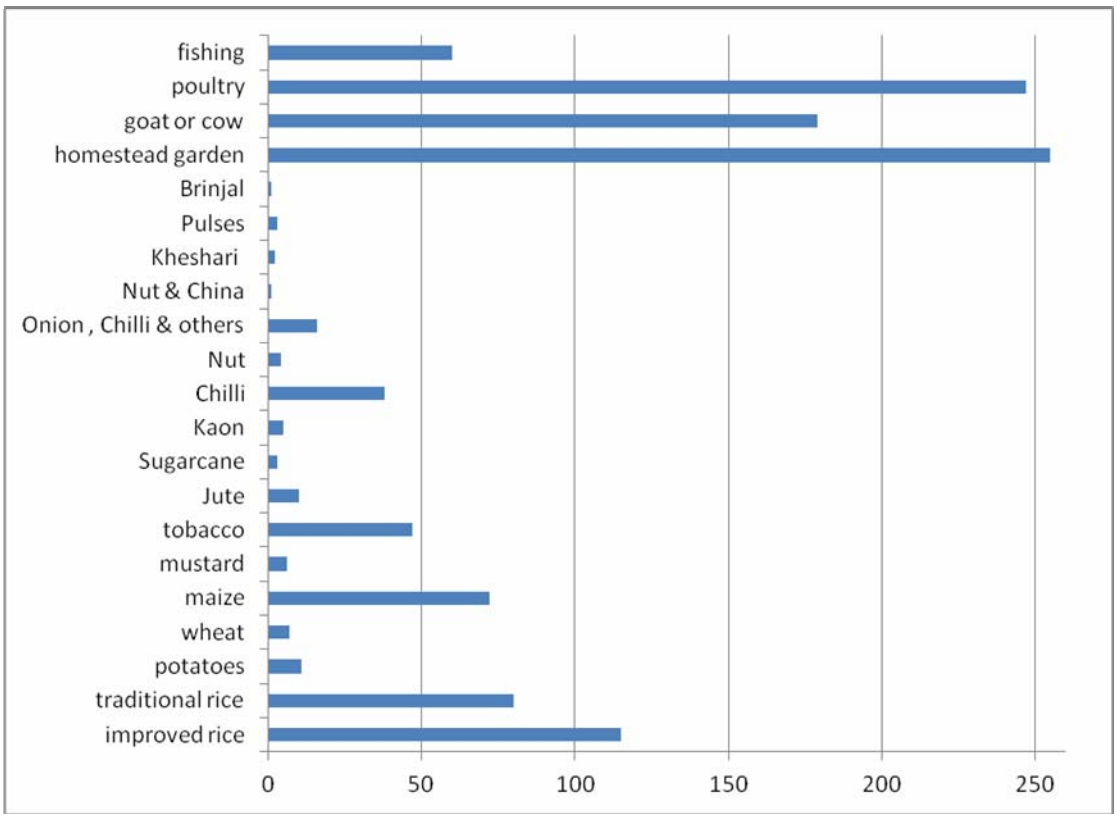
Refer to section 3.2.

Soil quality/ river erosion and flooding:

Please refer to section 3.1 for a description of the different types of land cultivated.

Soil quality is poor to very poor in the chars and is one of the major determinant for the type of crops to be cultivated (refer to annexe 3 for a description of main cropping systems). Level of sand content in the soil decreases soil fertility and soil capacity to retain water. Sandy soil can accommodate only special crops and need more irrigation. The sand content depends on the river flow: in some areas, sediments are accumulating, increasing soil fertility. In other places river erosion is grabbing arable land pieces by pieces. The number of cropping seasons and the type of crops are good indicators of the soil quality of arable land. In flooded lands, jute is the only adapted crop. In our sample, only 7% of rice farmers were able to have 2 harvests in past year.

Nb of respondent cultivating or raising the following productions:



Agricultural technics:

The natural environment of the chars is a challenge for productive farming. Farmers can however improve yields through selection of seeds, appropriate use of fertilisers and proper irrigation.

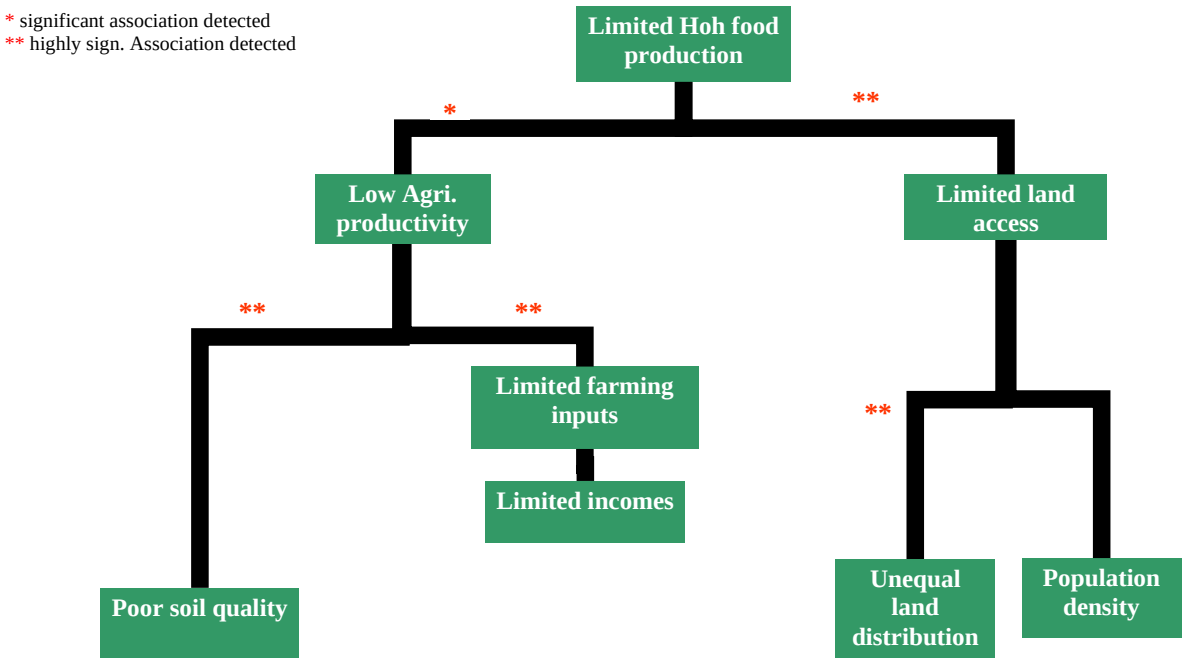
A quite large variety of seeds and fertilisers are available on local markets and improved rice varieties are largely cultivated.

Irrigation is critical for improving productivity. Water and water pumps are usually available. Water pumps for irrigation cost between 25 000 and 30 000 Tk and can be rented by farmers. Poor soils do not retain water and need therefore more irrigation and are more costly.

Farming technics are usually very similar from one farmer to another. Dosage of fertiliser is usually known by farmers who exchange a lot of information. A weak aspect is the appropriate timing of fertilisation and irrigation during the crop cycle that is not always optimal.

These technics are accessible for farmers with a capacity to have cash at appropriate time of the year. Fertiliser, seeds, irrigation (fuel) are widely accessible and are mainly constrained by incomes even if fertiliser are sponsored by public sector. Micro credit organisations are playing an important role for this purpose.

5.1.Hypothesis pathway



Association of causal factors and undernutrition levels:

Causal factor	Relation with Wasting P value	Relation with Stunting P value	Relation with Hoh food production P value
Rice production	NS	NS	
Rice productivity	NS	NS	0.045*
Nb of crops/year	NS	NS	P<0.001**
Size of land	NS	NS	P<0.001**
Unequal land distribution	NS	NS	P<0.001**
Land ownership	0.027* Land owners have less wasting compared to all other groups	0.008** Land owners have less stunting compared to all other groups	P<0.001**

NS= Not significant association. * significant association with probability <5% ** significant association with probability <1%

NB: As associations with undernutrition need to be analysed taking into account all factors, please refer to the regression analysis and ranking section.

6. Hypothesis 2: 'poor access to food'

Access to food is mainly constrained by: household food production; purchasing power and distance to markets.

Household food production

Please refer to hypothesis 1.

Level of incomes

Levels of incomes are a major issue and are impacting many pathways. The main economic activity is by far agriculture production. Seasonal peak of agriculture activity increases the demand for labour at certain times of the year. Farmers don't hesitate to migrate out of their district for farming labour as in other regions, agricultural season can vary (see seasonal calendar in section 21). Wages are low in the region compared to others, leading to high seasonal migrations. Other economic opportunities are available in town in the district or elsewhere. Many people met during the survey had migrated to Dhaka for a temporal job. In this survey, on average, men worked 10 days in the past month in the same district (only 43% never worked as daily labour in the past month). 50% of men migrated for labour outside the district for on average 71 days in the past year. There are big variations among households. Men staying in island chars are more migrating on average ($p=0.017$*) especially when they have limited access to land.

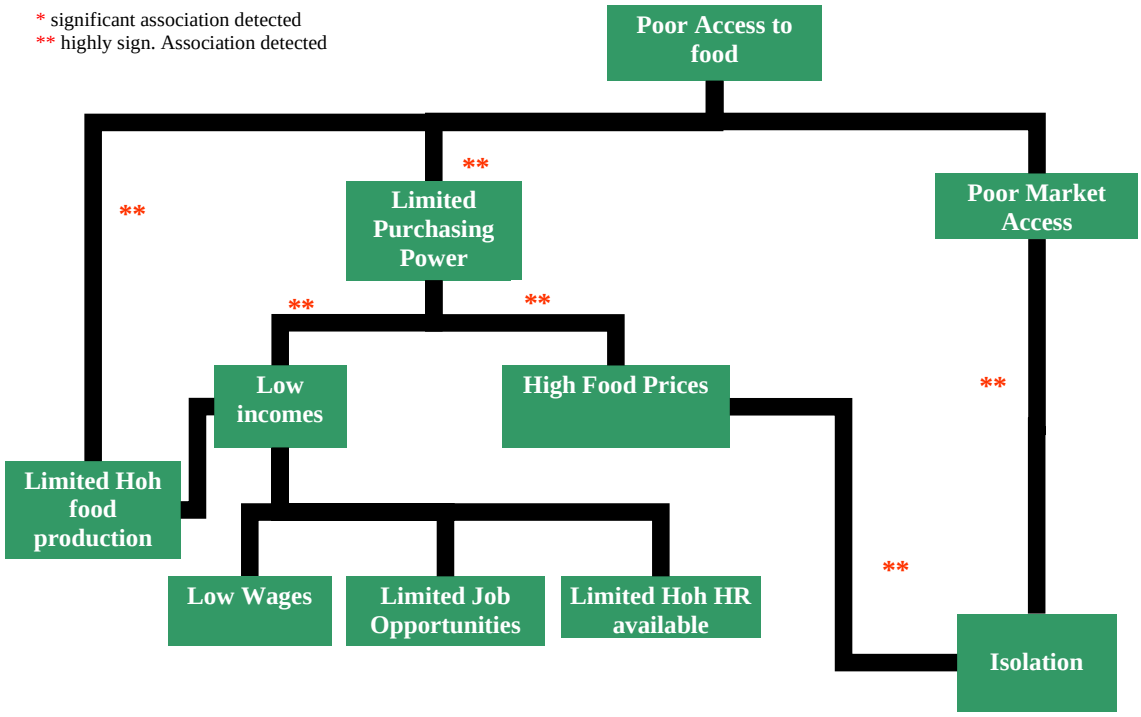
Women can also work outside the household especially when working for tobacco companies in Lalmonirhat ($p=0.005$**) or when the hoh has no access to land ($p<0.001$**). Only 24 women out of 390 hoh met had worked outside the household in the past month and most of them where met in Lalmonirhat.

Access to markets and food prices

Food prices are quite high especially nutritious food items. Local markets in island chars exist but are poorly supplied and items are much more expensive than on the mainland. Nevertheless, the household head has no choice but going to the market to sell few items in order to purchase staple food. Time and money necessary is a constraint for farmers (please refer to hyp 9). Food is available in the markets.

Distance to main markets has been estimated, village by village. Access to food is estimated by the household diet diversity score, listing the categories of food eaten by the household on a 24h recall.

6.1.Hypothesis pathway



Association of causal factors and undernutrition levels:

Causal factor	Relation with Wasting P value	Relation with Stunting P value	Relation with HDDS P value
Households food access (HDDS)	NS	NS	
Levels of incomes	NS	NS	P=0.001**
Livelihood Groups	NS	NS	P=0.001**
Size of land	NS	NS	P=0.001**
Distance to markets	NS	NS	NS
Food prices	NS	NS	NS
Men Daily labour (d/month)	NS	NS	P=0.017* Higher the migration, lower the HDDS
Women daily labour	NS	NS	NS

*NS= Not significant association. * significant association with probability <5% ** significant association with probability <1%*

NB: As associations with undernutrition need to be analysed taking into account all factors, please refer to the regression analysis and ranking section.

7. Hypothesis 3: 'Unequal intra-household food distribution'

There is a tradition in Bangladesh to favour boys compared to girls. In this survey it was tried to look if the sex of the child is a determinant of access to nutritious food and undernutrition. Also, men are often prioritised during the meal and it was explored if it was not at the expense of child access to food.

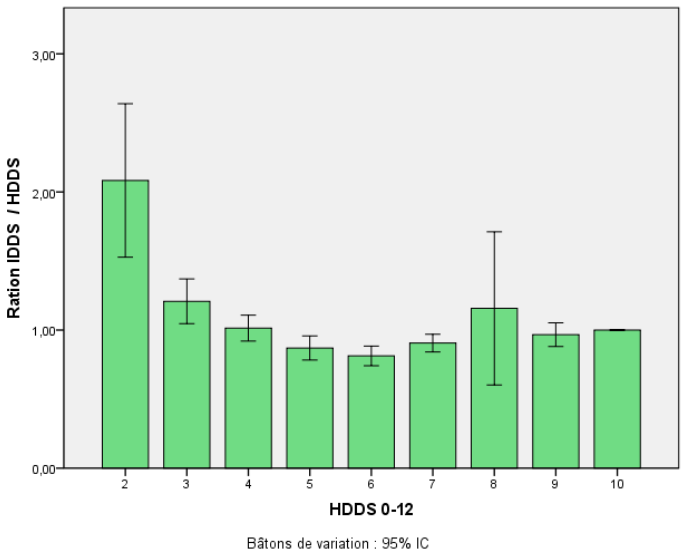
Favouring boys compared to girls:

When taking children more than 24 months (not breastfeeding), the IDDS for girls is significantly lower than for boys (p=0.039*) although the difference is not very big (IDDS is about 10% less for girls than for boys). This difference is not significant if looked only at children from Lalmonirhat.

Also, access to health care can be different for boys and girls as it implies men decision making on expenses. See hypothesis 18 for further insights on differences in terms of health care. Nevertheless, there is no significant difference of undernutrition and IDDS for boys and girls in our sample.

This tradition of favouring boys is still practiced but all respondents to our interviews mentioned that this is a practice which is changing year after year. Girls are continuously more and more educated and are often more successful than boys but are too often quickly removed from school for economic reasons (access to school costly in transport, jobs opportunities).

Favouring adult compared to children:

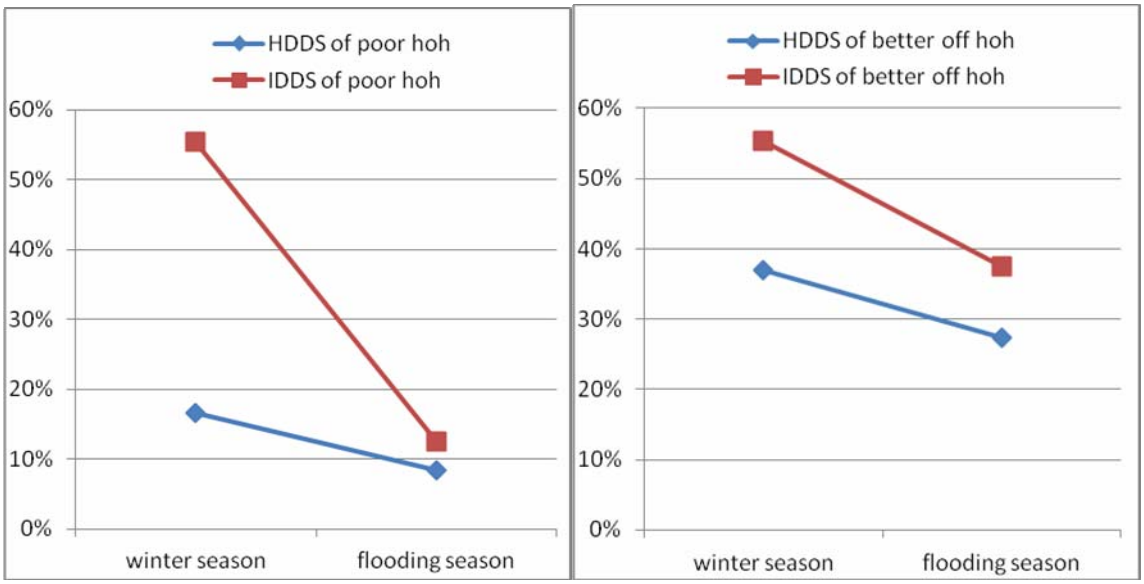


In our interviews we have understood that males are prioritised for food in the households. We estimated the intra household food distribution by the ratio between the Individual Diet Diversity score (IDDS) of the child and the Household Diet Diversity Score HDDS (quintiles) as indicated in the graph on the left.

A ratio IDDS/HDDS > 1 is an indication that the diet of the child is more diverse than the diet of the household. It is an indication that the child is favoured in terms of food access within the household. Looking at results from our survey, we can see (graph above) that poor households (with a low diet diversity score) tend to prioritise the diet diversity of the child (high ration IDDS/HDDS). Even in poor households, we can therefore have a child with an appropriate diet and potentially an appropriate growth. This is a coping mechanism for poor households. It can have very negative impact on the diet diversity of adults; especially women (refer to hypothesis 7). This is more significantly occurring when women have higher education levels.

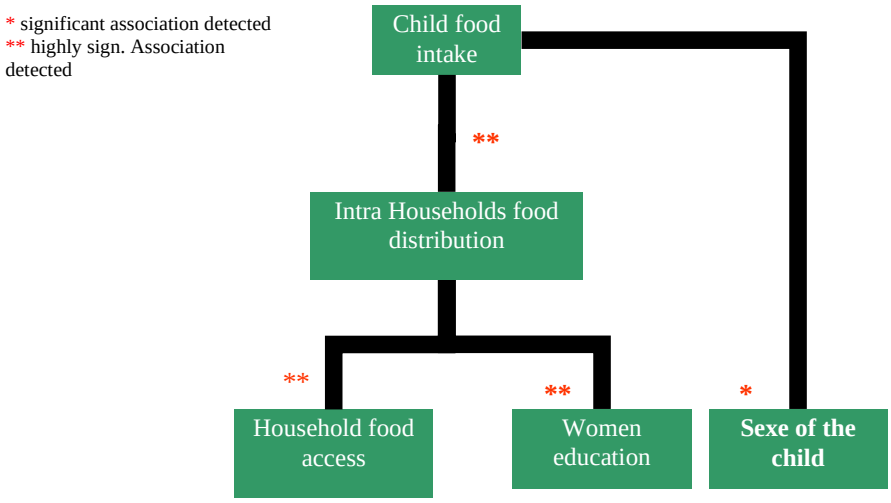
Looking specifically at child without any breastfeeding and HDDS <4 (N=38), IDDS scores are extremely linked to ration IDDS/HDDS (R of Pearson 0.728**). The ratio IDDS/HDDS is then interestingly significantly related to wasting (R of Pearson: 0.349*).

Result of a focus group discussion exercise is also very informative. We spitted households based on their level of incomes and asked IDDS and HDDS from one season to another:



We can see that poor households during the better off season of winter have a low HDDS but a quite high IDDS: they prioritise their children for food sharing. But this strategy is not enough during the flooding season where all the members of the family, even the children, have a very low access to food.
For better off households, we can see that they also prioritise children and that HDDS and IDDS are reduced during the flooding season but not as much as for poor households.

7.1.Hypothesis pathway



Association of causal factors and undernutrition levels:

Causal factor	Relation with Wasting P value	Relation with Stunting P value	Relation with IDDS
Ratio IDDS/HDDS	NS	NS	P<0.001**
Sex of the child	NS	NS	P=0.039*

NS= Not significant association. * Significant association with probability <5% ** significant association with probability <1%

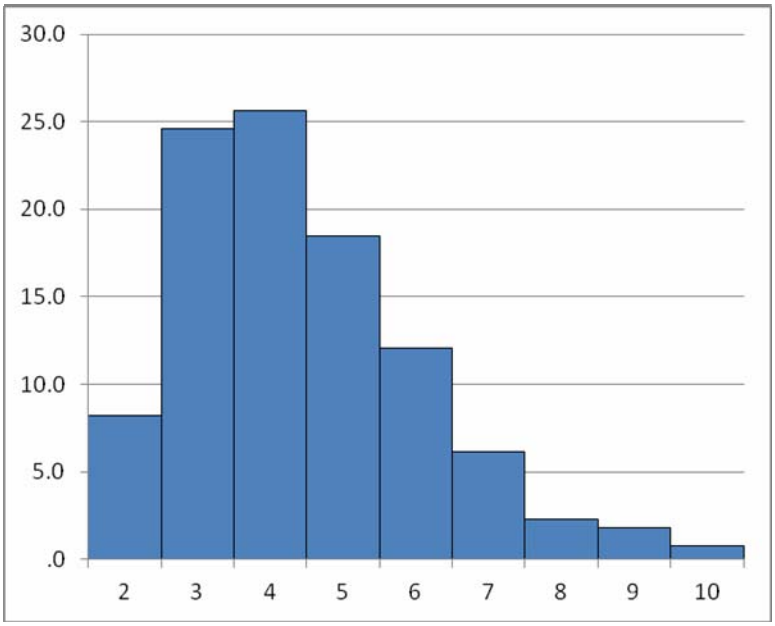
NB: As associations with undernutrition need to be analysed taking into account all factors, please refer to the regression analysis and ranking section.

8. Hypothesis 4: 'poor diet diversity'

70% of the diet diversity of children can be explained by the diet diversity at household level, the intra-household food distribution and the education level of mothers (linear regression model, p<0.05*).

Household Diet Diversity:

The average HDDS in the sample is 4.43 (on a scale of 12) which is quite low.



Histogram of HDDS scores (0 to 12) by % of respondents

Families are eating very basic food based on rice and some vegetables. Milk and eggs can be consumed especially if produced at hoh level but meat is very rarely taken. Fishing has been very intense and fish is becoming a rare resource, with a good price on the market and therefore often sold rather than consumed. Vegetables can be produced at household level (homestead garden) and their production is increasing in the chars due to influence of NGOs and government programmes.
When identifying sub groups we see that 8% of hoh have a HDDS below 3; 50% a HDDS of 3 or 4 and only 42% of hoh with a HDDS more than 5. Cooking in oil, eggs, fish, milk, pulses, fruits are only found for higher categories of hoh:

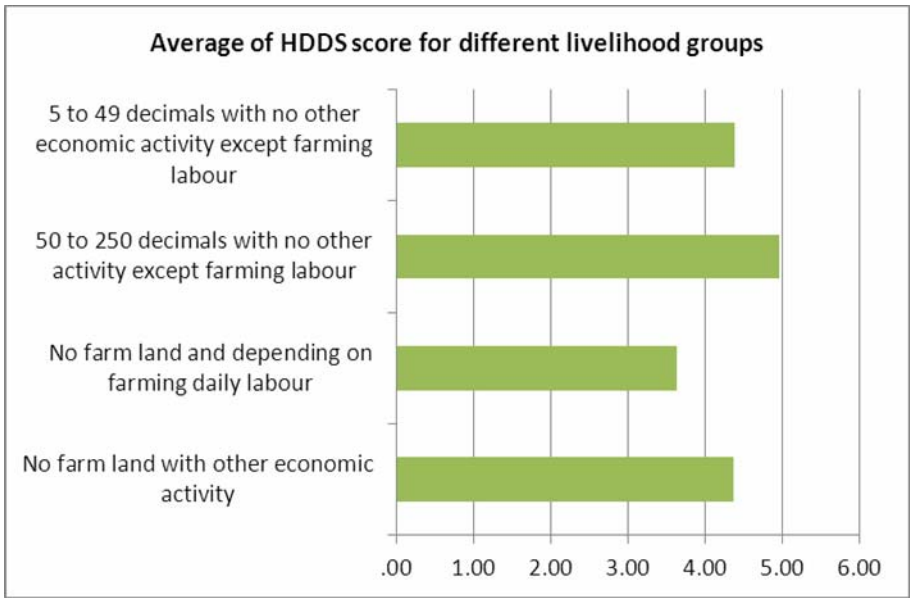
HDDS profiles:

Group 1: HDDS<3	Group 2: HDDS 3-4	Group 3: HDDS = 5-6	Group 4: HDDS >6
32 Hoh (8%)	196 Hoh (50%)	119 Hoh (31%)	43 Hoh (11%)
Grain, cereals	Grain, cereals	Grain, cereals	Grain, cereals
Roots or tubers	Roots or tubers	Roots or tubers	Roots or tubers
	Vegetables	Vegetables	Vegetables
		Fish or shellfish	Fish or shellfish
		oil, fat, butter	oil, fat, butter
			Fruits
			Eggs
			pulses
			milk or milk products
			Coffee, tea, other

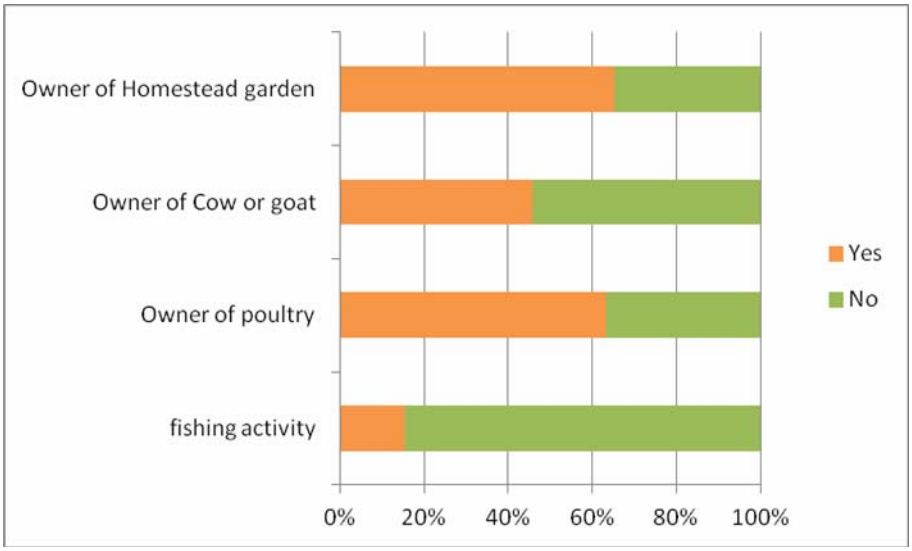
Included in this table are food categories eaten by at least 50% of the households in their respective groups.

The population surveyed is quite divided with a large majority having a poor diet, some of them being able to complete with oil/fish and sometimes eggs. Only a small minority (11%)

can have a much more complete diet. This minority are large land owners or some households having another economic activity and not having land:



Crops and livestock diversity available at household levels explain a part of the diversity of the diet. Beside staple crops, homestead garden, livestock and fishing activity can provide a good source of nutritious food:



But producing is not consuming especially when you need cash and you might prefer selling quality food in order to purchase staple crops. Combining production and food diet we can see that 90% of poultry owner had eggs in their diet whereas only 50% of cow owners where having milk in child diet. And 80% of homestead garden owners had vegetables in their diet.

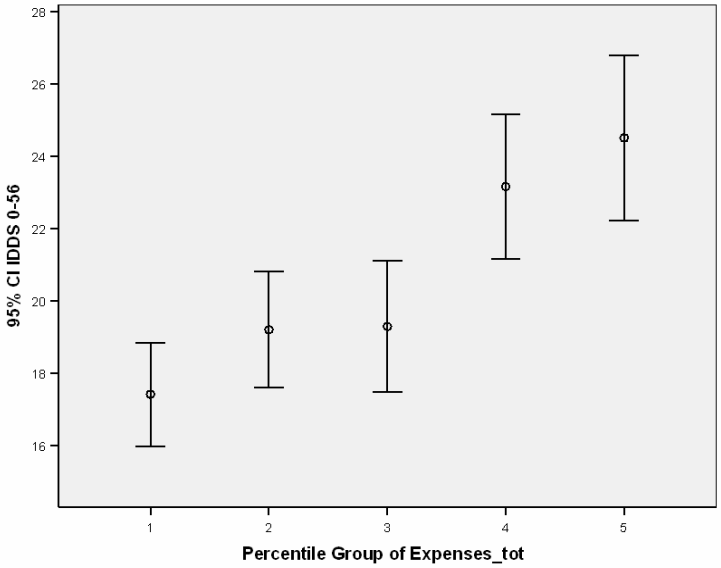
Ex of Homestead garden:

Homestead garden have an impact on whether or not Hoh and children (above 24 months) have vegetables and pulses in their diet but it does not significantly change the HDDS and IDDS as livestock do (most households -70%- are taking vegetables anyway).

Fishing activity is more common in island chars. In our study, 15% of hoh had been fishing in past month especially in Tista River (25% were fishing). The time of the survey was not a good season for fishing but quality of the fish is said to be better. It is a physical activity and some fishermen groups from mainland can be well organised during the main fishing season. Fish is quite expensive so selling is usually more common than consuming: 50% of hoh fishing had fish in their diet as compared to 40% otherwise (but not significant difference). Fish is getting scarce in the chars, with more and more human pressure. For example, over one night fishing, 1.5Kg of prawns worth 400Tk was collected by 2 fishermen.

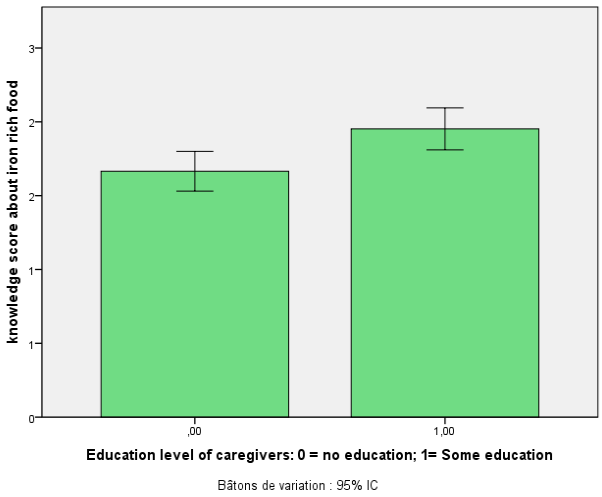
Intra-household food distribution:
Please refer to hypothesis 3: even hoh with low HDDS where able to maintain a good IDDS by prioritising the child.

Incomes:
Households with higher incomes have better diet diversity at household level and child individual level:



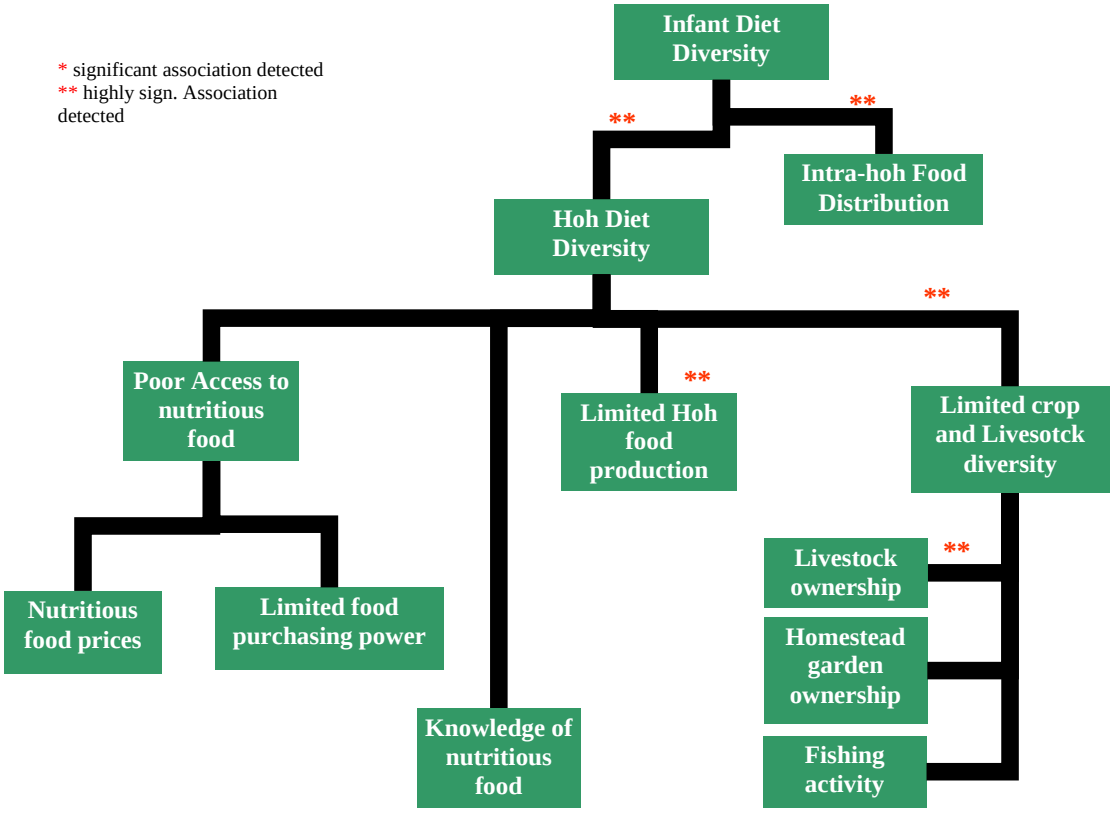
Education levels:

Traditionally, leafy vegetables are not considered as valuable source of food. Homestead gardens were not very common in the chars but this is changing thanks to development programmes who improved as well the awareness on nutritious rich food.
=> Knowledge on food quality and nutritive values are good: 2/3 of respondents were able to provide 2 correct food items rich in iron. From our survey we also identified that knowledge is higher in Lalmonirhat compared to Gaibandha possibly linked to higher formal education levels (based on results of our survey as well)



However, this specific knowledge on food quality items does not have influence on quality of diet at hoh level neither at child individual level. On the other side, formal education levels of men has impact on HDDS (more linked to economic status).
More importantly, formal education levels of women have an impact on HDDS and IDDS.
FGD informed that knowledge is usually coming from long influence of development programmes in the villages. Most of the respondents were women who are usual the designed "targets" for these programmes but it would be interesting to see the level of awareness of men who are the ones to purchase food items in the market.

8.1.Hypothesis pathway



Association of causal factors and undernutrition levels:

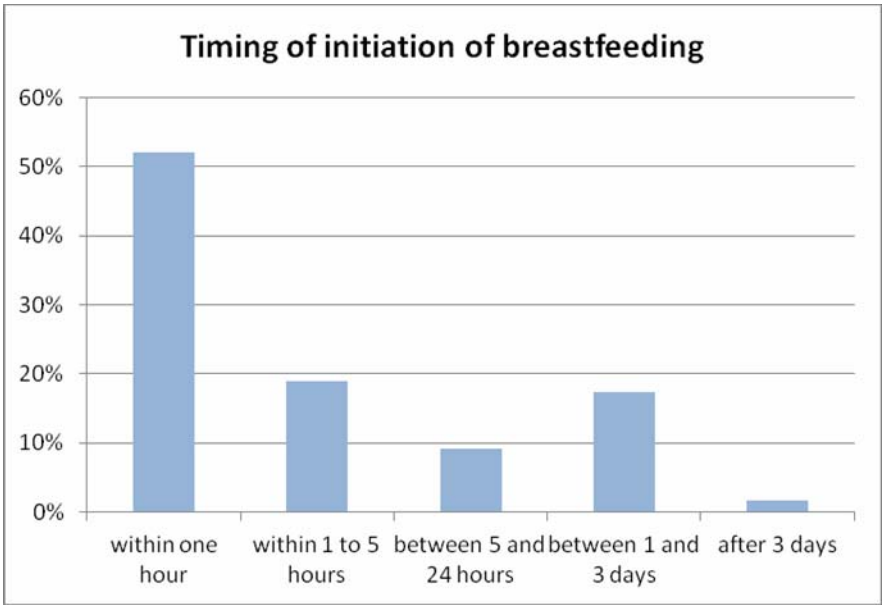
Causal factor	Relation with Wasting P value	Relation with Stunting P value	Relation with IDDS
IDDS	NS	NS	
Ratio IDDS/HDDS	NS	NS	P<0.001**
Sex of the child	NS	NS	P=0.039*
Households food access (HDDS)	NS	NS	P<0.001**
Incomes	NS	NS	P<0.001**
Livelihood Groups	NS	NS	P<0.001**
Knowledge of nutritious food	NS	NS	NS
Education level of Care Giver	NS	NS	P=0.03*
Rice Production	NS	NS	P<0.001**
Homestead garden	NS	NS	NS
Cow or goat ownership	NS	0.05*	P=0.003**
Poultry ownership	0.015* more poultry increases risk of wasting	NS	P<0.001**
Fishing activity	NS	NS	NS

*NS= Not significant association. * Significant association with probability <5% ** significant association with probability <1%*

NB: As associations with undernutrition need to be analysed taking into account all factors, please refer to the regression analysis and ranking section.

9. Hypothesis 5: 'Breastfeeding practices'

Breastfeeding initiation:
50% of children in our sample had an initiation of breastfeeding within one hour after birth as recommended by WHO.



NB: for this indicator, we select only children less than 24 months. After that, we estimate that mothers will have difficulties to recall exactly the timing of initiation.

The proportion of poor initiation of breastfeeding is quite high and we can still observe an important proportion of women starting breastfeeding 1 day or more after birth. This practice is mainly linked to traditional habits. A FGD on decision making process in the households provided interesting insights:

When the husband is present

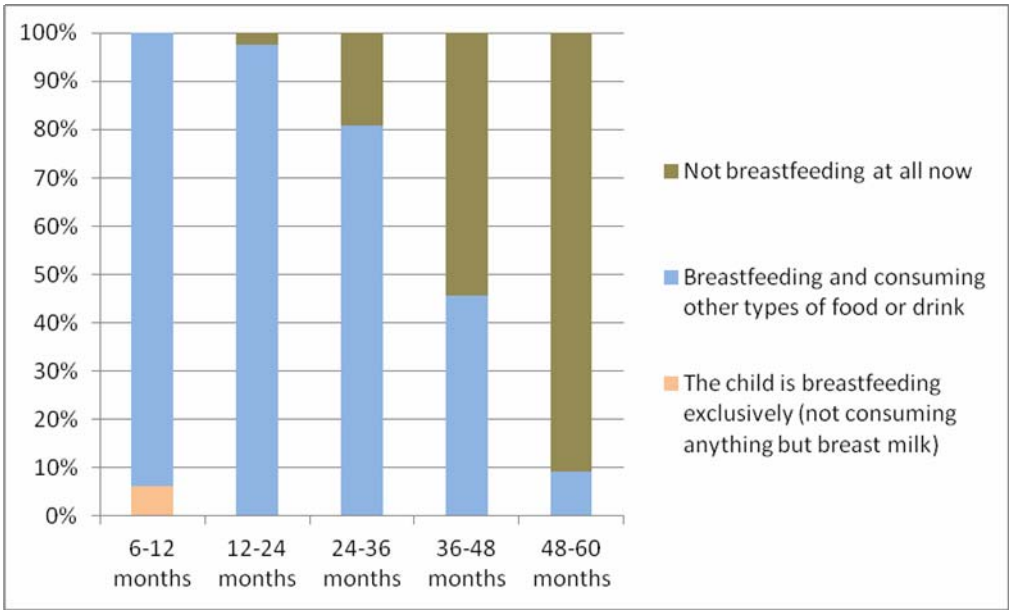
Decision about:	Decision maker:	Influenced by:
Food expenses	Husband	Wife gives advice on what is needed
Type of Food	Often wife.	
Health expenses	Husband	
Health seeking behaviour	Husband	Wife; neighbours
Breastfeeding, CP	Mother in Law	
ANC /PNC of mothers	Husband	Neighbours, Mother in law

When the husband is not present (migration labour):

Decision about:	Decision maker:	Influenced by:
Food expenses	Wife	
Type of Food	Wife	
Health expenses	Wife	
Health seeking behaviour	Wife	
Breastfeeding, CP	Mother in Law	
ANC / PNC of mothers	Wife	

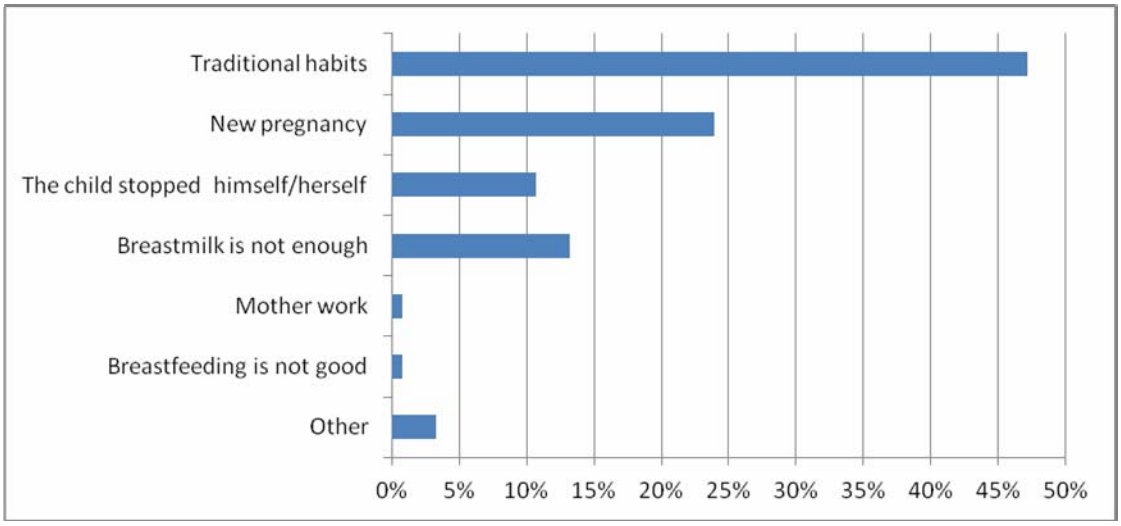
Breastfeeding and care practices are the responsibility of the mother in law. Education levels or incomes level do not influence this practice. Mothers in law had often very poor access to formal education and had poor education levels. It is interesting to see that poor initiation of breastfeeding is also associated with poor feeding practices during pregnancy (eating less food during pregnancy than before) which is also a strong tradition in this area. Women visiting health services for ante natal care tend to have better breastfeeding initiation. Mother in law may have a lack of knowledge on the advantage of exclusive breastfeeding initiation and of colostrum.

Breastfeeding profiles as reported by caregivers:



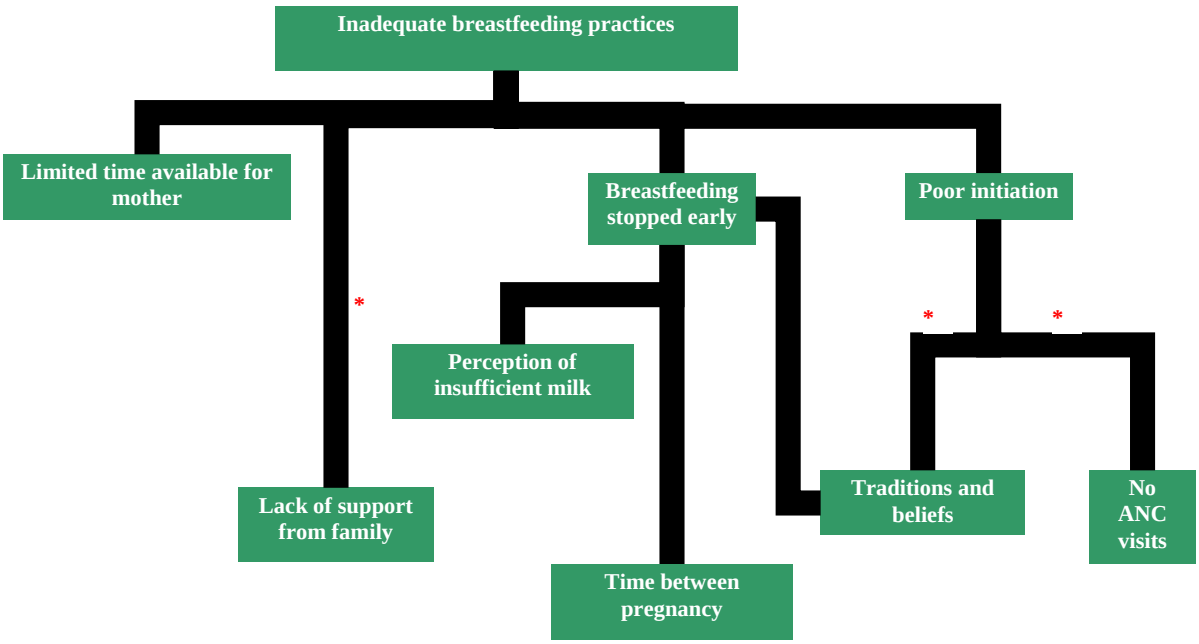
As recommended by WHO[6], complementary feeding should start between 6 and 8 months (see hypothesis on complementary feeding practices). Exclusive breastfeeding is rarely strictly practiced. Interviews and FGD are indicating that there is a strong tradition to add honey for young children to get a sweet voice. Nevertheless, breastfeeding is largely practiced and is stopped for the following reasons:

[6] WHO 'indicators for assessing infant and young child feeding practices' 2007. Vol I.



'Traditional habits' and 'breast milk is not enough' are mentioned especially when mothers stopped breastfeeding early (less than one year).
'New pregnancy' is mentioned as a reason for stopping breastfeeding typically when the child was above 1 year old.

9.1.Hypothesis pathway



Association of causal factors and undernutrition levels:

Causal factor	Relation with Wasting P value	Relation with Stunting P value	Early initiation of breastfeeding
Early initiation of breastfeeding	0.004**	NS	
Child Feeding Index based on Sumonkanti Das &al	NS	NS	**NS**
Appropriate timing of complementary feeding	NS	NS	**NS**
Age stopping breastfeeding	NS	NS	**NS**
Reason stopping breastfeeding	0.05*	0.05*	**NS**
Education level of Care Giver	NS	NS	NS
Ante natal Care	NS	NS	**0.058**
Food eaten during pregnancy	0.016*	NS	**0.021***
Unwanted pregnancy	NS	NS	**NS**
Family support	NS	NS	**0.038***
Early pregnancy	NS	NS	**NS**
Size of land	NS	NS	NS
Land ownership	0.027* Land owners have less wasting compared to all other groups	0.008** Land owners have less stunting compared to all other groups	NS
Sex of the child	NS	NS	NS

*NS= Not significant association. * Significant association with probability <5% ** significant association with probability <1%*

NB: As associations with undernutrition need to be analysed taking into account all factors, please refer to the regression analysis and ranking section.

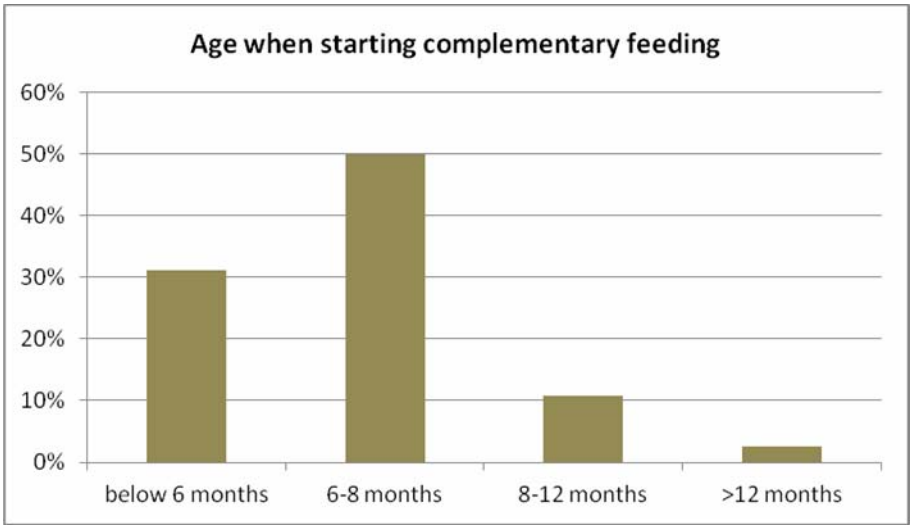
From these results we can stipulate that children with poor early initiation of breastfeeding (>1hour) see their risk of being wasted 4 times increased.

10. Hypothesis 6: 'Complementary feeding practices'

Infant and child feeding continuum:
To take into consideration the different adapted feeding practices changing with the age of the child, we used a Feeding Index defined by S.DAS for analysing DHS survey in Bangladesh (see bibliography for reference). This index compiles diet diversity, age of complementary feeding and breast milk status for different age groups. For breastfeeding practices, please refer to the specific hypothesis.

Timing of complementary feeding (CF):

WHO recommends starting complementary feeding between 6 and 8 months, when breast milk is not enough alone any longer to support child growth. The mean age of introducing complementary food (CF) in the sample is 6.8 months (±5.6). However, more than a third (33.7%) of the children received CF much too early (0-5 months) and 20% received CF much too late (8 months or more). There is no significant difference on timely CF when comparing incomes or livelihood groups or sex of the child. Timely complementary feeding is mainly linked to education and traditions (see further below).



These figures should be interpreted as an optimistic picture: it is traditionally common to provide other food beside breastfeeding and some women do not consider it as complementary feeding. Although explained during the interview, we can expect that there is a bias in this information collected.

Type of complementary food:

Often children are offered plain rice, or rice powder mixed with water as complementary food which are very poor in terms of nutritious value. Items are offered repeatedly.
The 7 days dietary pattern indicates that there was not much diversity of different food items such as meat, fish, vegetables, fruits etc. in the daily menu.

Dietary profiles of children by age groups and by IDDS categories:

AGE <24 months (115 children, 30%)	IDDS <= 3 50 Children (44%)	IDDS = 4-5 44 Children (38%)	IDDS >= 6 21 Children (18%)
Grain, roots or tubers	5 d/week	7 d/week	7 d/week
Other fruits and vegetables		4 d/week	5 d/week
Foods cooked in oil		4 d/week	6 d/week
Meat, poultry, fish, seafood		1 d/week	2 d/week
Milk and milk products			4 d/week
Vit-A rich plant foods			2 d/week
Eggs			2 d/week
Pulses/legumes/nuts			1 d/week

Included in this table are food categories eaten by at least 50% of the children in their respective groups.

AGE >=24 months (273 children, 70%)	Group 1 : IDDS <= 3 55 children (20%)	Group 2 : IDDS = 4-5 117 children (43%)	Group 3 : IDDS >= 6 101 children (37%)
Grain, roots or tubers	7 d/week	7 d/week	7 d/week
Other fruits and vegetables	3 d/week	5 d/week	6 d/week
Foods cooked in oil		3 d/week	5 d/week
Meat, poultry, fish, seafood		2 d/week	3 d/week
Milk and milk products			4 d/week
Vit-A rich plant foods			3 d/week
Eggs			2 d/week
Pulses/legumes/nuts			1 d/week

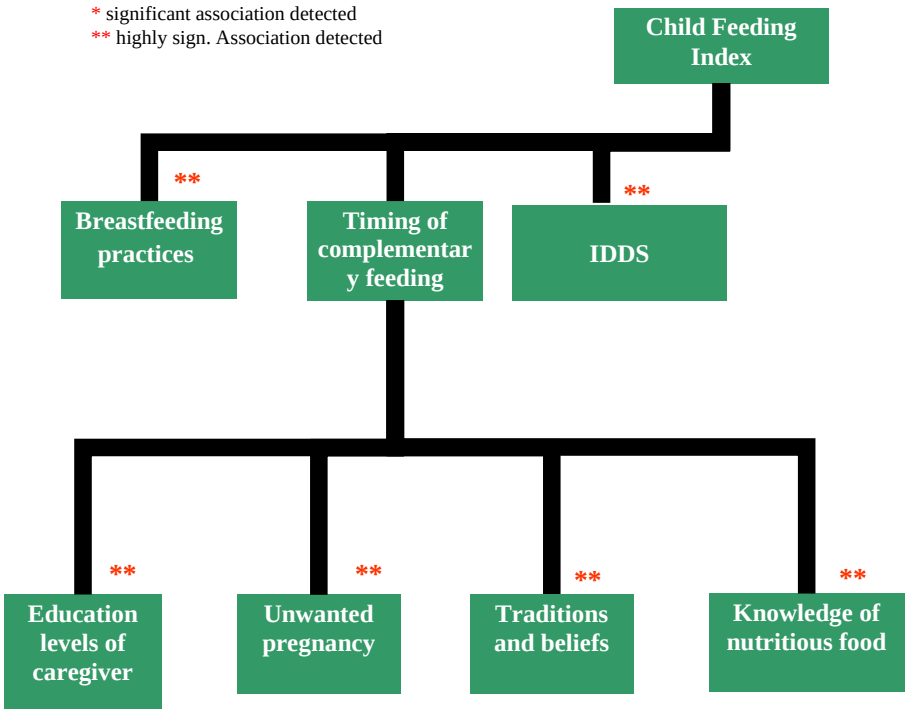
Included in this table are food categories eaten by at least 50% of the children in their respective groups.

Younger children have lower diversity in their diet (compensated by breastfeeding) but the profiles are similar. Diet diversity is very limited in chars especially when considering that the winter season is the best season of the year in terms of access to food (refer to section on seasonal calendar for further details)
The basic meal is composed of rice and vegetables, sometimes cooked in oil. Richer food is available on special days of the week when men are coming back from the market. The quantity of nutritious food is mainly due to poor food accessibility and intra-household food distribution (refer to hypothesis on diet diversity).
About 60% of the children did not have any eggs in last 7 days and most of them had it only 1 or 2 days/week. More than 70% of the children did not have pulses/legumes/nuts in one week of time.

Tradition, education and awareness:
Prolonged breastfeeding is one of the common practices in this society. When mothers start complementary feeding, in 50% of cases it is too early or too late as mentioned above. During discussions in the field, we met both women who were very well informed about complementary feeding practices and others who were not. Awareness and development programmes have improved the knowledge but there is still room for improvement. This knowledge is higher among educated women and has a positive impact on adequate timing of complementary feeding ($p<0.001$**). As the level of education in Lalmonirhat district is better than in Gaibandha, we also see a difference between the 2 districts ($p<0.001$**).
Women with formal education are more sensitive to the messages delivered and put them more into practice. Women with low or no formal education tend to be less sensitive to these messages. They know the messages usually provided but they are more reluctant to put them into practice.
Interestingly, women who went for Ante Natal Care had better feeding practice ($p<0.001$**). It is not possible to say only on the basis of the data collected that this is a causal association. However, interviews and visits of community health workers confirmed that they are working very hard to sensitise pregnant women to be part of ANC programs. They take advantage of these visits to promote adequate feeding practices. ANC visits seem to be a useful platform for awareness of good practices especially for adolescent mothers.
Beside the fact that food access can be very low, leaving limited choice for women, we observed that traditions are also influencing adequate complementary feeding. Poor feeding practices of mothers during pregnancy (which is a common traditional practice) is associated with poor complementary feeding. As mentioned for breastfeeding practices, mother in law

have a high influence regarding the care of the child. Better understanding of traditional practices and decision making process would be interesting to investigate further.

10.1. Hypothesis pathway



Association of causal factors and undernutrition levels:

Causal factor	Relation with Wasting P value	Relation with Stunting P value	Timing of complementary feeding
Timing of complementary feeding	NS	NS	
Child Feeding Index based on Sumonkanti Das &al	NS	NS	**NS**
Early initiation of breastfeeding	0.004**	NS	**NS**
IDDS	NS	NS	NS
Ratio IDDS/HDDS	NS	NS	NS
Sex of the child	NS	NS	NS
Households food access (HDDS)	NS	NS	NS
Food eaten during pregnancy	0.016*	NS	0.019*
Family support	NS	NS	NS

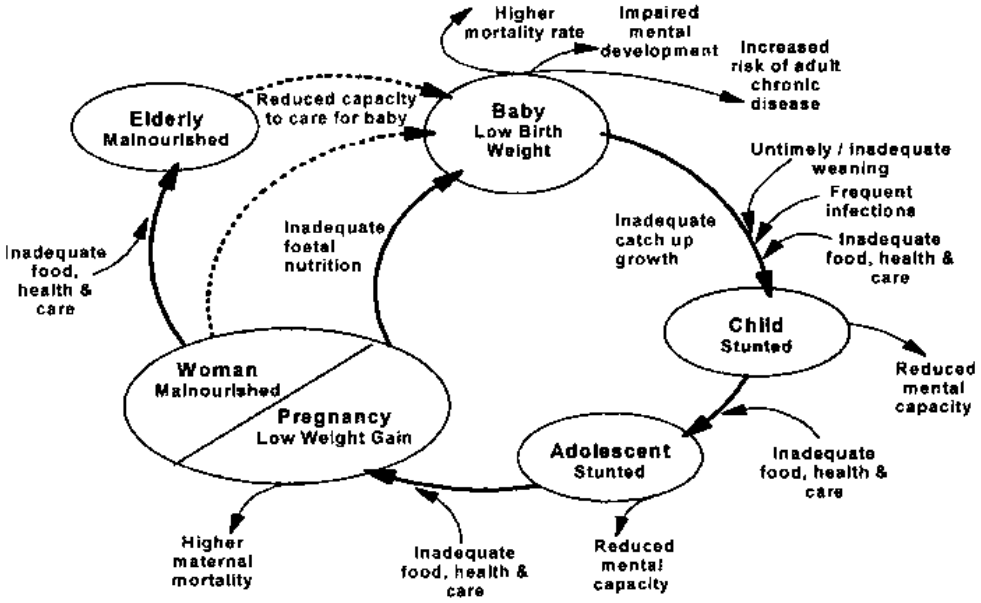
Knowledge of nutritious food	NS	NS	0.008**
Education level of Care Giver	NS	NS	0.005**
District	NS	NS	0.004** Better timing in Lalmonirhat
ANC visits	NS	NS	0.004**
Unwanted pregnancy	NS	NS	0.006**

*NS= Not significant association. * Significant association with probability <5% ** significant association with probability <1%*

NB: As associations with undernutrition need to be analysed taking into account all factors, please refer to the regression analysis and ranking section.

11. Hypothesis 7: 'Low birth Weight (LBW)'

Low birth weight (new born below 2.5Kg at birth) is a well-known cause of undernutrition which is better described in the nutrition life cycle than in the UNICEF framework:



Source: Commission on the Nutrition Challenges of the 21st Century (2000) Final report to the ACC/SCN

Low birth weight is associated with impaired immune function, poor cognitive development, and high risks of developing acute diarrhoea or pneumonia. Consequences for children are dramatic:

- Higher risk of mortality: It has been estimated that almost half of infant deaths in Bangladesh from diarrhoea or pneumonia could be prevented if LBW was eliminated (ACC/SCN, 2000).
- Growth is retarded (stunting) and they are also much more likely to fall sick

- They are more likely to suffer from diet-related diseases such as diabetes, coronary heart disease and hypertension[7]

Scope of the problem:
A prevalence of more than 15% of LBW indicates a public health problem. Worldwide, 15.5 per cent of all births are classified as low birth weight. 95.6 per cent of them occur in developing countries. 50% of them occur in South Central Asia where the prevalence of LBW is 27%. As a comparison, low birth-weight levels in sub-Saharan Africa are around 15 per cent.
The case with of Bangladesh is even more critical with 36% national prevalence estimated in 2000. This dramatic figure has significantly decreased. However, in the northern rural area of Bangladesh, prevalence of LBW has recently been estimated at more than 50% of births which is one of the highest rates in the world[8].

Geographic area	Prevalence of LBW
Worldwide	15.5%
South Central Asia	27%
Bangladesh	36%
Northern Rural area of Bangladesh	>50%

Based upon: '*Low Birth Weight: country, regional and global estimates'* WHO, UNICEF, 2004.

Causes of LBW:

The majority of low birth weight in developing countries is due to intrauterine growth retardation for which causes are complex and multiple, but cantered on the foetus, the placenta, the mother, and combinations of all three. The maternal environment is the most important determinant of birth weight. Major determinants are poor maternal nutritional status at conception, low gestational weight gain due to inadequate dietary intake, and short maternal stature due to the mother's own childhood undernutrition and/or infection.
During this study, we identified three potential major drivers of low birth weight: early pregnancy, poor medical care of women and poor diet of women.

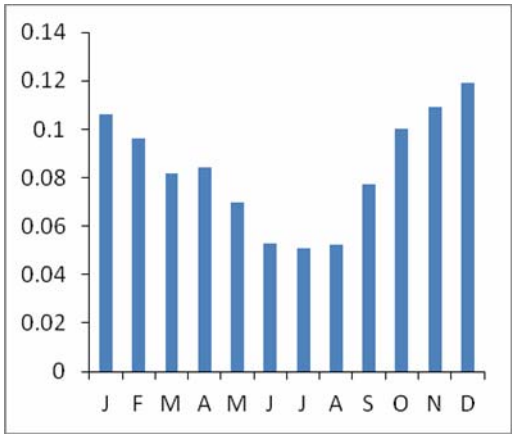
Poor Diet of Women:
Maternal nutritional status is a major factor of LBW. It was not possible to measure this factor during our survey as it is not feasible to recall the nutritional status of the mother during her past pregnancy. However, the diet of women depends highly on food access of the household (estimated by HDDS in our survey) but not only.
In all our focus group discussions, there is a similar pattern for food sharing among the family members. Men, coming back from the market or from a day of hard labour, and because of their social status, have the best part of the meal in terms of quality and quantity. Children and the elderly come second. Women are taking the remaining.

Another aspect worth exploring: seasonality. The diet of women, as for the hoh is seasonal, linked to food accessible at household level (see hypothesis 2 for more details). We have seen that during the hunger gap or monga season, children suffer less than women as they are

[7] '*Low Birth Weight : country, regional and global estimates'* WHO, UNICEF, 2004.

[8] '*Can mother's perception of infants's birth size prowy a birth weight ?*' S.Mehra, AB Labrique, M Rashid, AA Shamim, P Christian, KP West Jr. Jivita project, Johns Hopkins Bloomberg school of public health. 2005.

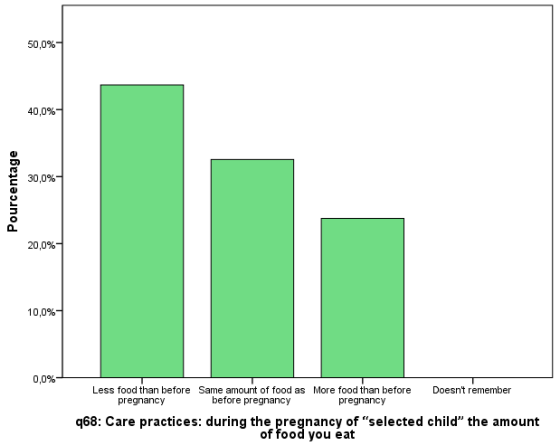
prioritised, which is not the case of women. We can therefore estimate that the diet of women is particularly limited during the monga season. Birth deliveries are also seasonal:

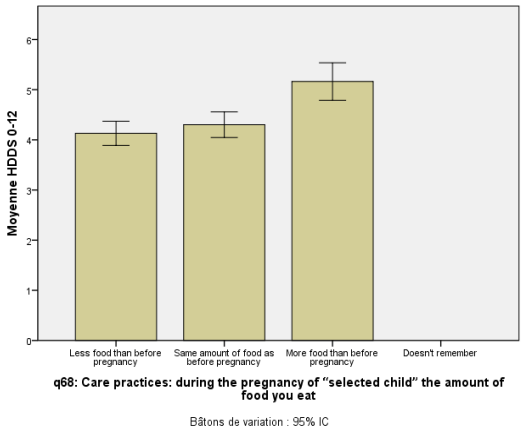


Birth rates by month
Source: HKI nutrition surveillance programme, Chilmari.

Most of deliveries occur during winter season mainly due to the seasonality of weddings, seasonality of welfare and access to food, seasonality of farming labour. We had this information from surveillance data and it was confirmed by traditional birth attendants and medical staff interviewed.
Risk of low birth weight is increased when women have limited food access during the third semester of their pregnancy, which, as we can deduct, mainly starts in June / July / august. *It seems that pregnant women have the lowest quality diet of the family, when the family has the lowest access to food of the year and when they need it the most.*

In our survey, only 24% of women were eating more during their pregnancy than before.





As mentioned above, this can be explained by seasonality, access to food (ANOVA, $p<0.001$) but also due to the strong *traditional practice of young mother to reduce their food consumption during pregnancy* in order to facilitate the delivery and reduce risks of complication or mortality during the delivery. It is a well-known practice which has been confirmed during our interviews with traditional birth attendants (TBA), medical staff and mothers: 43% were eating less than before during their pregnancy. Risks of complications or mortality are important in Bangladesh: perinatal mortality rate (stillbirth and early neonatal

mortality) is estimated at 59 for 1000 pregnancies in rural Bangladesh[9]. Main causes of child mortality are septicaemia, birth asphyxia, prematurity, ARI or diarrhoea but 'evil spirits' are very often blamed. Small babies are perceived by women and Traditional Birth Attendants easier to deliver, especially for young mothers with poor nutritional status. It is perceived as a way to reduce the risk of mortality for mothers during delivery. Elder women and TBA continue to convince young mothers to eat less during their pregnancy. As a vast majority of births occurs at home (85% in 2007[10]) with a TBA, this tradition is widely practiced. Until appropriate medical care can be delivered to women during delivery, this practice will likely persist.

The *quality of the diet* of women and especially of micro-nutrients is also important to explore as a cause of low birth weight. As in all rural Bangladesh anaemia has a high prevalence. Field observations showed that very limited prepared meals were including food with iodine. Interviews of traders and men indicated that iodised salt is almost never purchased by men in the market as prices are significantly higher.

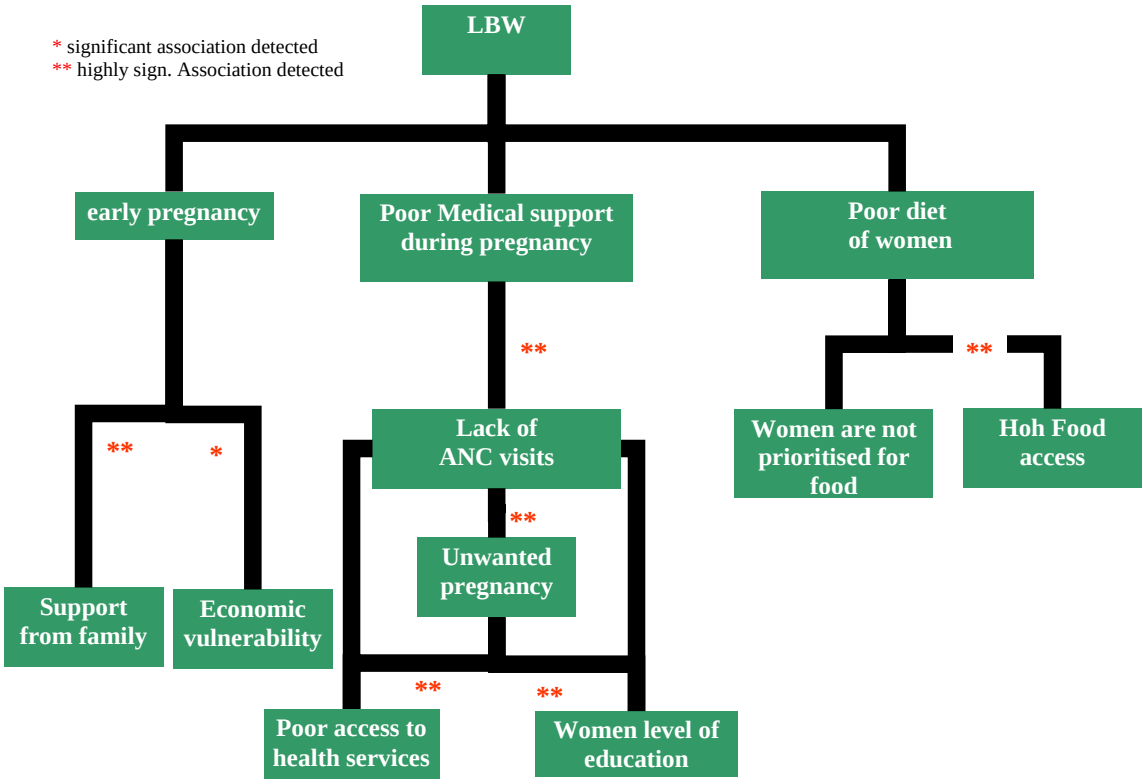
Early pregnancy:
It is a well-known and documented practice in Bangladesh. In the chars, the average age of first pregnancy is just below 17 years old and is similar across districts and types of chars.[11] We will not come back here on the reasons of early pregnancy which are not specific to the area studied. In this survey age of first pregnancy is significantly related to the family support reported by the care giver, economic levels of the hoh, and poor family planning of teenagers.

Poor medical support and unwanted pregnancy:
Although constantly improving over the past decade (from 30% of women attending medical care in 1996 to 60% in 2007 at national level), access to medical care is still insufficient in rural Bangladesh[10]. Health seeking behaviours and access to medical care (see hypothesis 16 and 15) are major determinants of attendance for ante-natal and post-natal care visits where pregnancy is monitored by trained medical staff and micro–nutrients and vitamins are distributed to pregnant women as well as immunisation. In our sample, 64% of women had ANC mainly from community health workers; of which 62% had vitamin and micro-nutrient supplementation and 73% had the support of their family for medical visits after delivery. This is coherent with national average. In this study *unwanted pregnancy* is significantly related to less food eaten during pregnancy; vitamin supplementation; age of pregnancy, and education levels of women.
Uncontrolled pregnancy is quite common: 26% of the mothers interviewed declared they were not willing to get pregnant at that time.
Family planning services are normally available but are too often too far or not very well furnished to satisfy the high demand of women and men to control pregnancy. From discussion with women and community health workers, women are usually aware of potential methods (except low educated women and teenagers) but access and availability of family planning are some major constraints. From interviews of medical staff and researcher, we heard that it can be a common practice to try to induce abortion using medicine for treatment of post-partum haemorrhage. Lack of care and tentative of abortion can damage the normal

[9] '*Perception of evil spirits as the cause of infant death in rural bangladesh*' S.Mehra, AB Labrique, P Christian, KP West, AA Shamim, R Klemm, M Rashid, Jr. Jivita project, Johns Hopkins Bloomberg school of public health. 2005.
[10] '*Bangladesh Country profile'* WHO. 2007.
[11] '*A profile of Households living on mainland and island chars'* Chars Livelihood Programme 2005.

development of foetus if surviving. Unwanted pregnancy is however not significantly associated with poorer care practices in our survey.
Physical and psychological stress of women during pregnancy can also be important especially women with farming or economic activity. They usually don't restrain their physical activity during pregnancy.

11.1. Hypothesis pathway:



Association of causal factors and undernutrition levels:

Causal factor	Relation with Wasting P value	Relation with Stunting P value
Ante natal Care	NS	NS
Post natal care	NS	NS
Food eaten during pregnancy	0.016*	NS
Unwanted pregnancy	NS	NS
Vit supplementation	Ns	NS
Family support	NS	NS
Early pregnancy	NS	NS
Risk of LBW[a]	NS	0.059

NS= Not significant association. * Significant association with probability <5% ** significant association with probability <1%
[a]*=Combination of the LBW risk factors cumulated*
NB: As associations with undernutrition need to be analysed taking into account all factors, please refer to the regression analysis and ranking section.

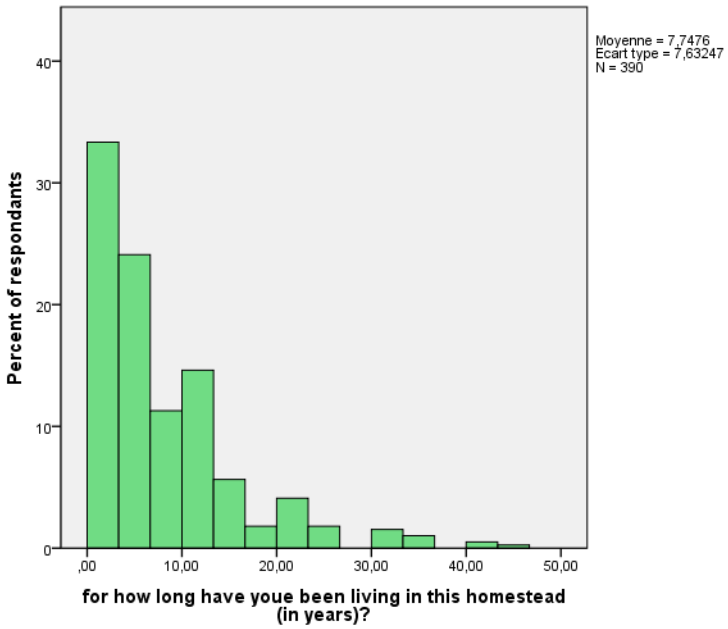
12. Hypothesis 8: 'Poor psychological care'

During the first phase (step 1 and 2), the study failed to identify psychological factor as a potential cause of undernutrition: no interviews conducted mentioned this potential hypothesis as a contributor to undernutrition.
Studies are showing that if mothers are depressed, it is significantly increasing the risk of undernutrition for their children.
Many field workers are addressing issues of gender violence for example, but in the first phase of the survey none of the respondents thought about the potential linkage between mother psychological status and the health status of the child.
This hypothesis has been added during the course of the study which explains why it is not well informed.
The psychological status of women is a component of the mother-child relation and can impact breastfeeding, feeding practices, care of the child, stimulation of the child Pre natal and post natal psychological status of the mother has a demonstrated impact on birth weight and child growth (Pattel 2006; Rhaman 2004).
Although very incomplete, we identified three important potential factors of depression of women:

Domestic violence:
From CLP, baseline survey, majority of violence against women is domestic. In Gaibandha district, 13% are estimated to be physically tortured and 10% were opposed to visit family members or to work outside their home. Based on interviews, domestic violence is more important in island chars of Gaibandha district.

Adolescent mother:
For economic and traditional reasons, women are married very early even if the official law forbids it. They usually get pregnant within 2 years explaining the number of adolescent mothers (please refer to hypothesis on low birth weight).

Instability, stress, depression:
As mentioned, an island char exists for about 30 to 40 years. It means people can have a change of homestead several times during their lifetime.



In our survey, the majority were not in the same homestead 8 years ago!

Homestead which has been recently removed (left) and 10m away, households waiting for the land to disappear (right).

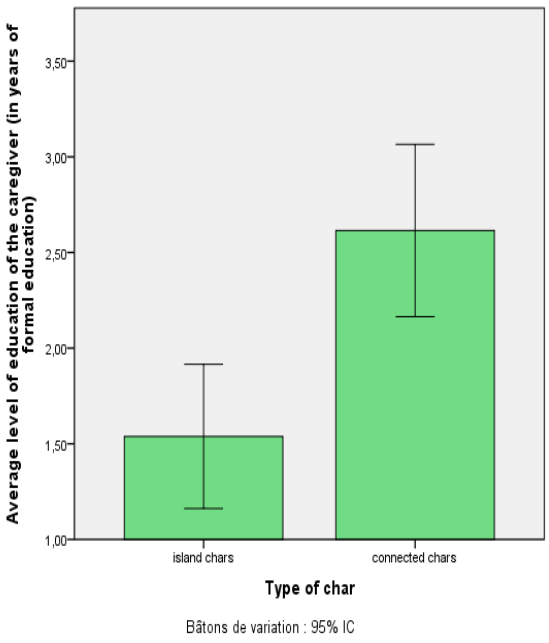
Also, only 56% are owner of the land of their homestead and 50% had their house flooded in past season. Land erosion is grabbing the land step by step. “At night, I cannot sleep. I try to hear the river and if other pieces of my land are disappearing. It can disappear very quickly taking away all the houses. I roam overnight around the homestead” mentioned one villager living just beside the edge.

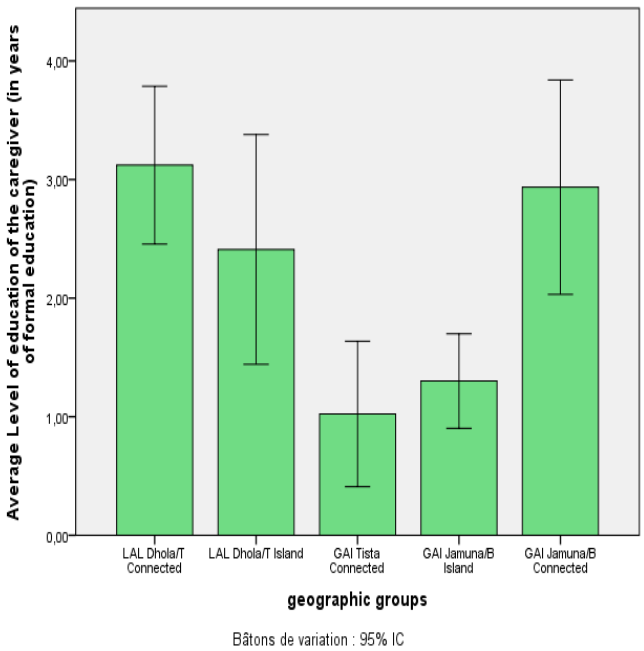
Trends:
These trends are getting worse and worse due to higher population density and failure to find in time an appropriate new homestead. Families can end up in illegal settlements in precarious conditions. Every day is a challenge.
On the other hand, social behaviours are changing. Several key informants working in the chars for more than 20 years clearly mentioned that domestic violence and early marriage are decreasing. As men are often migrating to find labour, women are then in charge of the households for consecutive months making their social status stronger.

13. Hypothesis 9: 'limited social services available'

Policy instruments are available at national level: National Nutrition Programmes[12]; Safety Nets; Health Care…with comprehensive protocols and sound strategy. However these services face difficulties to reach remote communities of chars for two major reasons: access and lack of adapted resources.

Schools and education:
During our survey we found that Primary schools and/or Madrasa are present in every village which is an important progress as compared to some decades ago. Secondary schools are scarcer and access can be difficult. When it is free and accessible, it is easy for family to send their children. When they need to take transport, it costs time and money and adolescent girls are often abandoning schools to get married. Enrolment in primary school is very high but is cut by half for secondary school and then only around 10% graduate mostly coming from better off households. There used to be a gender difference in primary school but it is no longer the case (interview with Teachers and other key informants).
The level of education is an important social factor: men with more education tend to have higher incomes ($p<0.05$*). Teachers also mentioned during the survey that some uneducated parents tend more and more to ask advice to their educated children. Education is bringing respect to a person. But in an area where 55% of children are stunted, teachers also notably observe that boys and girls have difficulties to keep focused during the class, a majority of them are not able to follow the programme.





Level of education of women is higher in Lalmonirhat district than in Gaibandha. It is also much higher in connected char than in island chars.

Health care:
Please refer to health seeking behaviour hypothesis.

[12] Although this programme is now officially closed

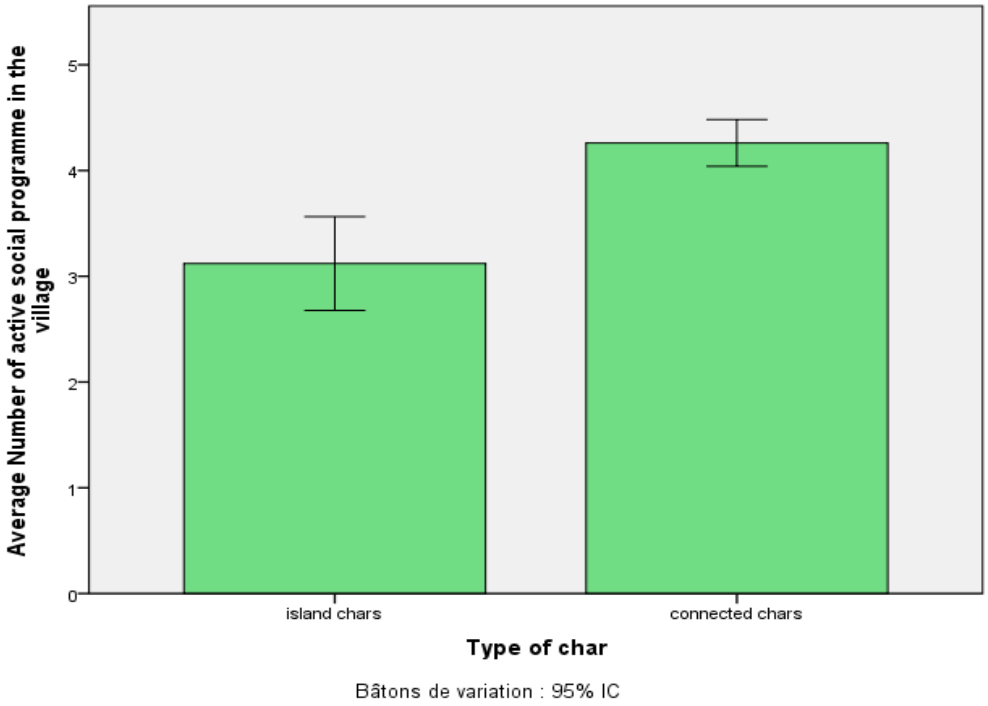
Family planning:
Communities are often mentioning pregnancy control as a major problem linked with population density and access to land.
In our sample, 26% of women mentioned they were not willing to get pregnant at that time. According to health workers interviewed, when the service is available, 50 to 80% of women are using contraceptive methods. Pills and injections every three months are the most popular methods. The poor pregnancy control is more an issue of availability of service and access. Although not quantified, family planning services are not very often present at local level and often lack of medicine.

Nutrition programmes:
National Nutrition programme has been closed.

Water and Sanitation / Food security / safety nets / Disaster Risk Management:
A number of NGOs are working in these technical fields. Needs are vast and difficult to cover on the long term: seasonal flooding is affecting all programmes delivery and sustainability; soil erosion and migration is also hampering these programmes. Most have integrated DRM strategies to adapt their interventions (raised platforms, latrines, emergency shelters, livestock improvements…). However, few are mainstreaming undernutrition in their objectives.
Safety Nets are very limited in the villages visited.

Micro-credits:
Quite a number of organisations work in micro credit which is an essential instrument for farmers to manage purchasing of agricultural inputs. The service is however erratically available in island chars.

Access to social services is better in connected villages but can be very different from one village to another depending on the number of programmes active in one area. There are a number of NGOs working in the area under study. Some work in few places but with a comprehensive approach, other are targeting larger number of villages. The number of programmes active in one village does not follow any standard rule. In general however, number of active programmes are higher in the connected chars than in island chars ($p<0.001$**). Island char are more demanding in terms of logistic, finance and organisation. At the time of the study, even with dedicated transport means, the survey team needed 4 hours to reach some villages from closest urban area.



Association of causal factors and undernutrition levels:

Causal factor	Relation with Wasting P value	Relation with Stunting P value	Relation with Social Services available
Social services available	NS	NS	
Benefiting from any social programme	NS	0.04*	NS
Knowledge of nutritious food	NS	NS	NS
Knowledge of Diarrhoea causes	NS	NS	NS
Island vs. connected char	0.042*	NS	P<0.001**
District location	NS	NS	
Geographic groups	0.005** (Gaibandha island chars with more wasting)	NS	P<0.001**

*NS= Not significant association. * Significant association with probability <5% ** significant association with probability <1%*

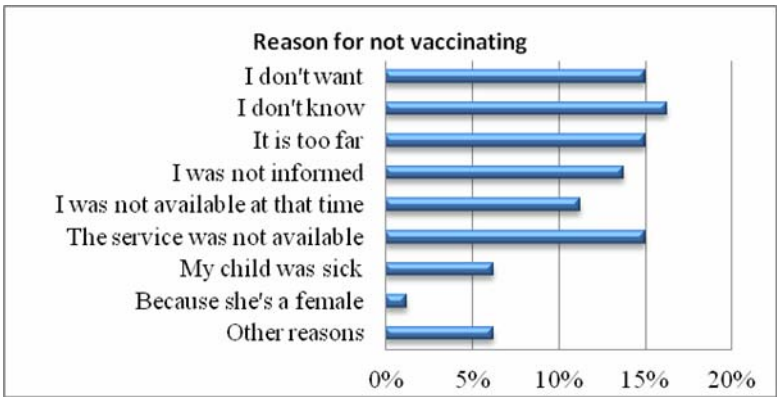
NB: As associations with undernutrition need to be analysed taking into account all factors, please refer to the regression analysis and ranking section.

14. Hypothesis 10: Immunization coverage

Immunisation coverage is important to protect children from major diseases especially for children who have a weak immunisation system (low birth weight children; after poor

breastfeeding practices; malnourished children) living in an unhealthy environment (poor sanitation and hygiene practices; flooded house; contact with animals…).

In our survey we identified if children were vaccinated against measles, Diphtheria, Polio, Hepatitis and BCG vaccine. 25% of children surveyed were not fully vaccinated which is coherent with CLP baseline survey of 2005.
National vaccination programme is providing free vaccines at national level. Mothers are not always following strictly this vaccination programme. This is mainly due to awareness; access to services and some poor practices.



Poor practices:
Immunisation coverage is significantly lower for girls than for boys (p=0.005) with 60% of children not fully vaccinated being female. More than 31% of respondents mentioned "don't want" or "don't know" as a reason for not fully vaccinating their child. We can see also that most of these children are found in the island chars of Gaibandha (p=0.001) were health practices are more traditional. Immunisation score is also significantly linked to the level of education of care-giver (Pearson R=0.168*). Children with poor immunisation are also children with poor hygiene (Pearson R=0.139**).

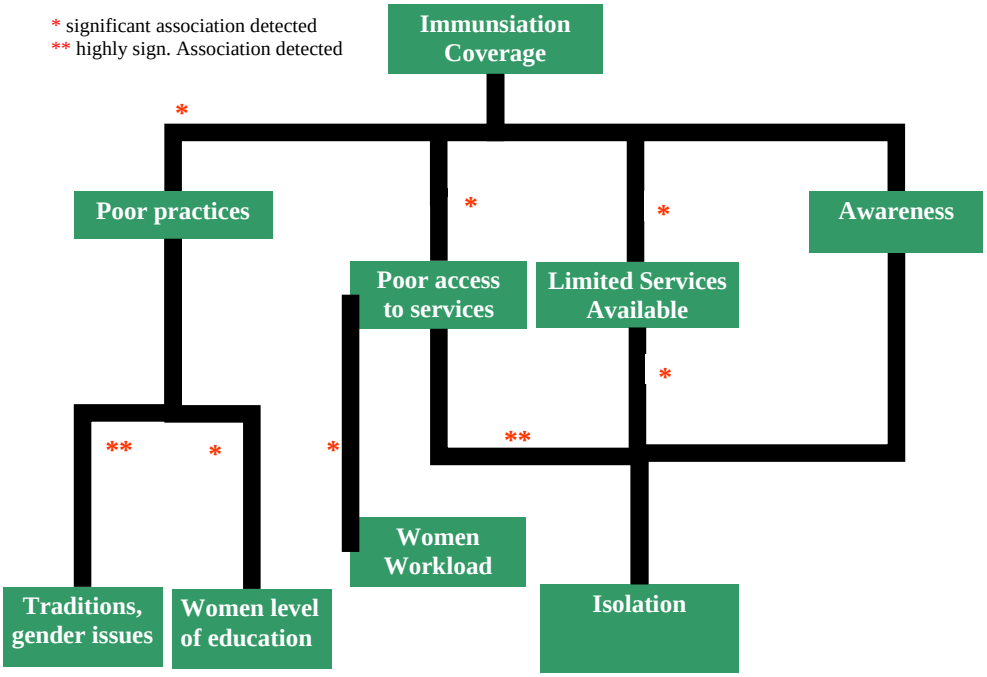
Access to quality services:
Access: During national immunization days, either people go to another char to get immunization for their children or go to the main land which is usually a day long program for the family and cost money as well. It is forbidden for some women to move out of their char alone so if the husband is not available, they cannot go. Women can also have limited time available to move such distances (5 to 10km for some island chars). 60% of not fully vaccinated children are found in the island chars (chi2, p=0.047).

Availability: In addition, 11% of respondents mentioned that there was simply no services available in their area (see hypothesis 15). The immunisation coverage is significantly associated with the number of social programmes available in the village (ANOVA, p=0.006). During our interviews, informants were often mentioning erratic services. Vaccination programmes could be active one year and being stopped without follow-up of the vaccination started. Discussion with the service providers at the health centres indicate that almost all the centres are lacking equipment and trained manpower to fulfil all the demand.

Awareness:

One of the main reasons for not receiving immunization is poor communication about the day of vaccination and type of vaccines available. This is obviously more delicate in the isolated area of the chars.

14.1. Hypothesis pathway:



Association of causal factors and undernutrition levels:

Causal factor	Relation with Wasting P value	Relation with Stunting P value
Immunisation coverage	NS	NS
Social services available	NS	NS
Sex of child	NS	NS

NS= Not significant association. * Significant association with probability <5% ** significant association with probability <1%

NB: As associations with undernutrition need to be analysed taking into account all factors, please refer to the regression analysis and ranking section.

There is no association between the immunisation coverage score and undernutrition levels.

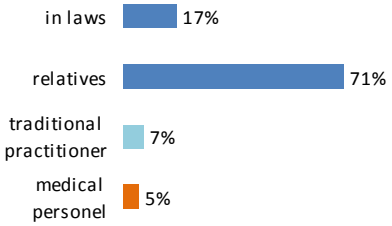
15. Hypotheses 11: 'Poor health seeking behaviour'

Some results of the survey on health seeking behaviours:

When your child had serious diarrhoea:

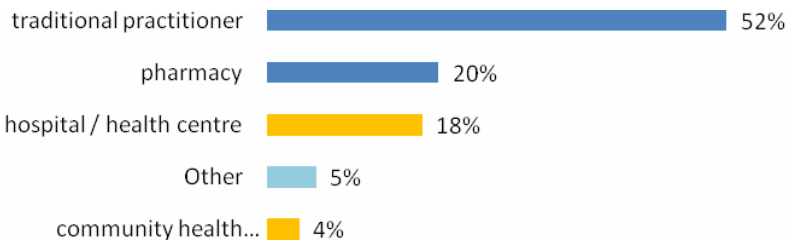
Did you look for advice?

Who did you see for advice?

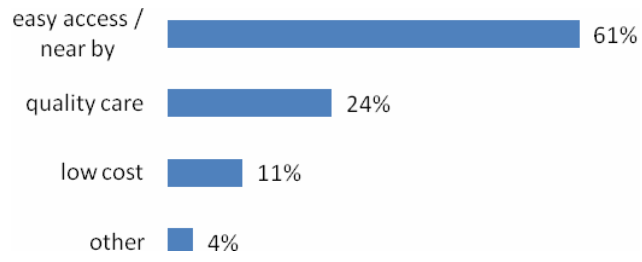


Did you finally bring your child for treatment?

Where have you gone for treatment?



How did you choose the place to go?



Health services available:
Field observation, interview and data collected for each village visited show that health services are very unequal from one place to another. Villages close to commercial centres or connected to the mainland have better health facilities available especially for severe cases. In remote places, pharmacists and traditional doctors are often present. Community clinics can

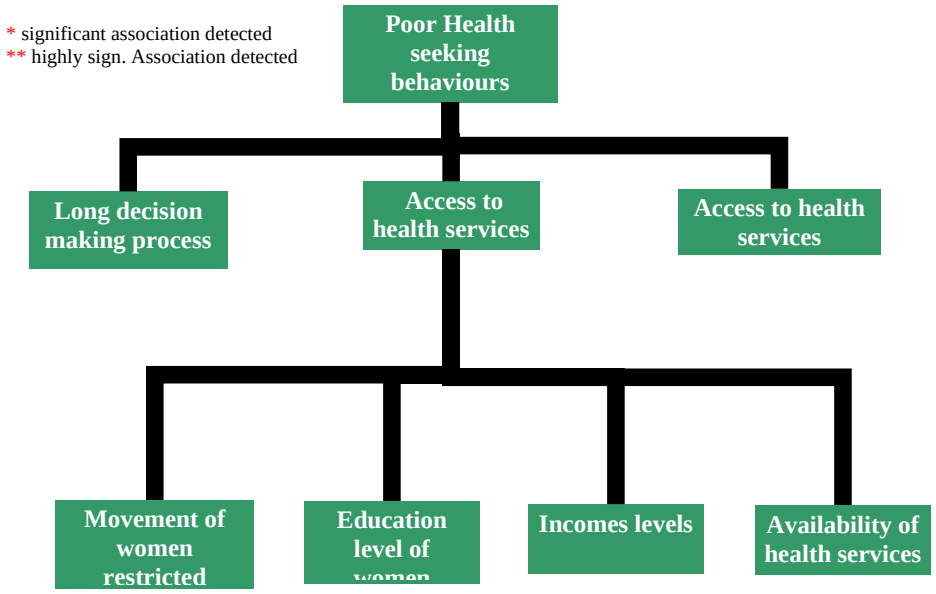
be present and offer highly appreciated and accessible service (free of charge and perceived as providing good quality care). Their presence is however hazardous.
A number of NGOs are supporting community clinics. For example, Gonoshastho Kendro is proposing a monthly visit of specialised doctors in some remote villages. These visits have a very popular success: 300 to 400 persons could come from long distances. Mobile boat clinics are also an interesting initiative. Globally, health services are still very far from covering the needs of the population in the chars.

Access to health care and health seeking behaviours:
Physical access: women are restricted in their movements
Women are more restricted in their movements, especially in the island chars area. They are rarely authorised to move outside the village without company. Transport cost and time can also be an issue. Close-by health facility is in the vast majority of usual cases the number one choice.

Financial access:
Medicines are usually available, even in local markets through pharmacists who can also provide consultations. People prefer to go to pharmacies because it is relatively cheaper than going to the hospital. The choice of the health structure is depending on the financial capacity of the household ($p<0.05$*).

Traditions:
Traditional healers or pharmacists are still by far the main health services providers. People visit them first as they are close by, not expensive and know each other. People trust them. It does not mean they don't trust government clinics or community health clinics. When they are available locally, people don't hesitate to go there. It is more a matter of a long process which can involve a number of persons.
Health and care of the child are more traditionally a matter managed by mother and mother-in-law. But when complicated cases happen, it can be necessary to move outside the village and spend some money on health care. Men are then the decision makers. It can be a decision with important financial consequences so it can take time and they look for advice from neighbours, traditional healers…A pharmacist mentioned: "when there are complications, I send them to the upazilla clinic. I know it is not a good one and they will have to move to the district hospital but often they don't have any connection with the district hospital and they ask me a lot of support so they can get there. I prefer to direct them to the upazilla clinic and they manage by themselves." A local survey on causes of mortality mentioned the same reason for non-treatment of these cases: delays, from first visits to traditional healers to the appropriate hospitals, can take weeks.
In these cases, people with mobile phones, with good social connection with urban centres have more chance of getting appropriate and timely health services.
Regarding acute malnutrition, most health workers met some cases in their village, although they give their diagnosis based on the physical appearance only. When it is really severe case, they refer to hospitals. Chronic undernutrition on the other hand is not detected. In the area visited there is no place for referring cases of acute undernutrition which is a major issue when 11% of children are wasted in the best season of the year. Early detection of cases at community level would be a serious asset for the treatment of severe cases.

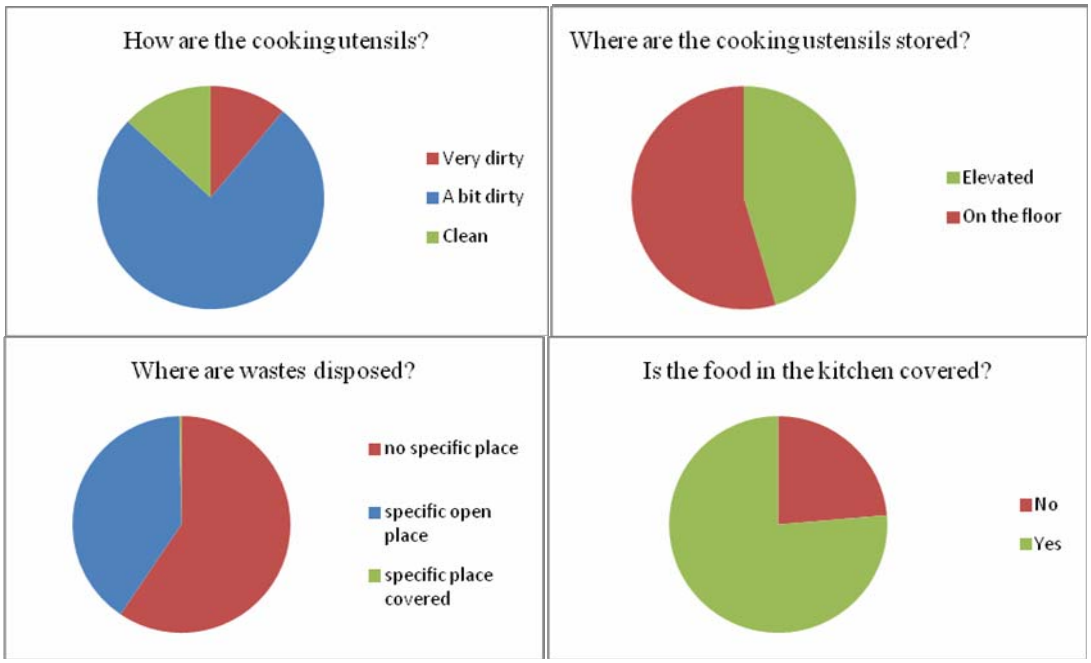
15.1. Hypothesis pathway:



Association of causal factors and undernutrition levels:
During the survey, we could not identify an adapted indicator or index for health seeking behaviours so no results are presented.

16. Hypothesis 12: 'Unhygienic cooking practices'

Unhygienic cooking practices are a common source of contamination of intestinal parasites and bacteria leading to diarrhoea and poor health status. There is general lack of knowledge at national level on food safety. In our survey, only 30% mentioned boiling food as a good practice to reduce food poisoning. We have observed during our survey, the cooking practices in place in the chars regarding the cooking place, the storage of raw food/water and the washing practices:

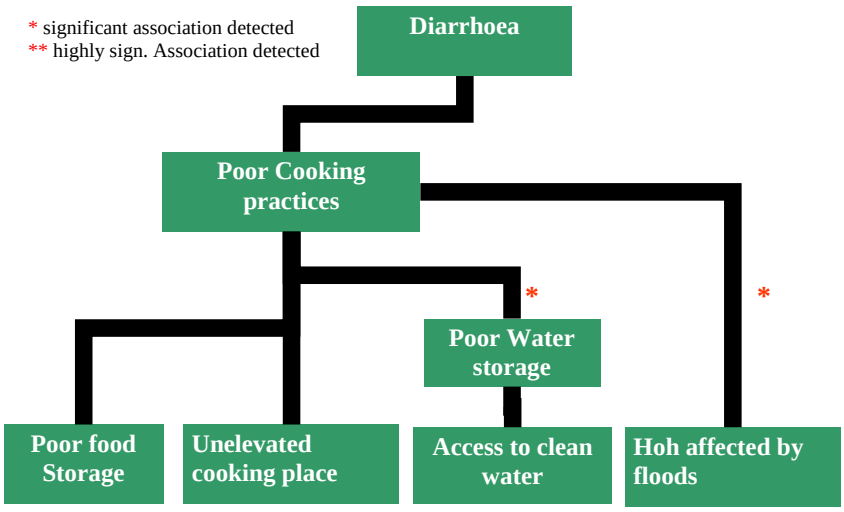


Animals are always kept within the compound and not far from the cooking place (see hypothesis 12).
Many household mentioned using water from tube wells to wash dishes but it is common to see women washing dishes and bath in ponds where water is stagnant. Dishes are usually dried in the sun.

We calculated a *cooking hygiene index*. This index is based on the answer to several questions related to cooking hygiene practice. Each answer corresponding to an appropriate practice would score 1. Each answer corresponding to an inappropriate practice would score 0. The *cooking hygiene index* if the sum of these answers.
It appears that this index is significantly related to the location of households. Households living in Gaibandha in the large rivers of Bramhapoutro or Jamuna have lower score ($p=0.001^*$). Lower score are significantly related to households living in flood affected area ($p=0.02^*$) but not to incomes.

Flooding season:
In the flooding season, all practices are strongly disturbed. Elevated storage of water has to be organised, storage of cooking utensils has to be adapted (often on the roof)…The survey occurred in winter season when the conditions are optimal for households.

16.1. Hypothesis pathway



Association of causal factors and undernutrition levels:

Causal factor	Relation with Wasting P value	Relation with Stunting P value	Relation with Diarrhoea P value
Cooking Hygiene Index	NS	NS	NS
Cooking place elevated	NS	NS	NS
Cooking utensils storage	NS	NS	NS
Clean cooking utensils	NS	NS	NS
Waste disposal	NS	NS	NS
Food storage method	NS	NS	NS
Water storage method	0.07	0.011*	NS

NS= Not significant association. * significant association with probability <5% ** significant association with probability <1%

NB: As associations with undernutrition need to be analysed taking into account all factors, please refer to the regression analysis and ranking section.

17. Hypothesis 13: 'High prevalence of diarrhoea'

The predominant types of diarrhoea are infectious (bacterial, viral or parasitic). Diarrhoea is highly prevalent in Bangladesh and in the chars: in our survey 20.5% of children had a diarrhoea episode in the past weeks as declared by the respondent. Interview with medical doctors, community health workers and FGD indicated clearly that diarrhoea episodes are more frequent during the winter peak and is mainly due to viral infection. Another peak

occurs during the flooding season. The main sources of contamination are water, food or hands, all of which are related to the control of excreta.

Control of excreta:

Control of Human excreta:

In our survey, 27% of women mentioned defecating in open space and 56% in a latrine. 80% of children below 5 years would defecate in open space or in the compound. However, from our interviews and FGD we can estimate that open space defecation is under-reported. Awareness programmes have reached island chars and knowledge of causes of diarrhoea are relatively well known (53% of respondents were able to mention three correct causes of diarrhoea and 90% at least one correct cause) as well as the good practices (83% mentioned using sandals when going to the latrines). However, from our observation and interviews, this knowledge is not practiced for several reasons.

⇨ *Access to latrines*

Some households do not own latrine (30% in our survey) and it is very shameful to use the one of a neighbour. This is especially true for women who need a safe and very private access to latrines. In our sample no single woman would use a latrine if it was not a private one ($p<0.001$).

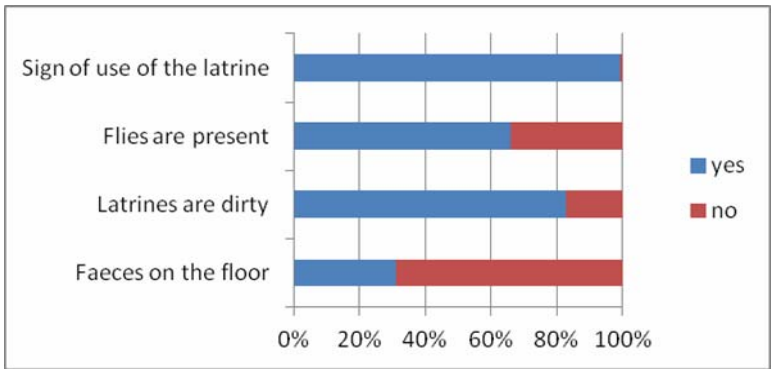
In our survey, owner of latrines were more significantly found in household not affected by floods ($p=0.025$) and for households which have settled in the same place for a longer period ($p<0.001$) whatever the district or the isolation of the village. Owners of latrines have also better economic resources ($p=0.003$), higher education levels ($p<0.001$) and better knowledge of causes of diarrhoea ($p=0.004$).

⇨ *Latrines conditions*

Ex of latrines observed in the chars during this survey:



Latrines were visited during the survey showing that latrines when available are almost all used but are often not well maintained in proper hygienic condition. It requires time, money and costly resistant materials. Platforms of latrines can be cemented (available in local market) but are often modified.



⇨ *Practices*

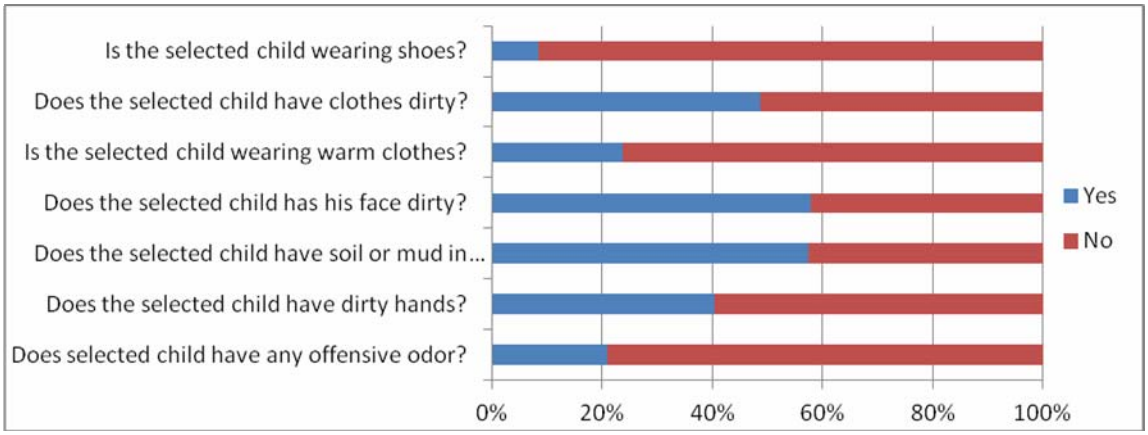
They vary across family members. For children of our survey, defecation in open space or in the compound is the most common practice. Women would use latrine if they have access to it. Men are more moving out of the household and not always use latrines.

Control of animal excreta:

Although contamination is minimal from animal excreta to humans, the proximity of humans and animals is striking in the chars. The situation is worth in the flooding season. In 78% of the households visited, human or animal faeces were visible in the compound, linked to the presence of animals. Cows, poultry, and goats are common and live in the household compound.

Contamination through dirty hands:

In our survey, we observed poor hygiene of the child measured (see graph below). Use of soap or ashes is not very practiced. Personal hygiene such as taking bath/shower regularly, washing clothes etc. are usually poor.



Contamination through food: refer to hypothesis 5.

Contamination through water:

Few households (15%) don't have tube wells in their compound. They fetch water in neighbouring tube wells (private or public). Water from tube wells is of good quality according to a recent survey from CLP. The water does not contain arsenic as in other regions of Bangladesh and acceptable bacterial contamination. Very few households boil or treat the water before drinking. Water in this area is rich in iron, which is according to researchers partly absorbed and would reduce iron deficiencies (see hyp 14).

Tube wells do not cost much (500 to 1000 tk) and water tables are quite easily accessible (most are 20-30 feet deep when 50 feet is recommended). They can be more or less deep, but most don't get dry. Some get flooded and useless in June/July /august period.

However they are rarely protected (16% are raised) or maintained in proper hygienic conditions with cemented platforms (15.4%). This increases the risk of contamination when collecting water. Households with cemented platforms are those with higher education levels ($p<0.001$**), higher knowledge of causes of diarrhoea ($p=0.013$*) and interestingly also those having a higher care practice score[13] ($p=0.028$*). Level of incomes is not significantly associated with cemented platforms ($p=0.101$).

Flooding season:

The survey took place during January and February 2011 but interviews, FGD and reports on the flooding season were important sources of information. Floods affect all sources of contamination. For houses affected by floods it is impossible to control excreta and maintain proper hygiene in the household.

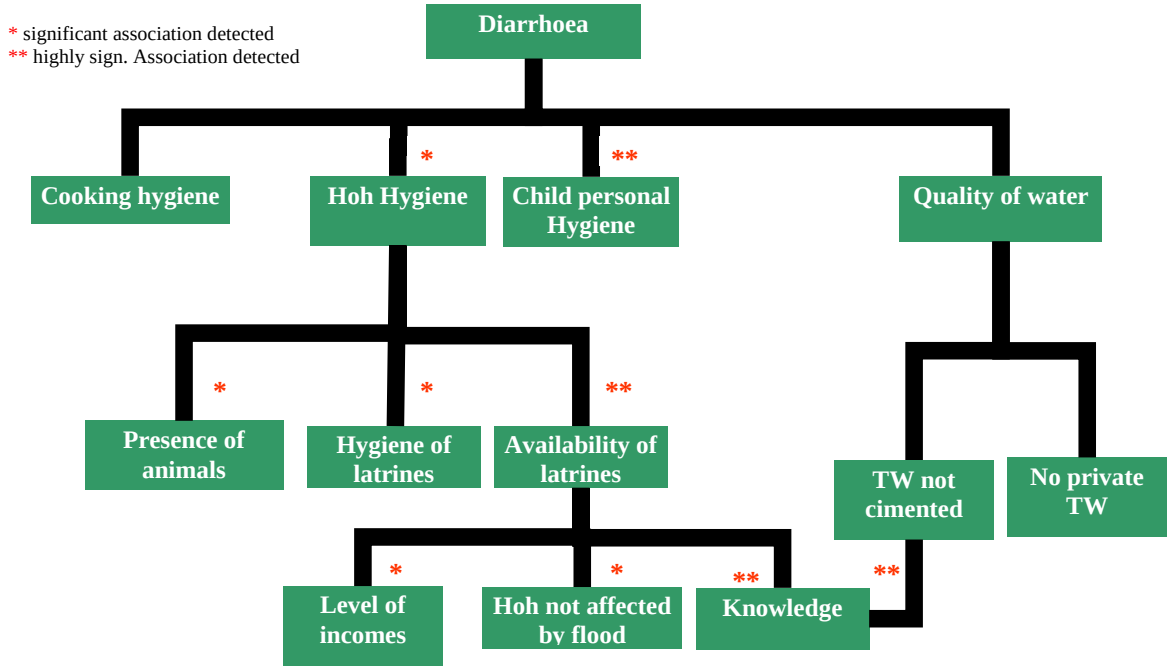
Use of latrine is not possible. Houses vulnerable to floods can have their latrines destroyed every year. Courage and money is necessary to rebuild them every year. These households are discouraged to build latrines and defecate in open space all year long.

Some tube wells are submerged forcing people to fetch water in non-affected private tube wells from neighbours. Storage of water becomes an issue. Hygienic cooking practices are also impossible to maintain.

Also, humans and animals are even more confined in the same environment for affected households.

[13] *Care Practices score is determined by observing mother and child interactions during the time of the interview. The higher the score, the closer the interaction.*

17.1. Hypothesis pathway



Association of causal factors and undernutrition levels:

Causal factor	Relation with Wasting P value	Relation with Stunting P value	Relation with Diarrhoea P value
Diarrhoea			
Cooking Hygiene	NS	NS	NS
Presence of poultry	0.015*	NS	NS
Presence of cows	NS	NS	NS
Presence of livestock	NS	NS	NS
Hygiene of child	NS	NS	NS
Household hygiene	NS	NS	0.001**
Latrine hygiene	NS	NS	NS
Declared use of latrine by women	NS	NS	NS
Declared use of latrine by children	NS	NS	0.007*
Owner of latrines	NS	NS	0.09
Hoh affected by floods	NS	NS	0.012*
Longevity in the same hoh	NS	NS	NS
Raised TW	NS	NS	NS
Cemented TW	NS	NS	NS

NS= Not significant association. * significant association with probability <5% ** significant association with probability <1%

NB: As associations with undernutrition need to be analysed taking into account all factors, please refer to the regression analysis and ranking section.

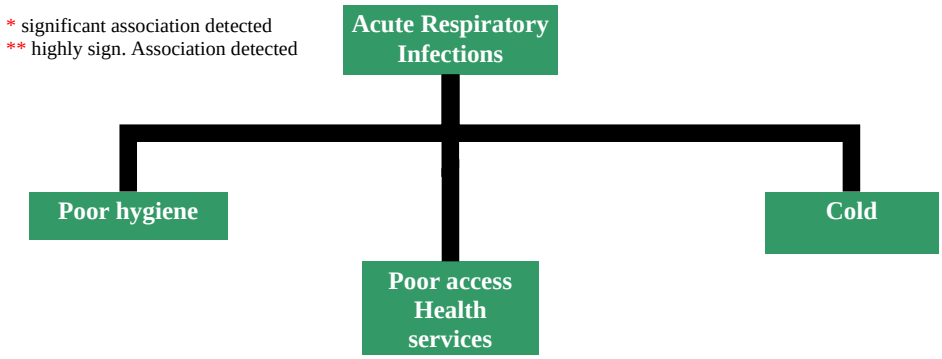
18. Hypothesis 14: 'High prevalence of Pneumonia'

Acute lower respiratory tract infection is the leading cause of childhood death globally and in Bangladesh. Most of cases are linked to viral infection (mainly Respiratory Syncytial Virus, an Influenza virus) although severe cases are often linked to a combined bacterial and viral infection. Antibiotic treatments of anaemia can therefore have a positive impact. Researchers have discovered that poor dental hygiene can increase a person's chances of getting aspiration pneumonia.

In our survey, 11% of children declared having trouble breathing and coughing in the past 2 weeks. It is a particularly common disease in the chars as temperature in the winter season can be very cold for short periods (less than 5°C). As it is often a short period of few weeks, families are not very well prepared and don't spend much money on warm clothes or warm shoes. The environment in the chars can be quite humid as well.

Proximity between family members in the house is another factor of contamination.
Due to a data collection issue (see below), it is difficult to reach conclusions on this hypothesis but health workers and mothers confirmed it is a common issue at this time of year especially for young children. Viral diarrhoea is also common at the same time of year but only mycoplasma pneumonia can lead to diarrhoea.

18.1. Hypothesis pathway:



Association of causal factors and undernutrition levels:

Data collection issues: There are some doubts regarding the quality of the data collected for respiratory infections. One of our four teams had a significantly different prevalence of coughing. Information from this team was therefore removed from the database but this can be a sign that the question might have been handled differently from one team to another leading to doubts about the quality of this specific question.

Causal factor	Relation with Wasting P value	Relation with Stunting P value	Relation with Coughing P value
Coughing	NS	NS	
Child hygiene	NS	NS	NS
Child wearing cloth	NS	NS	NS
Child wearing shoes	NS	NS	0.026* more coughing when child wears shoes
Island vs. connected char	0.042* more wasting in island chars	NS	0.029* more coughing in connected chars
District location	NS	NS	0.005** More coughing in Lalmonirhat

NS= Not significant association. * significant association with probability <5% ** significant association with probability <1%

NB: As associations with undernutrition need to be analysed taking into account all factors, please refer to the regression analysis and ranking section.

19. Hypothesis 15: 'Micronutrient deficiencies'

Micronutrient deficiencies are a specific type of undernutrition but are also related to wasting and stunting. Three main nutrients are here considered: Iron, vit A and iodine. Due to less consumption of different vegetables and fruits, micronutrient deficiencies are high among the population of the chars. During the field visit we found the skin disease, cracks in the lips, inflammation in the tongue were common among most of the children and mothers. These has also been confirmed by the health centres and hospitals visited.

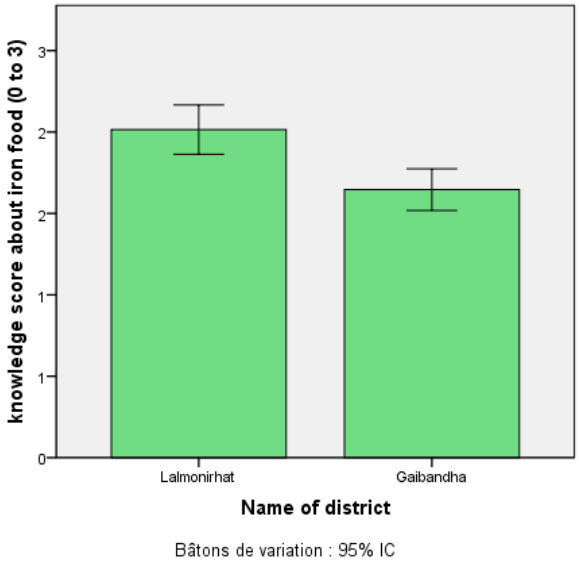
Vit A deficiencies:

Vit-A deficiencies weakens the immune system, often causing children to become ill, increasing the risk of mortality and undernutrition. Regions with high mortality rates of children such as Bangladesh are likely to have a vit-A deficiency problem. Studies in Bangladesh have confirmed widespread low intakes of vitamin A in the diet and high prevalences of signs and symptoms of xerophthalmia (sign of vit-A deficiency). These prevalences are all well in excess of WHO threshold levels at which a major public health problem is considered to exist. During our field survey, while visiting one of the family planning clinics, we found 2 children with difficulties at night vision which is a first sign of Vit-A deficiencies.

Few vegetable rich in vit-A are found in the chars and milk/liver is too rarely consumed. In the questionnaire, we found that 40% of children had vit-A rich food during the past 7 days and in the vast majority of cases, it was once per week. It is not linked to the presence or not of a vegetable garden. *The main source of vit-A are eggs* and there is a

significant association of poultry ownership and vit-A rich food taken by the child (p=0.05*).
Interestingly vit A intake of the child is not linked to the level of education or knowledge on nutrient contents of food but is linked to the fact that women received ante natal care and micronutrients during their pregnancy (p=0.008*). Leafy vegetables are not very well appreciated in the chars and can explain also these associations. Multivitamins supplements are easily found in local pharmacies.

Iron



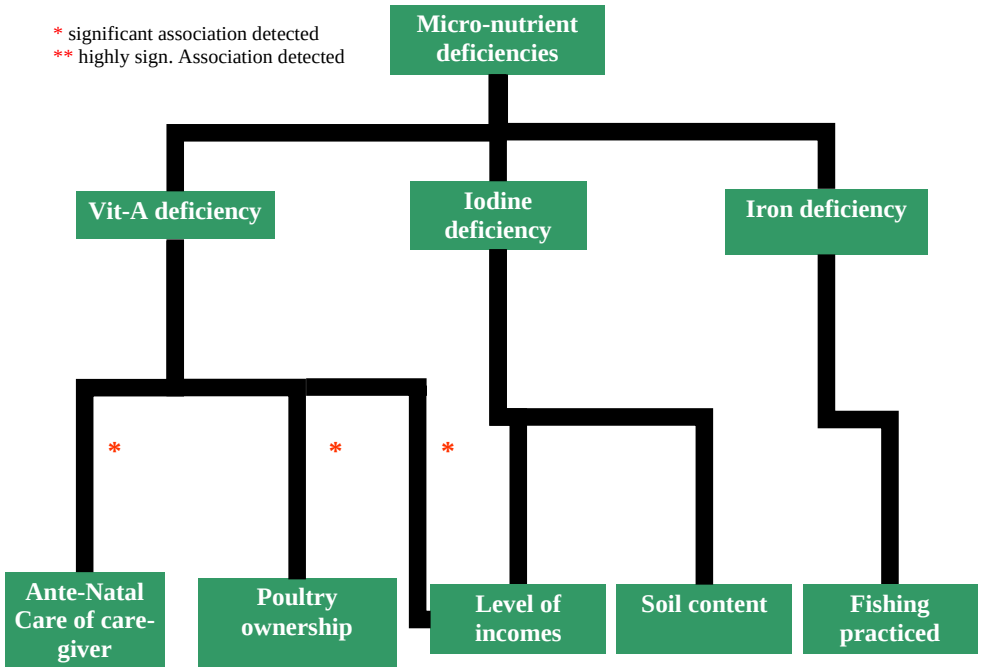
Anaemia prevalence in Gaibandha district is around 25% for adult women and is not associated with incomes levels according to local studies.[14] Iron rich ground water could explain the relatively low level of anaemia in this region as compared to data at national level (40% prevalence for adult women). Anaemia was not measured during this survey. Only 15% of respondents were *not* able to mention one source of food rich in iron and 25% were able to mention three types of iron rich food. *The level of knowledge is moderately good but could be improved, especially in Gaibandha district:*

Iodine

Iodine deficiency is another major health problem in this area and can be seen with goiter mainly on adults. Discussion with different NGOs and health professionals confirmed that due to frequent flood in this area, the soil loose iodine. Local crops do not contain enough iodine. Fish and eggs can be a good source of iodine as almost nobody is using iodized salt for cooking. Iodine salt is also available on the market but 50% more expensive and the vast majority don't buy it in order to keep as much money as possible.

[14] '*The burden of anemia in rural Bangladesh: the need for urgent action'* National surveillance project. HKI, IPHN. Bulletin n16.2006

19.1. Hypothesis pathway



Association of causal factors and undernutrition levels:

Causal factor	Relation with Wasting P value	Relation with Stunting P value
Vit A rich food	NS	NS
Knowledge of iron rich food	NS	NS

NS= Not significant association. * significant association with probability <5% ** significant association with probability <1%

NB: As associations with undernutrition need to be analysed taking into account all factors, please refer to the regression analysis and ranking section.

20. Regression analysis

Based on the descriptive analysis of each hypothesis, we selected the causal factors which seem to be the most significant in explaining undernutrition (wasting and stunting). We then classified these factors by immediate / underlying / basic causes to avoid strong correlations between the variables of the model.

We did linear regressions testing each model with Weight for Height Z scores and Height for Age Z score.

We did logistic regressions testing each model with wasting (wasted vs non-wasted) and stunting (stunted versus non-stunted).

In all the models we included age and sex as a control variable.

We did this analysis taking into consideration all the sample and, in a second step, taking younger and older age groups.

The following tables present the results schematically, introducing only causal factors that were significantly contributing to the model.

The R^2 value precise the percentage of the variance explained by the model.

ASSOCIATIONS WITH WASTING

	ALL SAMPLE	**CHILDREN < 24 Months**	**CHILDREN >= 24 Months**
Immediate causes	NS	NS	NS
Underlying causes	NS	R^2=10.9% Age of child Timely initiation of Breastfeeding Food taken by mother during pregnancy	R^2=2% Poultry ownership (more poultry more wasting)
Basic causes	R^2=5.6% Education level	NS	R^2 = 9.1 % Education level Unequal land distribution

ASSOCIATIONS WITH STUNTING

	ALL SAMPLE	CHILDREN < 24 Months	CHILDREN >= 24 Months
Immediate causes	R^2=1.3% Age of child	R^2=17.8% Sex of child Feeding index	NS
Underlying causes	R^2=5.7% Age of Child Child hygiene Cattle/goat ownership	R^2=9.5% Age of child	R^2=2.9% Child hygiene
Basic causes	NS	R^2=37.4% Age of child Unequal land distribution Education level	NS

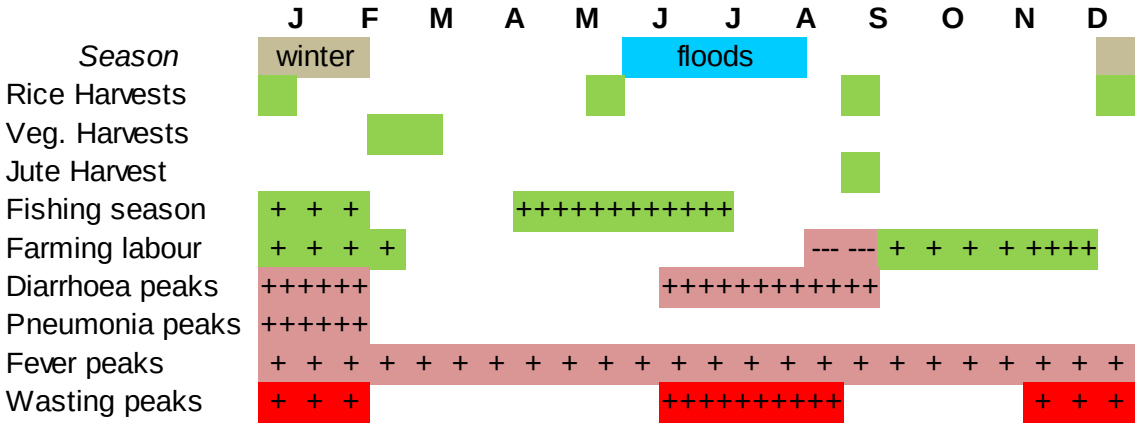
R^2= % of variance explained by the model (when model p value<0.05)
NS: model not significant (when model p value>0.05)

The linear regression models were able to explain up to 37% of the variance of undernutrition. As a comparison, the analysis of Bangladesh Demographic and Health Survey explains less than 20% of the variance with much larger samples. There are indeed several constraints in this type of analysis (refer to the limitation section of the methodology).

It is interesting to see in these models which risk factor is identified as a significant contributor. The significant risk factors identified are different for the two age groups. This result was expected. The added value of these models is that they consider the association with other risk factors. The risk factors identified have an association with undernutrition that is independent with the other risk factors in the model.

21. Seasonality of undernutrition

Main factors affecting undernutrition are seasonal. Life in the chars follows the flows of the rivers and the coldness of winter. Agriculture, fishing, diseases, hygiene and wasting are changing during the year. There are two peaks of wasting: the major one during the floods and soon after and a less important one during the winter time. The following seasonal calendar has been established after a large number of interviews (farmers, community workers, health workers) and after reviewing information from HKI national surveillance systems.



22. Ranking Hypothesis

Using all the information collected from regression analysis, descriptive analysis and qualitative analysis, we have ranked causes of undernutrition. As mentioned in the methodological section this ranking is judgemental but based on objective criteria. A review of the justification of this ranking is detailed at the end of this section.

Hypothesis	Evidence from regression analysis[1]	Evidence from descriptive analysis[2]	Evidence from qualitative analysis[3]	Ranking conclusion[4]
H1, Food production	(+)	(+)	(-)	Low priority
H2, Access to food	(-)	(+)	(+)	Low priority
H3, Intra hoh food distribution	(-)	(+)	(-)	Rejected
H4, Diet Diversity	(+)	(+)	(-)	Low priority
H5, Breastfeeding practices	(++)	(++)	(++)	Major cause
H6, Complementary feeding practices	(++)	(+)	(++)	Major cause
H7, Low birth Weight	(+)	(++)	(++)	Major cause
H8, Psychological care	?	?	(+)	Untested
H9, Limited social services available	(+)	(+)	(+)	Important cause
H10, Immunisation coverage	(-)	(-)	(-)	Rejected
H11: Poor Health Seeking behaviours	?	(+)	(++)	Important cause
H12, Unhygienic cooking practices	?	(-)	(-)	Rejected
H13, Prevalence of Diarrhoea	(+)	(+)	(++)	Major cause
H14, Prevalence of Pneumonia	?	?	(++)	Major cause
H15, micronutrient deficiencies	?	?	(+)	Untested

RULES FOR RANKING:

1: Based upon linear and logistic regression models presented in section 20

(-) if no causal factors associated with undernutrition
(+): when causal factors are associated;
(++) when causal factors are strongly associated ($p<0.001$) in several models.
(?) when unable to test the hypothesis (lack of indicator of poor quality of the data collected)

2: Based upon descriptive analysis presented in section5 to 19

(-) when descriptive analysis is not coherent with the problem tree.
(+) when descriptive analysis and problem tree are coherent.
(++) when descriptive analysis is coherent and association among causal factors are strongly significant ($p<0.001$).

3: Based upon secondary data review, Focus groups discussions, Key informants interviews, NCA workshops, seasonal calendar, historical trends of undernutrition presented in sections 4 and 21

4: based on the three sources of information collected and interpretation, the hypothesis are ranked between 4 categories

Major cause / Important cause /low priority causes : based upon the perceived level of their impact on undernutrition levels.
Rejected cause: Evidence gathered suggests that this hypothesis is not a strong driver of undernutrition.
Untested cause: Evidence gathered is not enough to support the classification. Further evidence need to be collected to submit a judgement.

The following table, based on the seasonal calendar and qualitative assessment, is estimating the ranking of causes for the flooding season.

	Winter Season (time of the survey)	Estimation for Flooding season
Major Causes	H5: Breastfeeding practices H6: Complementary feeding practices H7: Low birth Weight H13: Prevalence of Diarrhoea H14: Prevalence of Pneumonia	H5: Breastfeeding practices H6: Complementary feeding practices H7: Low birth Weight H13: Prevalence of Diarrhoea H2: Access to food H4: Diet Diversity
Important Causes	H9: Limited social services available H11: Poor Health Seeking behaviours	H9: Limited social services available H11: Poor Health Seeking behaviours H1: Food production
Low Priority causes	H1: Food production H2: Access to food H4: Diet Diversity	H14: Prevalence of Pneumonia
Rejected Hypothesis	H3: Intra hoh food distribution H10: Immunisation coverage H12: Unhygienic cooking practices	H3: Intra hoh food distribution H10: Immunisation coverage H12: Unhygienic cooking practices
Untested Hypothesis	H8: Psychological care H15: micronutrient deficiencies	H8: Psychological care H15: micronutrient deficiencies

Justification for the ranking:

H1, Food production

Land access is the priority issue of a majority of households. Land ownership is related to undernutrition but not food production. Land ownership is more than that: it is a social and political status. No other factors were linked to undernutrition. It has been therefore classified as a low priority causes for the winter season. However, food production is estimated to become an important cause in the monga season were household food access is much more difficult which will impact the child food intake.

H2, Access to food

Access to food can be adequate with complementary economic activities. Some households without land are doing well. At the time of the study (winter season) no factors related to food access were associated with undernutrition. Nevertheless, the peak of wasting before the harvest season and when economic opportunities are limited is a important information. Furthermore (referring to the descriptive analysis of the hypothesis 2), FGD have clearly establish a dramatic decrease of food access during the flooding season, especially for poorest households. This indicates an important contribution of food access as a risk factor of undernutrition during the flooding season.

H3, Intra hoh food distribution

We have seen that in fact poor households with limited access to food are coping by prioritising their child (more boys than girls). It has a positive (and not a negative) impact on the diet of the child. It is important to note that this coping mechanism is not possible in the monga season as access to food is too poor. Also, it is important to consider the food intake of women which must be very poor in those cases (refer to hypothesis on low birth weight). This hypothesis is therefore rejected.

H4, Diet Diversity

Diet diversity of the child is not linked to undernutrition levels of the child. Diet diversity levels are not too bad. Considering that we are in the best season of the year for food access, we can certainly assume that the flooding season is having a major impact on the diet of the child.

H5, Breastfeeding practices

Regression and descriptive analysis have been able to detect the association between initiation of breastfeeding and wasting. Breastfeeding practices are supposed not to change with season as it is mainly linked with traditional practices. It is a major cause all year round.

H6, Complementary feeding practices

Complementary feeding practices are depending on both traditional practices and economic resources of the household. Child feeding index is related to stunting. Descriptive analysis showed that there is still an important (and certainly underestimated) percentage of women not having appropriate practices. It can get only worse in the flooding season.

H7, Low birth Weight

Although it was not possible to measure LBW from this study, LBW prevalence, descriptive analysis and a concomitance of information (traditional practices, women care, seasonality of birth, micronutrient deficiencies) indicate that is must be a major factor of growth retardation. Academic studies have demonstrated the impact Low Birth Weight can have on undernutrition. Having such a high prevalence of LBW in our area of study must not be ignored even if it is not measurable during a cross sectional survey.

H8, Psychological care

This hypothesis has not been tested as it was lately incorporated in the study. It is an area to explore further as there are some indications (adolescent mother, domestic violence, instability…) that it could be a significant factor.

H9, Limited social services available

We have not been able to directly measure this cause but we have clearly identified obvious needs in terms of health services, nutrition services, and social services that are not available in some villages. Island chars of Gaibandha are particularly affected. People living in island chars have significantly higher levels of wasting and people not benefiting from social programmes have significantly higher levels of stunting. A plausible explanation is the lack of social services accessible to local populations.

H10, Immunisation coverage

Immunisation is critical in this environment with high prevalence of diseases and poor immune systems of children born with LBW. However we found good vaccination coverage.

The coverage could still be improved with better logistic and communication organisation. It was not linked with undernutrition and therefore this hypothesis is rejected.

H11: Poor Health Seeking behaviours
It is an important issue partly explaining the important health issues. It is often a long and difficult way to get cured. From looking for advices, taking the decision, moving to the appropriate service, getting organised with relatives, it can take a long time which can aggravate the health condition of children.

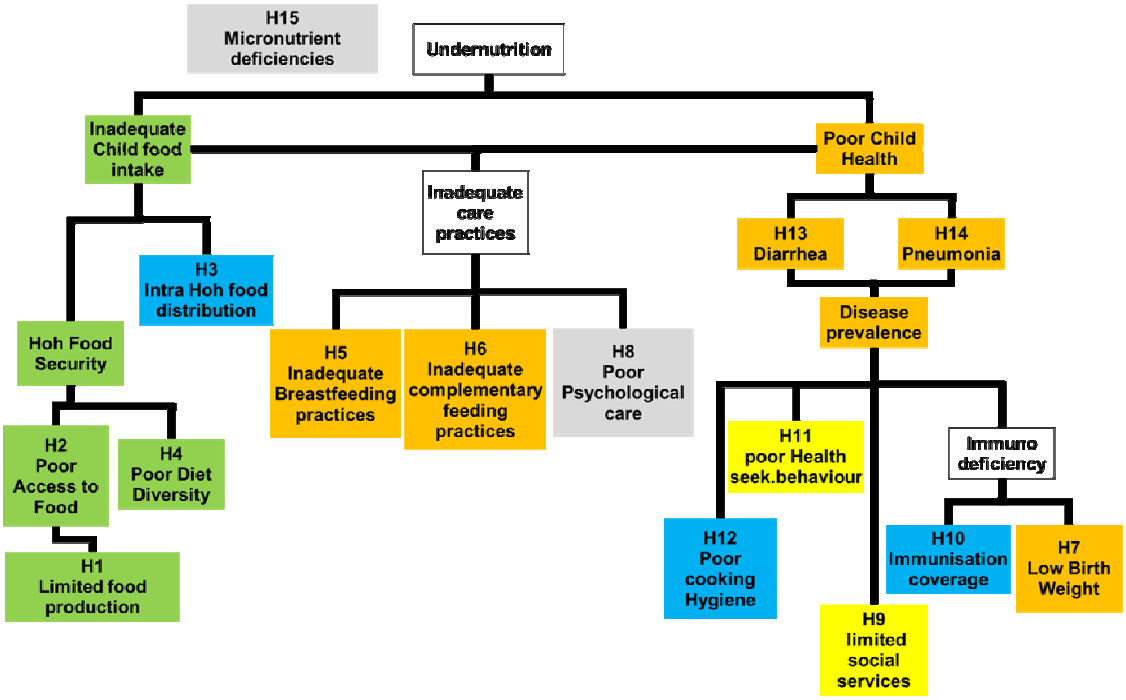
H12, Unhygienic cooking practices
There was no evidence of association with undernutrition or diseases. Although practices must be worse in the flooding season we rejected this hypothesis.

H13, Prevalence of Diarrhoea
Although we were not able to detect association with undernutrition, we maintain that diarrhoea is a major factor associated with undernutrition. Looking at seasonal variation of diarrhoea and wasting which are concomitant and interviews with key informants are supporting this classification.

H14, Prevalence of Pneumonia
ARI and especially pneumonia are highly prevalent in the winter season. It coincides with a peak of wasting and is believed to be a major cause during that season. In the other seasons of the year, it does not seem to be an important issue.

H15, micronutrient deficiencies
It has not been able to test this hypothesis during this survey.

Causal model during Winter Season



Causal model during Flooding Season