MSc Thesis Report

Nanette van der Spek
Student number 910611789100

'The association between complementary feeding indicators and linear child growth and the determinants of inappropriate feeding practices among children 6-23 months in Rwanda.'

- A secondary analysis of the 2010 Demographic and Health Survey -

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Examiner:	Prof. Dr.Ir. Ellen Kampman
Daily supervisor:	Dr.Ir. Alida Melse
Extra supervisor:	Dr.Ir. Renate Winkels

Wageningen University
Division of Epidemiology and Public Health
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ABSTRACT

Inappropriate complementary feeding practices are one of the major causes of linear child growth retardation in the first two years of life. This study is done to estimate the prevalence of the WHO complementary feeding indicators *continued breastfeeding at one year, timely introduction of complementary feeding, minimum dietary diversity, minimum meal frequency* and *minimal acceptable diet* among 6-23 months old children in Rwanda. Cross-sectional data on 2393 children aged 6-23 months was obtained from the 2010 Rwanda Demographic and Health Survey. Cox Proportional Hazard models were used to assess the association of the WHO indicators and linear child growth and to identify the most important determinants of inappropriate complementary feeding practices. This secondary analysis showed that most of the complementary feeding practices were inappropriate for children of 6-23 months in Rwanda. The minimum dietary diversity reached a percentage of 29.7%, the minimum meal frequency was reached by 50.1% of the children and the minimal acceptable diet by 20.2%, which means that only one in five children of 6-23 months consumed an acceptable diet. Timely introduction of solid, semi-solid and soft foods was reached by almost 64% of the sample and the continued breastfeeding rate at 1 year was rather high (95%). Multivariate analysis showed that age of the child, maternal education, maternal age, household wealth index and working status of the mother were important determinants of inappropriate complementary feeding practises. Especially younger children (6-11 months), children from the Western region of Rwanda and children living on the highest altitudes need to be targeted with infant and young child feeding interventions. Further in-depth research is needed on dietary quantity and quality to be able to understand specific nutrient gaps in the diet of these children.

Keywords: Complementary feeding, infant and young child nutrition, WHO indicators, linear child growth, stunting, Demographic and Health Survey, Rwanda.

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INTRODUCTION

The prevalence of stunting worldwide declined between 2000 and 2013 from 33% to 25% (UNICEF/WHO/WorldBank 2013). This decrease in stunting has a positive impact on achieving the 4th Millennium Development Goal of reducing the mortality of children under 5 by two-third, between 1990 and 2015. However, in Rwanda the number of under-five stunted children is still very high, with a prevalence of 44% in 2010, from which 17% was severely stunted (RDHS 2010). These numbers are worrying as stunting is associated with risks of short-term morbidity and mortality, non-communicable diseases in later life, declined learning capacity and lower productivity (Black et al. 2013; McDonald et al. 2013).

Stunted growth (*linear child growth retardation*) has multiple causes and is thought to begin even prior to birth through intra uterine growth restriction (IUGR). After this period, it generally continues during the first two years of the child's life in which most of the stunting occurs during the complementary feeding period, between 6-23 months of age (Brown et al. 1998). It has been estimated that by ensuring optimal complementary feeding 5% of deaths among children under 5 years of age could be prevented (Jones et al. 2003).

The period of 6-23 months is important because as the child grows and becomes more active, breast milk alone is no longer sufficient to meet the child's nutritional needs. Complementary feeding needs to be introduced to fill this energy and nutrient gap and prevent the child from becoming stunted. In the transition to participating in the family diet children of the age of 6 months and older should be fed small quantities of adequate and safe solid and semi-solid foods throughout the day (WHO 2003). Despite these recommendations and the health benefits of appropriate complementary feeding, inappropriate complementary feeding is commonly practiced in many low- and middle-income countries. This is partly due to the fact that complementary feeding consists of a complex set of behaviours, comprising timing of introduction, food choices to ensure dietary diversity, preparation methods, food quantity, feeding frequency, responsiveness to infant cues, and safe preparation and storage of foods (Stewart 2013). Each behaviour, in turn, may have context-specific determinants that influence these complementary feeding practices.

Previous studies on complementary feeding practices show that younger maternal age, lower maternal education, unemployment, non-marital status of the mother, inadequate antenatal clinic visits, lack of post-natal care visits, infant delivered at home, young infant age, male sex of the infant, poor household wealth status, inadequate maternal exposure to mass media (newspaper, television, radio) and geographical differences are the main risk factors associated with inappropriate complementary feeding practices among children aged 6-23 months in developing countries (Patel et al. 2010; Kimani-Murage et al. 2011; Hazir et al. 2012; Joshi et al. 2012; Kabir et al. 2012; Senarath et al. 2012; Victor et al. 2012; Aemro et al. 2013). However, these determinants were not consistent between countries and specific areas, suggesting that the context is important when trying to determine factors that will be targeted in interventions. To effectively influence complementary feeding behaviour in a specific country through the development and strengthening of intervention programs, you need to have comprehensive knowledge about the risk factors associated with this behaviour in that particular local context.

Until now, there has been no scientific literature published on determinants that influence complementary feeding practices in Rwanda. Solely, the 2010 Rwanda Demographic and Health Survey provides some information about infant and young child feeding practices. The DHS collected information about the number of times a child is fed (feeding frequency) and from how many food groups this food was consumed (food diversity). According to the results 25% of breastfed children age 6-23 months were given foods from four or more food groups in the 24 hours preceding the survey, and 51% were fed the minimum number of times in the preceding 24 hours. Only one in five (17%) breastfed children fell into both categories; that is, their feeding practices met minimum standards with respect to food diversity as well as feeding frequency (RDHS 2010). Clearly, research is needed to identify predictors of complementary feeding practices in order to increase the percentage of children that is fed appropriately. This study is done to estimate the prevalence of the WHO complementary feeding indicators *continued breastfeeding at one year, timely introduction of complementary feeding, minimum dietary diversity, minimum meal frequency* and *minimal acceptable diet*. Furthermore, the association of these indicators with linear child growth will be investigated and the determinants of the inappropriate complementary feeding practices among 6-23 months old children in Rwanda will be determined, using the 2010 Demographic and Health Survey.

Study objectives

Objective 1: To estimate the prevalence of the WHO complementary feeding indicators *continued breastfeeding at one year, timely introduction of complementary feeding, minimum dietary diversity, minimum meal frequency* and *minimal acceptable diet* among 6-23 months old children in Rwanda, using the 2010 Demographic and Health Survey.

Objective 2: To explore the association of the WHO complementary feeding indicators with linear child growth outcomes among 6-23 months old children in Rwanda, using the 2010 Demographic and Health Survey.

Objective 3: To identify determinants of inappropriate complementary feeding practices among 6-23 months old children in Rwanda, using the 2010 Demographic and Health Survey.

METHODOLOGY

STUDY DESIGN AND DATA COLLECTION

The data source for the study was the cross-sectional data of the 2010 Rwanda Demographic and Health Survey (2010 RDHS), a nationally representative survey funded by the U.S. Agency for International Development (USAID). It has a wide range of monitoring and impact evaluation indicators in the field of population, health and nutrition. The objective of the survey is to provide up-to-date information on fertility, family planning, childhood mortality, nutrition, maternal and child health, domestic violence, malaria, maternal mortality, awareness and behaviour regarding HIV/AIDS, HIV prevalence, malaria prevalence, and anaemia prevalence. This study is a secondary analysis of the 2010 Rwanda Demographic Health Survey. We registered and requested for access to data from DHS online archive and received an approval to access and download de-identified DHS data files. The DHS procedures and the use of the data for research purposes have been previously approved by the Rwanda National Ethics Committee and the Institutional Review Board of ICF International.

The field work of the 2010 RDHS was conducted from September 26 2010 until March 10 2011 and carried out by the National Institute of Statistics of Rwanda (NISR) in collaboration with the Ministry of Health (MoH). The sampling procedure was done using a two-stage sample design. The first stage involved selecting 492 villages, selected with probability proportional to the villages' size and with independent selection in each sampling stratum. The second stage of the design involved the sampling of 26 households of each selected village. Information was collected on households, women and men age 15-49, and children under the age of 5 within the household. Following this procedure, a nationally representative sample of 13.671 women (age 15-49) from 12.540 surveyed households, and 6.329 men (age 15-59) from half of these households, were interviewed. This represents a response rate of 99 percent for women and 99 percent for men (RDHS 2010). The DHS included an anthropometric component in which height and weight measurements of men and women, and children under 5 years old in a subsample of 50% of the households was collected.

The total weighted sample size consisted of 2393 last-born children aged 6-23 months who were living with the respondent at the time of the survey. Multiple children from one mother were only included in the analysis if the children were born at the same time (twins). See Appendix I for dataset construction and inclusion/exclusion flow chart. HAZ-scores and stunting were calculated for the weighted subsample from whom height and age information was collected (n = 1181), using the 2006 WHO Child Growth Standards (De Onis 2006).

ASSESSMENT OF COMPLEMENTARY FEEDING INDICATORS

The new and updated WHO Infant and Young Child Feeding (IYCF) indicators were used to assess the complementary feeding practices in Rwanda (WHO 2008). The WHO defined eight core infant feeding indicators and four optional indicators, based on a recall of the mother on foods given to her child in the 24 hours preceding the survey. Five of these indicators, concerning complementary feeding practices, were calculated (see Table 1) with some modifications due to limitations of the collected data in the RDHS 2010 (see Missing value analysis, Appendix II).

For extended information and descriptions of the five WHO indicators for complementary feeding practices, see Appendix III.

Table 1: WHO indicators for complementary feeding practices.

Indicator	Definition
Continued breastfeeding at 1 year	Proportion of children 12-15 months of age who are fed breast milk.
Timely introduction of solid, semi-solid or soft food	Proportion of children 6–8 months of age who receive solid, semi-solid or soft foods.
Minimum dietary diversity	Proportion of children 6-23 months of age who received foods from four or more food groups of the seven food groups. Remarks The different food groups are categorized as: a. infant formula, milk other than breast milk, cheese or yogurt or other milk products; b. foods made from grains, roots, and tubers, including porridge and fortified baby food from grains; c. vitamin A-rich fruits and vegetables; d. other fruits and vegetables; e. eggs; f. meat, poultry, fish, and shellfish (and organ meats); g. legumes and nuts. (for further explanation and details of the different food groups, see appendix IV).
Minimum meal frequency	Proportion of breastfed and non-breastfed children 6-23 months of age who received solid, semi-solid or soft foods (also including milk feeds for non-breastfed children) the minimum number of times or more. Remarks Minimum is defined as twice for breastfed infants 6-8 months, three times for breastfed children 9-23 months and four times for non-breastfed children 6-23 months. Meals include both meals and snacks.
Minimum acceptable diet	This indicator is calculated for breastfed children 6-23 months as having at least the minimum dietary diversity and the minimum meal frequency during the previous day and for non-breastfed children 6-23 months as receiving at least two milk feedings and having at least the minimum dietary diversity not including milk feeds, and the minimum meal frequency during the previous day. Remarks See remarks minimum dietary diversity and minimum meal frequency.

The complementary feeding indicators were expressed as dichotomous variables with value 0 for not meeting the indicator criteria and value 1 for meeting the indicator criteria. The prevalence of the indicators was calculated for the age groups of 6-11 months, 12-17 months, 18-23 months and 6-23 months. This was also done for the two separate groups (n = 2393 and n = 1181) to see whether the indicators were similar for both groups. If they were similar, the prevalence of the indicators for the total sample (n = 2393) could be used for further analyses. In case of non-similarity, solely the subsample (n = 1181) would be used to calculate the indicators which causes the loss of 1213 subjects.

Assessment of anthropometric measurements (linear child growth)

To assess linear child growth height-for-age Z-scores and the prevalence of stunting was calculated for the study population. According to the World Health Organisation, stunting is defined as the height-for-age Z-score of a child being more than two standard deviations (<-2SD) below the median height-for-age of the WHO Child Growth Standards (De Onis 2006). Stunting was divided into three groups of severely stunted (HAZ <-3SD), moderately stunted (-3SD ≥ HAZ <-2SD) and non-stunted (HAZ ≥-2SD) children. HAZ-scores and stunting were calculated for a subsample for which height and age information was collected. This subsample consisted of 1181 children, which is 49.5% of the total study sample. This is in line with the subsample of 50% of all the households with children under 5 years of age of which the RDHS 2010 collected anthropometric measurements. Height measurements were carried out using a Shorr measuring board, produced under the guidance of UNICEF. The children's height was measured lying down on the board (recumbent length).

Association between complementary feeding indicators and linear child growth

To investigate whether the complementary feeding indicators were associated with linear child growth, covariates that are known to be associated with linear child growth needed to be taken into account to correct for their effect on the outcome measure. Covariates that were selected to include in the model description are: age of the child, sex of the child, duration of breastfeeding, preceding birth interval, size of the child at birth, maternal age, maternal BMI, maternal education level, frequency of watching television and reading the newspaper and wealth index of the household as a measure of social economic status. Community covariates that were included were residence, geographical region, altitude of the community and access to safe drinking water and proper sanitation.

The Wealth Index (divided into quintiles) is a proxy of socio economic status (SES) and was constructed by the DHS using information concerning the household's ownership of a number of consumer items such as a television and car; dwelling characteristics such as flooring material; type of drinking water source; toilet facilities; and other characteristics that are related to wealth status (RDHS 2010).

Households had access to safe drinking water if they had access to an improved drinking water source which was located on premises or could be reached within 30 minutes (roundtrip). Improved drinking water sources included: piped water into dwelling; plot or yard; public tap/standpipe; borehole or tube well; protected (dug) well; protected spring; rainwater and bottled water. Previous survey data showed that most people who use bottled water as their main source of drinking water also have piped water on premises as a secondary source and is therefore considered as an improved water source (WHO 2012). Improved drinking water sources did not include unprotected wells, unprotected springs, water provided by carts with small tanks, tanker truck provided water and surface water taken directly from rivers, ponds, streams, lakes, dams or irrigation channels. Households had access to proper sanitation if they made use of improved sanitations facilities. Improved sanitation facilities included the facilities that properly separate human excreta from human contact: flush or pour-flush toilet/latrine to piped sewer system, septic tank or pit latrine; ventilated improved pit (VIP) latrine; pit latrine with slab or a composing toilet. Households that had access to one of the improved sanitation facilities but had to share them with two or more households were considered to have no access to an improved sanitation facility. Unimproved sanitation facilities included: pit latrines without slab or platforms or open pit; hanging latrines;

bucket latrines; open defecation in fields, forests, bushes, bodies of water or other open spaces, or disposal of human faeces with other forms of solid waste (UNICEF/WHO 2012).

Explanatory variables of inappropriate complementary feeding practices

Selection of factors that were included to investigate determinants for inappropriate complementary feeding practices were based on previous published evidence and divided into four groups of factors. The individual factors of the child included sex, age, whether the child was of multiple birth, whether the child was currently breastfed, birth order number, preceding birth interval, size of the child at birth and whether the child had diarrhoea episodes. The maternal/household factors included maternal age, maternal height, maternal BMI, whether the mother was stunted herself, the age of the mother at first birth, maternal working status, maternal education, maternal literacy, religion, wealth index, frequency of listening to the radio, watching TV or reading newspaper of magazine, number of household members and number of children under 5 in the household. The health care factors included the number of antenatal clinic visits during pregnancy, the place of delivery of the infant, the type of delivery assistance and the access to postnatal health care. Access to postnatal health care was assessed on whether the mother reported that the child had a health card. If the mother reported that they lost the card or never received a card, they were classified as not having a card. The community factors included residence (urban/rural), geographical region, the altitude of the community in meters and the access to safe drinking water and proper sanitation.

Statistical analysis

Because of the non-proportional allocation of the sample to the different provinces and to their districts and the possible differences in response rates, the use of sampling weights was required for all analysis. These weights accounted for the complex multi-stage survey design and corrected the standard errors appropriately to ensure the actual representativeness of the survey results at the national level (RDHS 2010). Ignoring oversampling of the population as a result of disproportionate multistage sampling runs the risk of biased point estimates and underestimation of standard errors.

Before conducting statistical analyses for the study objectives, data was checked for completeness, certain variables were recoded after which a missing value analysis was performed due to the high number of missing values in the RDHS 2010 (see Appendix V for Codebook; see Appendix II for Missing value analysis). After cleaning data for inconsistencies and missing values, descriptive statistics were used to present the prevalence of the baseline characteristics of the study sample. This was conducted for both the complete sample (n = 2393) and the subsample for whom valid anthropometric measurements were available (n = 1181) to see whether this subsample represented the complete sample. Baseline characteristics were also represented for stunted and non-stunted children separately. Chi-squared tests were used to test whether the differences for the categorical variables were statistically significant. Missing values were excluded for analysis.

Cox proportional hazard models were used to assess the relationship between the different complementary feeding indicator rates and moderate stunting (-2SD), severe stunting (-3SD) and height-for-age z-scores (HAZ). Results for the relationship with stunting were presented as prevalence ratios (PRs) with 95% CIs. Prevalence ratios were used as stunting is not rare and therefore using odd ratios would overestimate the association. Results for the relationship with HAZ-scores were presented as β-parameter estimates with 95% CI.

The complementary feeding indicators were examined against a set of independent variables to identify the determinants associated with inappropriate complementary feeding practices. Chi-square tests were used to test for the significance of the associations. Variables with P-value < 0.20 were entered into the model. Cox proportional hazard models with backward selection were used to assess whether the associations between the independent variables and the inappropriate feeding practices were statistically significant (P-value 0.05), after correction for confounders. Results were presented as PRs with 95% CIs. Finally, these significant variables were placed into one regression model to identify the most important determinants of inappropriate complementary feeding practices per feeding indicator.

The statistical analysis of the data was carried out using the statistical software program SAS version 9.3 (SAS Institute Inc., Cary, NC, USA).

RESULTS

BASELINE CHARACTERISTICS OF THE POPULATION

In Appendix VI, table 10 results are presented for both the total sample (n = 2393) as for the subsample who had valid information on anthropometric measurements (n = 1181). The distributions for these groups were very similar, which indicated that the children with valid information on anthropometric measurements are a representable subsample of the total sample. If you consider the total sample of 2393 children aged 6-23 months, 39% was stunted (-2 SD) and 17% was severely stunted (-3 SD), see Appendix VI, table 10. The majority (89%) lived in rural areas and a high percentage of 93% was currently breastfed. Of the mothers, 80% was working at the time of the survey; one-fourth (26%) was illiterate (cannot read at all) and almost half (48%) belonged to the poor or poorest households. Of all births, 81% was delivered in a health facility and 79% of the deliveries were done by a health professional.

Table 2 presents the baseline characteristics for stunted and non-stunted children separately. More male than female children were stunted (57% versus 43%) and stunting was higher among multiple births. The percentage of stunted children was also higher among mothers that were stunted themselves (31% compared to 20% of non-stunted mothers, P = <.0001). Children who were not delivered at a health facility or by a health professional had a higher prevalence of stunting and a higher prevalence was seen among children living in the rural areas or more specifically in the Western, Northern or Eastern region of Rwanda. Stunting increased by age as it is seen in figure 1 that 22.3% of the children of 6-11 months were stunted, compared to 42.1% of the children between 12-17 months and even 54.9% of the children between 18-23 months.

Table 2: Individual, maternal / household and community level baseline characteristics of stunted and non-stunted children aged 6-23 months, Rwanda 2010-2011 (n = 1181).

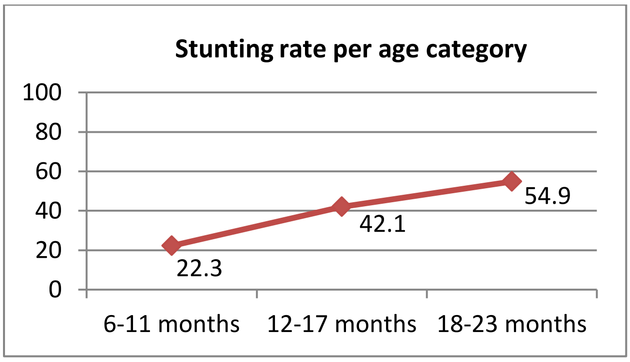
	Stunted children n = 464 (39.3%)		Non-stunted children n = 717 (60.7%)			
Characteristic	N	%	N	%	N miss	P-value*
Individual (child)						
Gender of the child						
Male	265	57.0	326	45.5	-	**<0.0001**
Female	199	43.0	391	54.5		
Child's age in months						
6-11 months	93	20.0	323	45.1	-	**<0.0001**
12-17 months	161	34.7	221	30.8		
18-23 months	210	45.3	173	24.1		
Breastfeeding initiation						
Immediately	296	65.6	503	70.7	18	0.1125
Within 1 hour	19	4.2	33	4.6		
After 1 hour	136	30.2	176	24.7		
Currently breastfed						
Yes	419	90.3	668	93.2	-	0.0864
No	45	9.7	49	6.8		
Birth order						
First born	108	23.3	228	31.8	-	**0.0019**
Second to fourth	213	45.9	319	44.5		
Fifth or more	143	30.8	170	23.7		
Type of birth						
Single	443	95.5	714	99.6	-	**0.0003**
Multiple	21	4.5	3	0.4		
Preceding birth interval						

No previous birth	110	23.7	228	31.8	-	**0.0099**
< 24 months	77	16.6	101	14.1		
> 24 months	277	59.7	388	54.1		
Size of child at birth						
Small	89	19.2	88	12.3	4	**0.0046**
Average	185	40.0	301	42.2		
Large	189	40.8	325	45.5		
Had diarrhoea episode recently						
No	347	74.8	549	76.6	-	0.4926
Yes, last 2 weeks	117	25.2	168	23.4		
Maternal/household						
Maternal age						
15-24 years	113	24.4	204	28.5	-	**0.0241**
25-34 years	231	49.8	375	52.3		
35-49 years	120	25.8	138	19.2		
Maternal height						
< 150 cm	91	19.6	83	11.6	1	**<0.0001**
150-155 cm	144	31.0	171	23.9		
> 155 cm	229	49.4	462	64.5		
Maternal BMI						
< 18.5 kg m^{-2}	24	5.2	38	5.3	1	0.0575
18.5-24.9 kg m^{-2}	383	82.5	551	77.0		
≥ 25 kg m^{-2}	57	12.3	127	17.7		
Respondent is stunted						
Yes	145	31.3	142	19.8	1	**<0.0001**
No	319	68.7	574	80.2		
Maternal age at first birth						
< 20 years	137	29.5	180	25.1	1	0.2834
20-29 years	314	67.7	518	72.4		
> 30 years	13	2.8	18	2.5		
Maternal working status						
Non-working	92	19.9	155	21.6	2	0.4870
Currently working	371	80.1	561	78.4		
Maternal education						
No education	95	20.5	112	15.6	-	**<0.0001**
Primary education	351	75.6	515	71.8		
Secondary or higher education	18	3.9	90	12.6		
Maternal literacy						
Cannot read at all	128	27.6	182	25.4	1	**0.0036**
Able to read only parts of sent.	57	12.3	49	6.9		
Able to read whole sentence	279	60.1	485	67.7		
Religion						
Christian	449	97.0	696	97.2	2	0.4033
Muslim	7	1.5	5	0.7		
Other	7	1.5	15	2.1		
Wealth index						
Richest	45	9.7	147	20.5	-	**<0.0001**
Richer	63	13.6	144	20.1		
Middle	98	21.1	134	18.7		
Poorer	137	29.5	139	19.4		
Poorest	121	26.1	153	21.3		
Number of household members						
1-4 household members	189	40.7	307	42.8	-	0.5234
5+ household members	275	59.3	410	57.2		
Number of children under 5 yrs						
One	154	33.3	303	42.4	4	**0.0010**
Two	259	56.1	318	44.5		
Three or more	49	10.6	94	13.1		
Frequency of listening to radio						
Almost every day	0	-	0	-	6	**0.0006**
At least once a week	267	57.8	474	66.4		
Less than once a week	132	28.6	188	26.4		
Not at all	63	13.6	51	7.2		

Frequency of watching TV					1	**0.0006**
Almost every day	0	-	0	-		
At least once a week	13	2.8	60	8.4		
Less than once a week	99	21.3	163	22.7		
Not at all	352	75.9	493	68.9		
Frequency of reading newspaper or magazine						
Almost every day	0	-	0	-	-	0.1206
At least once a week	4	0.9	15	2.1		
Less than once a week	66	14.2	123	17.2		
Not at all	394	84.9	579	80.7		
Health care						
Antenatal clinic visits						
None	10	2.2	14	2.0	12	0.1124
1-3 visits	304	67.1	438	61.2		
4+ visits	139	30.7	264	36.8		
Place of delivery						
Health facility	344	75.8	590	84.3	27	**0.0002**
Home / other	110	24.2	110	15.7		
Type of delivery assistance						
Health professional	339	73.0	584	81.5	-	**0.0006**
Other	5	27.0	133	18.5		
Access to postnatal care						
Yes	390	84.1	632	88.1	-	**0.0466**
No	74	15.9	85	11.9		
Community						
Residence						
Urban	39	8.4	94	13.0	-	**0.0207**
Rural	425	91.6	623	87.0		
Geographical region						
Kigali city	24	5.2	77	10.7	-	**0.0137**
South	101	21.8	174	24.3		
West	141	30.4	189	26.4		
North	76	16.4	101	14.1		
East	122	26.2	176	24.5		
Cluster altitude						
Lowest	97	20.9	197	27.5	-	**0.0054**
Low	117	25.2	181	25.2		
High	111	23.9	186	26.0		
Highest	139	30.0	153	21.3		
Access to safe drinking water						
Yes	212	46.2	371	52.5	15	**0.0399**
No	247	53.8	336	47.5		
Access to proper sanitation						
Yes	203	45.0	276	39.4	29	0.0821
No	248	55.0	425	60.5		

* P-values in bold indicate a significant difference with P < 0.05. Because the expected counts in some of the categories are small, chi-square tests might not be appropriate. In this case, the Fisher's exact test was done.

Figure 1: Stunting rate (-2SD) per age category



COMPLEMENTARY FEEDING INDICATORS

Five complementary feeding indicators were calculated for the total sample, with some modifications due to limitations in the collected data of the RDHS 2010 (these limitations are explained in the Missing value analysis, see Appendix II), see figure 2.

Figure 2: Status of WHO Complementary feeding indicators, children 6-23 months in Rwanda.

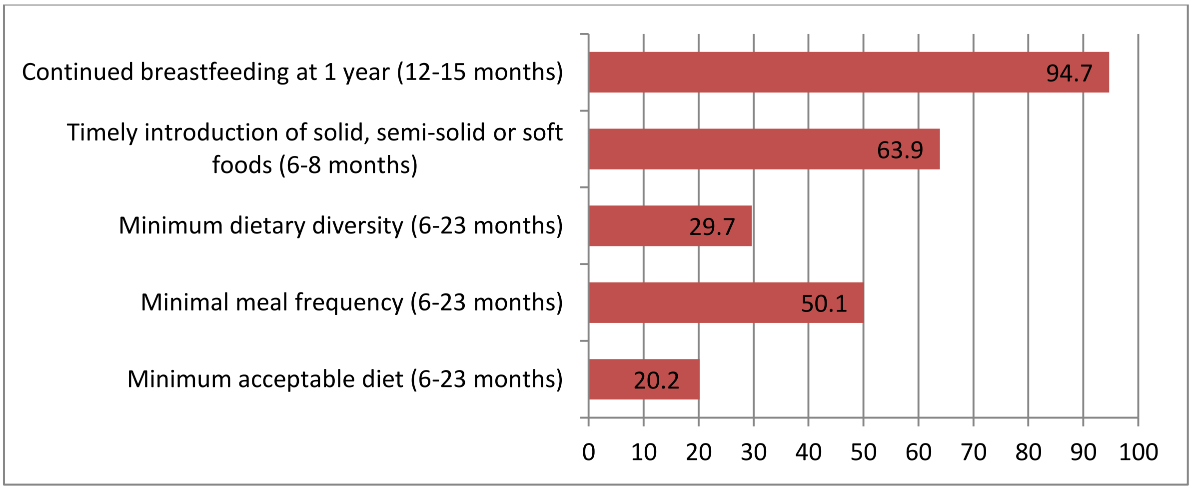


Table 3 shows the prevalence of the indicators in Rwanda by age, for breastfed, non-breastfed and all children separately. It shows that 94.7% is still being breastfed at the age of 12-15 months. Almost 64% is timely introduced to solid, semi-solid or soft foods, which means that they received these foods at the age of 6-8 months. Still 31.3% of the children aged 6-8 months were exclusively breastfed or predominantly breastfed (infant receives liquids like water, water-based drinks or juice besides breastmilk as the predominant source of nourishment) and consumed no other foods despite the advice to start with complementary feeding at the age of 6 months (see Appendix VI, table 11). Also, 2.5% of the children between 12-23 months were still being exclusively or predominantly breastfed. Looking into the characteristics of the mothers that were still exclusively or predominantly breastfeeding their children, almost all of the mothers had no or only primary education (96.5%) compared to 91% of the total population who had no or only primary education and the majority (93.0%) lived in the rural areas, compared to 89% of the total population living in the rural areas (see Appendix VI, table 12 and 13).

The minimum dietary diversity is 29.7% for all children of 6-23 months and is more likely to be met by non-breastfed children than by breastfed children (45.4% and 28.5% respectively). Minimum dietary diversity increases with age (20.1% 6-8 months, 33.1% 12-17 months, 36.6% 18-23 months). Minimum meal frequency is higher amongst breastfed children (51.9% for breastfed children versus 26.6% for non-breastfed children) with an overall minimum meal frequency rate of 50.1%. Minimum acceptable diet could only be calculated for breastfed children and has a prevalence of 20.2% for children between 6-23 months.

Table 3: Complementary feeding indicators among children 6-23 months in Rwanda by age group

Indicator	N	n	%	(95 % CI)
Continued breastfeeding at 1 year (12-15 months)	523	495	**94.7**	(92.6 ; 96.7)
Missing values: 0				
Timely introduction of solid, semi-solid or soft food (6-8 months)	419	268	**63.9**	(58.8 ; 68.9)
Missing values: 2				
Minimum dietary diversity rate				
Minimum dietary diversity rate for breastfed children (6-11 months)	820	161	19.7	(16.8 ; 22.5)
Minimum dietary diversity rate for non-breastfed children (6-11 months)	19	7	39.3	(18.1 ; 60.5)
Minimum dietary diversity rate for all children (6-11 months)	838	169	**20.1**	(17.3 ; 22.9)
Minimum dietary diversity rate for breastfed children (12-17 months)	720	228	31.6	(28.1 ; 35.2)
Minimum dietary diversity rate for non-breastfed children (12-17 months)	44	25	56.7	(43.3 ; 70.0)
Minimum dietary diversity rate for all children (12-17 months)	765	253	**33.1**	(29.6 ; 36.6)
Minimum dietary diversity rate for breastfed children (18-23 months)	681	244	35.8	(31.8 ; 39.8)
Minimum dietary diversity rate for non-breastfed children (18-23 months)	109	46	41.8	(32.3 ; 51.3)
Minimum dietary diversity rate for all children (18-23 months)	790	289	**36.6**	(32.8 ; 40.4)
Minimum dietary diversity rate for breastfed children (6-23 months)	2221	633	28.5	(26.4 ; 30.6)
Minimum dietary diversity rate for non-breastfed children (6-23 months)	173	78	45.4	(38.1 ; 52.6)
Minimum dietary diversity rate for all children (6-23 months)	2393	711	**29.7**	(27.6 ; 31.8)
Missing values: 0				
Minimum meal frequency rate				
Minimum meal frequency rate for breastfed children (6-11 months)	820	354	43.5	(39.8 ; 47.1)
Minimum meal frequency rate for non-breastfed children (6-11 months)	19	5	26.2	(5.2 ; 47.1)
Minimum meal frequency rate for all children (6-11 months)	838	359	**42.8**	(39.3 ; 46.3)
Minimum meal frequency rate for breastfed children (12-17 months)	720	373	52.3	(48.5 ; 56.2)
Minimum meal frequency rate for non-breastfed children (12-17 months)	44	12	27.3	(14.3 ; 40.3)
Minimum meal frequency rate for all children (12-17 months)	765	386	**50.4**	(46.7 ; 54.2)
Minimum meal frequency rate for breastfed children (18-23 months)	681	426	63.4	(59.4 ; 67.3)
Minimum meal frequency rate for non-breastfed children (18-23 months)	109	29	26.5	(17.9 ; 35.1)
Minimum meal frequency rate for all children (18-23 months)	790	455	**57.6**	(53.7 ; 61.4)
Minimum meal frequency rate for breastfed children (6-23 months)	2221	1153	51.9	(49.6 ; 54.3)
Minimum meal frequency rate for non-breastfed children (6-23 months)	173	46	26.6	(19.5 ; 33.8)
Minimum meal frequency rate for all children (6-23 months)	2393	1199	**50.1**	(47.8 ; 52.4)
Missing values: 23				
Minimum acceptable diet rate				
Minimum acceptable diet rate for breastfed children (6-11 months)	820	108	**13.2**	(10.9 ; 15.6)
Minimum acceptable diet rate for breastfed children (12-17 months)	720	152	**21.1**	(18.1 ; 24.1)
Minimum acceptable diet rate for breastfed children (18-23 months)	681	188	**27.7**	(24.1 ; 31.2)
Minimum acceptable diet rate for breastfed children (6-23 months)	2221	449	**20.2**	(18.5 ; 22.0)
Missing values: 21				

The proportion of children achieving the complementary indicators varied by region, see Appendix VI table 15. Continued breastfeeding at 1 year and timely introduction of complementary feeding was lower in Kigali (81% and 52% respectively) compared to the other regions. However, the minimum dietary diversity, minimum meal frequency and minimum acceptable diet rate was higher among children in Kigali. The Western region scored lowest on minimum dietary diversity and meal frequency and only 12.8% had an acceptable diet. The children from the Western region were three times less likely to reach the minimum dietary diversity than children from the region of Kigali.

Consumption of different food groups

The consumption of food groups by children that did receive solid, semi-solid or soft foods is presented in table 4. This table presents the types of foods given during the day preceding the interview for the different age groups. The age category 6-11 months is split into two categories of 6-8 months and 9-11 months because of the introduction of complementary feeding at this stage and the difference between the diet of a 6-8 months old infant and a 9-11 months old infant. The results show that almost 66% of the children received foods made from grains, roots, and tubers, including porridge and fortified baby food from grains. Only 35% of the children consumed vitamin-A rich fruits and vegetables, but 66% received other fruits and vegetables the previous day. Two-third of the children consumed legumes and nuts and 17% consumed meat, poultry, fish or shellfish the previous day. Consumption of infant formula, milk other than breast milk, cheese, yogurt or other milk products was rather similar in all age groups, with an average of 19%. All foods were less consumed by children of 6-8 months, but consumption became higher with increasing age. Eggs were an exception, children of 9-11 months received a relatively larger proportion of eggs (8%) compared to the other age groups.

Table 4: Consumption of food groups by age of children

Food group	Age of the child (months)									
	6-8		9-11		12-17		18-23		6-23	
	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95 %CI
Infant formula, milk other than breast milk, cheese or yogurt or other milk products	20.8	(16.7 ; 25.0)	23.6	(19.1 ; 28.0)	17.7	(14.5 ; 20.9)	18.1	(15.1 ; 21.1)	19.4	(17.3 ; 21.5)
Foods made from grains, roots, and tubers, including porridge and fortified baby food from grains	36.2	(31.3 ; 41.1)	64.3	(59.7 ; 68.8)	72.2	(68.5 ; 75.9)	76.8	(73.7 ; 79.9)	66.0	(63.7 ; 68.3)
Vitamin A-rich fruits and vegetables	20.4	(16.5 ; 24.3)	33.4	(28.9 ; 38.0)	39.8	(36.0 ; 43.7)	39.4	(35.5 ; 43.4)	35.2	(32.9 ; 37.5)
Other fruits and vegetables	39.5	(34.5 ; 44.4)	66.1	(61.3 ; 70.9)	70.2	(66.9 ; 73.5)	74.4	(71.1 ; 77.8)	65.5	(63.4 ; 67.6)
Eggs	3.3	(1.4 ; 5.1)	8.3	(5.6 ; 11.0)	3.5	(2.2 ; 4.8)	4.2	(2.5 ; 5.8)	4.5	(3.5 ; 5.5)
Meat, poultry, fish, and shellfish (and organ meats)	7.9	(5.3 ; 10.6)	19.4	(15.3 ; 23.4)	18.4	(15.4 ; 21.4)	18.7	(15.8 ; 21.6)	16.8	(15.1 ; 18.6)
Legumes and nuts	25.9	(21.3 ; 30.5)	64.7	(59.9 ; 69.5)	76.4	(73.1 ; 79.6)	81.7	(78.7 ; 84.7)	67.2	(65.2 ; 69.3)

Looking into the characteristics of the children that received the different food groups, it was seen that the children of the richest households consumed more infant formula, milk other than breast milk, cheese and yoghurt compared to the poorest households and they consumed more vitamin A rich fruits and vegetables, eggs and meat, poultry, fish and shellfish (see Appendix VI, table 14). Children of households in the highest cluster altitude consumed in general less food groups compared to the households on lower altitudes, but the biggest differences were seen for vitamin A rich fruits and vegetables, eggs and meat, poultry, fish and shellfish. When looking at the food group consumption in the different geographical regions, it was seen that in the Western region, almost all of the food groups were less consumed than in the other regions. The Eastern region scored lower in the consumption of foods made from grains, roots and tubers and the consumption of eggs. In contrast, they scored highest on the consumption of legumes and nuts compared to the other regions. The children that inhabit the region of Kigali scored highest on almost all food groups, except for the food group of legumes and nuts.

Association between complementary feeding indicators and HAZ-scores / stunting

Prevalence ratios for the association between the five complementary feeding indicators and severe stunting are shown in table 5. This association was also assessed for moderate stunting and HAZ-scores (see Appendix VI, table 16 and 17). Table 5 shows 10% less chance on severe stunting when timely introduced to solid, semi-solid and soft foods, however the results were not significant and remained non-significant after adjusting for covariates. For both the indicator of minimum dietary diversity and minimum meal frequency a non-significant higher risk for severe stunting of children 6-23 months was seen when reaching the indicator. When split in different age groups, the risk became the opposite direction for children of 18-23 months. After correcting for covariates, a 20% lower risk for severe stunting was seen for both indicators, however this was not significant. The only significant influence was seen for the minimum acceptable diet of children 18-23 months. They had a 42% lower chance on severe stunting when they consumed an acceptable diet. However, after correcting for covariates the significance of the association disappeared. Almost none of the indicators showed a significant association with moderate stunting and HAZ-scores, see Appendix VI, table 16 and 17. Only for the minimum meal frequency of children 18-23 months a significantly lower risk was seen for moderate stunting (crude PR 0.82, P = 0.0498), however this significantly lower risk disappeared after adjustment for covariates.

Most important determinants for inappropriate complementary feeding practices

Table 6 shows the most important determinants for the minimum dietary diversity, minimum meal frequency and minimum acceptable diet indicators. The continued breastfeeding rate was rather high in Rwanda (94.7%) which leaded to the decision to not include this indicator in the analysis on determinants of inappropriate complementary feeding practices. For the indicator of timely introduction of solid, semi-solid and soft foods no significant determinants were identified (see Appendix VI, table 19). The age of the child was associated with not meeting minimum dietary diversity, meal frequency and acceptable diet, especially children 6-11 months has a significant higher chance of not meeting these indicators. The education level of the mother was significantly associated with all of the three indicators, with almost a 35% lower chance of not meeting the minimum dietary diversity for mothers with a secondary or higher education compared to mothers with a primary education. Wealth Index was associated with minimum dietary diversity and acceptable diet. However, the association was not that strong, except for children in the richest households compared to the middle class households. Not meeting the minimum dietary diversity was significantly related to the Western region, with a 30% higher change of not meeting the indicator (P = 0.0309) compared to the Kigali region. Children living at the highest cluster altitude had a 15% higher change of not meeting the minimum dietary diversity compared to the children living on the lowest altitudes. Furthermore, maternal age, whether the mother was currently working and whether the child was currently breastfed were important determinants for minimum meal frequency, with a 72% higher chance of not meeting minimum meal frequency when not currently breastfed (P = <.0001).

Table 5: Cox proportional hazard model with prevalence ratios for the association of each WHO indicator with **severe stunting -3SD** (n = 1181)

Indicator	Crude PR*	(95% CI)	P value	Adjusted PR**	(95% CI)	P value
Continued breastfeeding at 1 year (12-15 months)	1.36	(0.37 ; 4.96)	0.6388	1.04	(0.30 ; 3.62)	0.9512
Timely introduction of solid, semi-solid or soft food (6-8 months)	0.81	(0.29 ; 2.25)	0.6877	0.90	(0.30 ; 2.67)	0.8483
Minimum dietary diversity						
Minimum dietary diversity for children 6-23 months	0.91	(0.67 ; 1.25)	0.5703	1.05	(0.77 ; 1.44)	0.7517
Minimum dietary diversity for children 6-11 months	0.95	(0.42 ; 2.15)	0.8995	1.30	(0.59 ; 2.86)	0.5213
Minimum dietary diversity for children 12-17 months	1.32	(0.81 ; 2.14)	0.2617	1.45	(0.88 ; 2.40)	0.1476
Minimum dietary diversity for children 18-23 months	0.71	(0.46 ; 1.09)	0.1176	0.79	(0.52 ; 1.20)	0.2645
Minimal meal frequency						
Minimal meal frequency for children 6-23 months	0.99	(0.76 ; 1.28)	0.9144	1.03	(0.79 ; 1.35)	0.8216
Minimal meal frequency for children 6-11 months	1.44	(0.74 ; 2.82)	0.2875	1.55	(0.81 ; 2.96)	0.1874
Minimal meal frequency for children 12-17 months	1.10	(0.69 ; 1.74)	0.6978	1.14	(0.71 ; 1.82)	0.5944
Minimal meal frequency for children 18-23 months	0.80	(0.57 ; 1.14)	0.2134	0.80	(0.55 ; 1.15)	0.2256
Minimum acceptable diet						
Minimum acceptable diet for children 6-23 months	0.82	(0.58 ; 1.17)	0.2782	0.97	(0.67 ; 1.40)	0.8586
Minimum acceptable diet for children 6-11 months	1.48	(0.64 ; 3.46)	0.3622	1.81	(0.82 ; 3.98)	0.1405
Minimum acceptable diet for children 12-17 months	1.12	(0.63 ; 1.98)	0.7002	1.36	(0.75 ; 2.48)	0.3080
Minimum acceptable diet for children 18-23 months	**0.58**	**(0.35 ; 0.94)**	**0.0284**	0.64	(0.38 ; 1.09)	0.1006

* Crude model adjusted for age and sex of the child

** Adjusted model for *continued breastfeeding at 1 year* adjusted for: sex child, age child, maternal age, wealth index, region and type of place of residence.
Adjusted model for *timely introduction of solid, semi-solid or soft food* adjusted for: sex child, age child, duration of breastfeeding, maternal age, maternal education, wealth index, region and type of residence.
Adjusted model for *minimum dietary diversity* adjusted for: sex child, age child, duration of breastfeeding, preceding birth interval, size of child at birth, maternal BMI, maternal education, wealth index, frequency of reading newspaper and watching television, region, type of residence, cluster altitude and access to safe drinking water.
Adjusted model for *minimal meal frequency* adjusted for: sex child, age child, maternal age, maternal education, wealth index, region, type of residence, access to safe drinking water.
Adjusted model for *minimum acceptable diet* adjusted for: sex child, age child, duration of breastfeeding, preceding birth interval, maternal age, maternal education, wealth index, frequency of reading newspaper and watching television, region, type of residence, cluster altitude and access to safe drinking water.

Table 6: Most important determinants for not meeting the minimum dietary diversity, minimum meal frequency or minimum acceptable diet.

	Crude PR	95% CI	P	Adj PR	95% CI	P
Determinants for not meeting minimum dietary diversity						
Child's age in months						
6-11 months	1.26	(1.18 ; 1.35)	**<.0001**	1.25	(1.14 ; 1.37)	**<.0001**
12-17 months	1.06	(0.98 ; 1.14)	0.1592	1.04	(0.94 ; 1.15)	0.4164
18-23 months	1.00			1.00		
Maternal education						
No education	1.18	(1.12 ; 1.25)	**<.0001**	1.11	(1.02 ; 1.20)	**0.0171**
Primary education	1.00			1.00		
Secondary or higher education	0.63	(0.54 ; 0.73	**<.0001**	0.66	(0.53 ; 0.82)	**0.0002**
Wealth index						
Richest	0.61	(0.53 ; 0.70)	**<.0001**	0.67	(0.55 ; 0.81)	**<.0001**
Richer	0.94	(0.85 ; 1.03)	0.1540	0.95	(0.83 ; 1.08)	0.3855
Middle	1.00			1.00		
Poorer	1.07	(0.99 ; 1.16)	0.0864	0.99	(0.89 ; 1.10)	0.8335
Poorest	1.12	(1.04 ; 1.21)	**0.0020**	1.05	(0.95 ; 1.16)	0.3553
Freq. of reading newspaper or magazine						
Not at all	1.00			1.00		
Less than once a week	0.52	(0.34 ; 0.80)	**0.0029**	0.86	(0.56 ; 1.32)	0.4881
At least once a week	0.76	(0.69 ; 0.84)	**<.0001**	0.86	(0.74 ; 0.99)	**0.0333**
Geographical region						
Kigali city	1.00			1.00		
South	1.42	(1.17 ; 1.73)	**0.0004**	1.06	(0.83 ; 1.35)	0.6547
West	1.75	(1.45 ; 2.12)	**<.0001**	1.30	(1.03 ; 1.65)	**0.0309**
North	1.49	(1.22 ; 1.82)	**0.0001**	1.11	(0.87 ; 1.42)	0.4121
East	1.50	(1.23 ; 1.82)	**<.0001**	1.17	(0.92 ; 1.48)	0.1946
Cluster altitude						
Lowest	1.00			1.00		
Low	1.08	(0.97 ; 1.20)	0.1677	0.95	(0.84 ; 1.08)	0.4373
High	1.11	(1.00 ; 1.22)	**0.0491**	0.96	(0.84 ; 1.10)	0.5250
Highest	1.32	(1.21 ; 1.45)	**<.0001**	1.15	(1.02 ; 1.29)	**0.0209**
Determinants for not meeting minimum meal frequency						
Child's age in months						
6-11 months	1.36	(1.05 ; 1.31)	**0.0067**	1.46	(1.26 ; 1.69)	**0.0427**
12-17 months	1.17	(1.22 ; 1.52)	**<.0001**	1.18	(1.01 ; 1.39)	**<.0001**
18-23 months	1.00			1.00		
Currently breastfed						
Yes	1.00			1.00		
No	1.54	(1.38 ; 1.71)	**<.0001**	1.72	(1.46 ; 2.03)	**<.0001**
Maternal age						
15-24 years	1.05	(0.96 ; 1.16)	0.2936	1.21	(1.03 ; 1.42)	**0.0217**
25-34 years	1.00			1.00		
35-49 years	0.90	(0.79 ; 1.01)	0.0708	0.84	(0.71 ; 0.98)	**0.0270**
Maternal working status						
Non-working	1.00			1.00		
Currently working	0.88	(0.79 ; 0.98)	**0.0185**	0.86	(0.75 ; 0.99)	**0.0405**
Maternal education						
No education	1.19	(1.07 ; 1.32)	**0.0009**	1.18	(1.02 ; 1.36)	**0.0242**
Primary education	1.00			1.00		
Secondary or higher education	0.74	(0.62 ; 0.88)	**0.0011**	0.76	(0.58 ; 0.98)	**0.0360**
Determinants for not meeting minimum acceptable diet						
Child's age in months						
6-11 months	1.17	(1.01 ; 1.13)	**<.0001**	1.16	(1.08 ; 1.24)	**<.0001**
12-17 months	1.07	(1.11 ; 1.24)	**0.0282**	1.05	(0.98 ; 1.14)	0.1829
18-23 months	1.00			1.00		
Currently breastfed						
Yes	1.00			1.00		
No	1.08	(1.02 ; 1.15)	**0.0126**	1.20	(1.10 ; 1.31)	**<0.0001**
Maternal education						
No education	1.13	(1.08 ; 1.18)	**<.0001**	1.09	(1.03 ; 1.16)	**0.0063**
Primary education	1.00			1.00		
Secondary or higher education	0.78	(0.70 ; 0.86)	**<.0001**	0.78	(0.67 ; 0.91)	**0.0014**
Wealth index						
Richest	0.71	(0.65 ; 0.78)	**<.0001**	0.76	(0.66 ; 0.87)	**<.0001**
Richer	0.90	(0.84 ; 0.97)	0.0040	0.92	(0.83 ; 1.01)	0.0881
Middle	1.00			1.00		
Poorer	1.01	(0.96 ; 1.07)	0.6184	0.98	(0.90 ; 1.05)	0.5179
Poorest	1.02	(0.96 ; 1.07)	0.5318	0.98	(0.91 ; 1.06)	0.6219

DISCUSSION

This secondary analysis of the RDHS 2010 showed that most of the complementary feeding practices were inappropriate for children of 6-23 months in Rwanda. The minimum dietary diversity (MDD) reached a percentage of 29.7%, the minimum meal frequency (MMF) was reached by 50.1% of the children and the minimal acceptable diet (MAD) by 20.2%, which means that only one in five children of 6-23 months consumed an acceptable diet as recommended by the WHO (WHO 2003). All three indicator scores increased by age and were lowest for the children of 6-11 months. Timely introduction of solid, semi-solid and soft foods was reached by almost 64% of the sample and the continued breastfeeding rate at 1 year was rather high (95%), especially in the regions outside of Kigali city. Multivariate analysis showed that younger age of the child and lower education levels of the mother were important determinants for inappropriate MDD, MMF and MAD. Maternal age, maternal working status and whether the child was currently breastfed were important determinants for MMF. A strong association with the highest cluster altitudes was seen for inappropriate MDD and also living in the Western region was identified as an important determinant for this indicator. Practically none of the indicators showed a significant association with linear child growth.

This paper is one of the first articles to report on complementary feeding practices and its most important determinants of Rwandan children between 6-23 months. The main strengths of the current study are the sampling method, appropriate adjustment for the complex sampling design including the use of sampling weights, high response rate to the DHS interview survey (99%) and the relatively low number of missing values (<1.0%) in the variables that were used for analysis. However, variables concerning postnatal care had to be excluded due to missing values and could not be taken into account as covariates or possible determinants. Also, no information was provided by the DHS on how the subsample for whom anthropometric measurements were collected was taken.

One important finding was the regional variation between complementary feeding practices. Continued breastfeeding at 1 year was lowest in Kigali (81%), as well as timely introduction of complementary feeding (52%). In contrary, the MDD, MMF and MAD indicators were highest among inhabitants of Kigali and lowest for the Western region, where only 13% received an acceptable diet. This was expected as the stunting rate of the Western region is among the highest of all (43%) and former literature suggested that there is an association between complementary feeding practices and stunting (Stewart 2013; Jones et al. 2014). Nevertheless, in the current study no clear pattern of association was seen between the WHO complementary feeding indicators and linear child growth. Part of this can be explained by the fact that stunting becomes predominantly visible after 18 months of age (WFP 2012). Prior to this period vertical growth may slow down, but the main part of the effect will only become visible after the age of 18 months. This can also be seen in the current study sample, as 22.3% of the children of 6-11 months were stunted, compared to 54.9% of the children between 18-23 months. Data on feeding practices prior to the current age of the child were not taken into account. It is most likely that due to this cross-sectional study design no associations are found and no causal inferences can be made from the data.

Another important reason why we did not see an association can be due to the fact that the WHO indicators were designed as simple indicators for monitoring trends on diet quality in large-scale data sets like the Demographic Health Surveys (WHO 2008; Jones et al. 2014). They focus on selected food-related aspects of child feeding, amendable to population-level measurements, and therefore simplify the complexity that is inherent to complementary feeding practices as it comprises of a multi-dimensional set of behaviours. The use of these indicators can importantly contribute in the assessment of (sub)national trends over time, the identification of populations at risk and for monitoring progress and impact evaluation (WHO 2008). However, they may not capture associations between the indicator scores and linear child growth at the individual level.

Meal frequency was based on the question: 'how many times did the child eat solid, semi-solid or soft foods other than liquids during yesterday in the day or at night?' which may be difficult for the mother to recall. A similar 24-hour recall method was also used for the other WHO indicators while evidence suggests that the use of single-day dietary methods to estimate individual habitual intake patterns is likely to result in misclassification if there is day-to-day variation in feeding practices or when the respondents' recall ability is poor (Piwoz et al. 1995). The MMF-indicator is intended as a proxy for energy intake from non-breastmilk foods. However, only frequency is taken into account and no information has been collected on the quantity of foods consumed even though an appropriate number of feedings depends on the amount consumed and the energy density of foods (PAHO/WHO 2003). Children that are fed low energy density foods can therefore be classified as reaching the indicator, while they did not receive enough calories for sufficient growth development.

This problem of misclassification is also seen for the indicator of continued breastfeeding at 1 year. Whether the child is categorized as being breastfed is based on the information whether the child received breastmilk during the previous 24 hours. No information was collected on the quantity of breastmilk consumed. The child can be classified as being breastfed, even when it did not receive breastfeeding regularly or in enough quantity. Research by Karumba et al. (2009) concluded that the majority of Rwandan mothers were breastfeeding poorly by breastfeeding for short durations or during work (Karumba 2009). In this sense, an overestimation of the continued breastfeeding rate at 1 year is a realistic possibility. This has also consequences for the classification of the meal frequency and minimum acceptable diet indicators as those are based on the number of times that the child received solid, semi-solid or soft foods, taking breastfeeding into account (4 times for non-breastfed children, 3 times for breastfed children 6-8 months and 2 times for breastfed children 9-23 months). It was seen that the MMF rate of breastfed children 6-23 months was twice as high as for non-breastfed children (52% versus 27%), which is also reflected in not *currently breastfeeding* being a strong determinant for not meeting MMF or MAD.

Previous literature showed that dietary diversity scores are a useful proxy for dietary quality of infants and young children in developing countries (Working Group on Infant and Young Child Feeding Indicators 2006; Moursi et al. 2008). The WHO MDD indicator uses a cut-off point of four food groups and has a low sensitivity (25-72%) and high specificity (70-97%) (Working Group on Infant and Young Child Feeding Indicators 2007). This implies that the indicator rarely misclassifies an inadequate diet as adequate, but more commonly misclassifies an adequate diet as inadequate (Jones et al. 2014). As a result the MDD rate of 29.7% might be an underestimation of the real situation in Rwanda and more children of 6-23 months might have a minimum dietary diversity than seen in the current study. Also, no distinction was made between the cut-off points for children of different age groups. Of course the nutrient diversity of the diet needs to be high, especially for non-breastfed children as they do not receive the highly valuable nutrients from breastmilk. Nevertheless, meeting the cut-off value of receiving four different food groups is less likely to be reached by the children of the age of 6-11 months compared to the children of the age of 12-17 months or 18-23 months. Further analysis of the food groups consumed showed that children who did receive complementary foods had mainly a lack of vitamin A rich fruits and vegetables, dairy products and meat, poultry, fish and shellfish in their diet. These food groups need to be taken into account when addressing dietary diversity in Rwandan children. However, the current data did not provide information on the quality or quantity of the foods that were consumed, limiting our understanding of specific nutrient gaps in the diet of these children.

We were not able to calculate the minimum acceptable diet for all children, only for breastfed children. This was due to the fact that data on number of non-breastmilk feedings, that is needed to calculate the MAD indicator for non-breastfed children, was not available in the RDHS 2010. However, as the proportion of non-breastfed children was relatively small (5.3%), inclusion of this group would not have had a major influence on the MAD rates. As discussed previously, relatively big differences were seen between the MDD and MMF of breastfed and non-breastfed children. However, due to the low proportion of non-breastfed children in the sample, no significant conclusions can be drawn from these differences. In line with the fact that an overestimation of the continued breastfeeding rate is plausible, it would be interesting to conduct research on breastmilk quantity and quality of children 6-23 months old in Rwanda. Currently, this is done as part of a longitudinal study to assess growth enhancing factors in Rwandan infants living in rural areas with high prevalence of stunting (Matsiko, personal communication). With this approach, a better view of (continued) breastfeeding practices can be formed and the group of non-breastfed children or poorly breastfed children can be further analysed.

No determinants for not timely introducing complementary feeding were of significant influence. This is probably due to the small sample size (n = 419) for which the analysis could be done as it is only calculated for the children of 6-8 months. Several factors were consistently identified as important determinants of inappropriate MDD, MMF and MAD. The education level of the mother was significantly associated with all three of the three indicators, with almost a 35% lower chance of not meeting the MDD for mothers with a secondary or higher education compared to mothers with a primary education. This is consistent with the literature, where maternal education is also identified as an important determinant (Patel et al. 2010; Joshi et al. 2012; Kabir et al. 2012; Victor et al. 2012). Household wealth index was used as a proxy of social-economic status and better complementary feeding practices were found among children from the wealthiest households. Especially dietary diversity has been previously associated with total household expenditure which indicated that household capacity to purchase adequate nutrition and household food security are prerequisites to achieve dietary diversification (Andrew et al. 2010; Kabir et al. 2012). However, this consistent positive relationship between household SES and dietary diversity can cause that adjusting for SES in the regression models for the association between MDD and linear child growth dampens the strength of this association (Jones et al. 2014). Another factor that was identified as having influence on not meeting minimum dietary diversity was altitude of the communities where the children were living. Children living at the highest cluster altitude had a 15% higher change of not meeting the minimum dietary diversity compared to the children living on the lowest altitudes. This can be explained by the fact that highlands are vulnerable to land degradation, including soil erosion and declined soil fertility. Rwanda - often referred to as *the land of a thousand hills* - faces these problems especially in the Western region, where the Western highlands of over 4.500 meters divide the country between the Nile and the Congo basin. The rural households in these areas have the highest percentage of unacceptable food consumption and relatively lower crop diversity. They are more isolated from the main road and have less access to facilities like health care and local markets (WFP 2012).

Similar studies on complementary feeding practices have been conducted in Tanzania, Ghana, Ethiopia, Zambia and several South Asian Countries (Andrew et al. 2010; Patel et al. 2010; Joshi et al. 2012; Kabir et al. 2012; Senarath et al. 2012; Victor et al. 2012; Aemro et al. 2013; Issaka et al. 2014). The continued breastfeeding rate at 1 year was similar to other studies that calculated this indicator. The introduction to complementary feeding indicator was rather low for Rwanda (64%) compared to Tanzania (92%) and Zambia (90%), however similar to Ghana (73%) and Ethiopia (61%). The MDD indicator of Rwanda (30%) was low compared to Ghana (51%), Tanzania (38%) and Zambia (37%). Only Ethiopia scored significantly lower on this indicator (7%). MMF percentages for these countries were similar and the MAD percentage for Rwanda (20%) was rather low compared to Ghana (30%) and Zambia (25%), however high compared to Ethiopia where only 5% of the children consumed an acceptable diet. Rwanda scored lower on all indicators compared to South Asian countries like Bangladesh, Nepal and Sri Lanka. India was an exception as this country scored significantly lower on all indicators.

In conclusion, this study showed that complementary feeding practices in Rwanda for children between 6-23 months are poor and only one in five children of 6-23 months consumed an acceptable diet. The WHO indicators can be used as simple indicators for monitoring trends in CF practices on population level and to identify vulnerable groups that are more likely to benefit from CF programmes. Further in-depth research is needed on dietary quantity and quality to be able to understand specific nutrient gaps in the diet of these children. Additionally, it is important to keep in mind that child growth is determined by multiple factors. The diet of the child is certainly one of them, but proper hygiene practices and access to adequate water, proper sanitation and health services are equally important determinants (Jones et al. 2014). Age of the child, maternal education, maternal age, household wealth index and working status of the mother were identified as important determinants of inappropriate complementary feeding practises. Especially younger children, children from the Western region of Rwanda and children living on the highest altitudes need to be targeted with infant and young child feeding interventions, including promotion of proper breastfeeding and dietary diversity programmes.

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Appendix

Appendix I : Dataset construction

Appendix I explains the dataset construction, including the construction of the weighed study sample of 2393 children of 6-23 months in Rwanda.

Appendix II: Missing value analysis

After recoding and checking the variables for inconsistencies, a missing value analysis was done due to the high number of missing values in the RDHS 2010. Appendix II shows the number of values and the number and percentage of missing values per variable. Furthermore, the decisions taken after the missing value analysis are explained.

Appendix III: Formulas for WHO indicators

Appendix III explains the formulas used to calculate the five WHO complementary feeding indicators *continued breastfeeding at one year, timely introduction of complementary feeding, minimum dietary diversity, minimum meal frequency* and *minimal acceptable diet* among 6-23 months old children in Rwanda, using the 2010 Demographic and Health Survey variables.

Appendix IV: Dietary diversity score

To see whether the diet of children of 6-23 months of age in Rwanda is nutritiously adequate the minimal dietary diversity score is calculated, using the DDS-7 indicator. Appendix IV shows the seven food groups that were taken into account and the food products that they entail.

Appendix V: Codebook for RDHS 2010 variables

In order to analyze the DHS data, variables need to be coded and recoded. Appendix V is a codebook for all the analysis conducted for this paper.

Appendix VI: Results

Appendix VI consists of tables of all the results that are referred to in the Results section of the paper, but that are not included in the paper itself.

Appendix VII: Protocol dose-to-mother doubly labeled water method

In Appendix VII the Standard Operating Procedure (SOP) for the assessment of breast milk intake and maternal body composition / energy expenditure in mother-child pairs can be found. This protocol, written by Roelinda Jongstra and Nanette van der Spek, was used as part of the BRINTA (Breastmilk INTAke) study, which was conducted at the Wageningen University Division of Human Nutrition in October 2014. This pilot study was done to quantify breastmilk intake of Dutch mother-child pairs, using the dose-to-mother doubly labeled water method, and part of the PhD of Erik Matsiko on nutrient adequacy and child growth patterns of the infants and young children in rural areas of Rwanda.

Appendix VIII: Patient Information Folder (PIF) of the BRINTA study

In Appendix VIII the Patient Information Folder that was used for the recruitment of participants for the BRINTA study can be found.

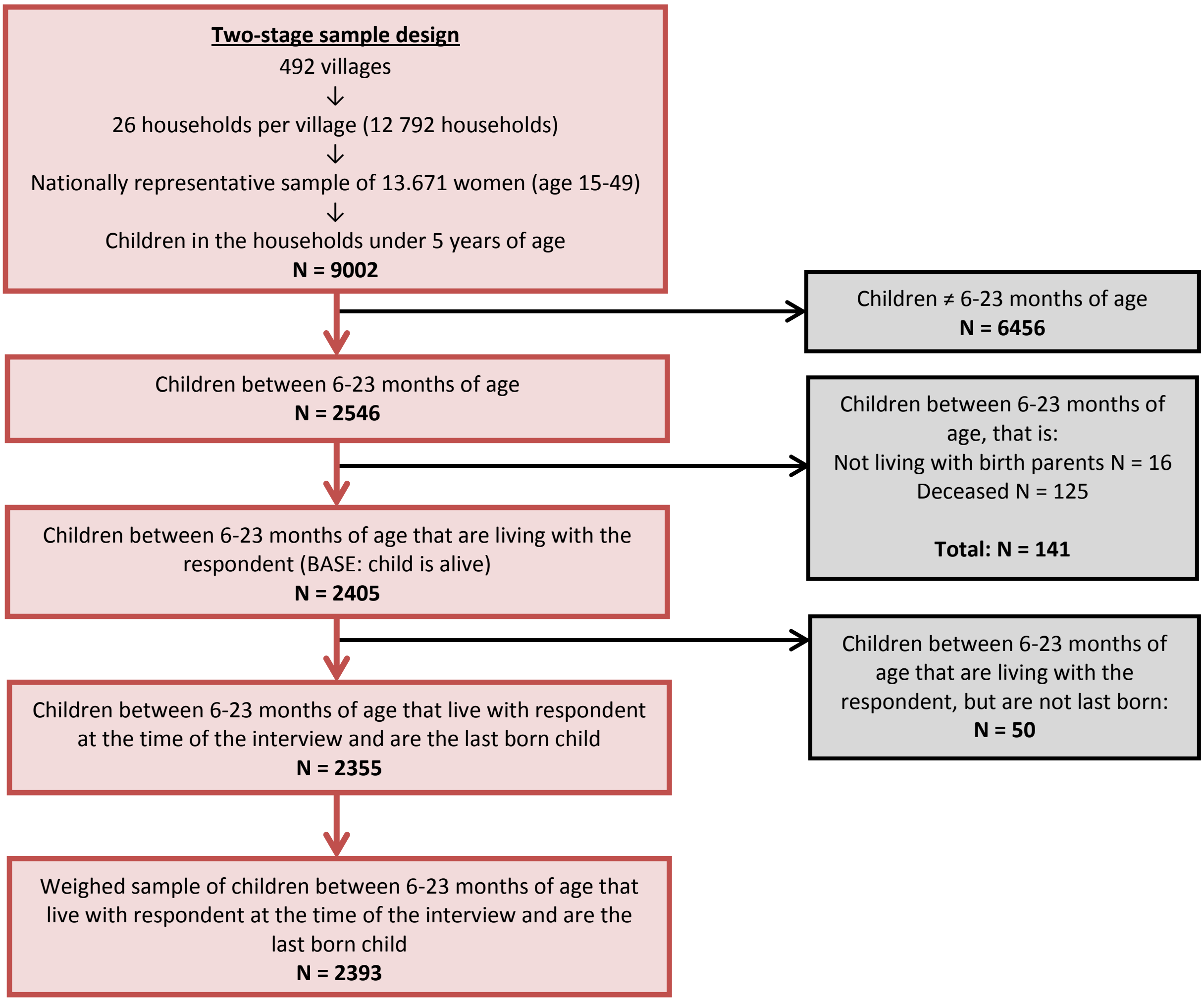
Appendix I: Dataset construction

Table 7: Sample construction for analysis

	Variable description	Variable code	Category	N	Frequency
1.	Children between 6-23 months of age	V008-B3	Yes No Total	**2546** 6456 9002	28.3 % 71.7 %
2.	Children between 6-23 months of age that lives with respondent at the time of the interview (BASE = living children (B5 = 0))	B9	Yes No Total	**2405** 141 2546	94.5 % 5.5 %
3.	Last born children* between 6-23 months of age that lives with respondent at the time of the interview	MIDX	Yes No Total	**2355** 50 2405	97.9 % 2.1 %
			Number of children for analysis	**2355**	
			Weighed sample for analysis	**2393**	

* Multiple children from one mother were only included in the analysis if the children were born at the same time (twins).

Figure 3: Inclusion and exclusion flow chart



APPENDIX II: MISSING VALUE ANALYSIS

After recoding and checking the variables for inconsistencies, a missing value analysis was done due to the high number of missing values in the RDHS 2010. Table 8 shows the number of values and the number and percentage of missing values per variable.

Table 8: Missing value analysis

Variable Code	Variable name	N	N Missing (n)	N Missing (%)
HW70	Height/Age standard deviation child (new WHO)	1166	1189	50.5
V409	Gave child plain water	2346	9	0.4
V411	Gave child tinned, powdered or fresh milk	2349	6	0.3
V411A	Gave child baby formula	2349	6	0.3
V412A	Gave child fortified baby food	2337	18	0.8
V414E	Gave child bread, noodles, other made from grains	2351	4	0.2
V414F	Gave child potatoes, cassava, or other tubers	2350	5	0.2
V414G	Gave child eggs	2350	5	0.2
V414H	Gave child meat (beef, pork, lamb, chicken, etc)	2351	4	0.2
V414I	Gave child pumpkin, carrots, squash (yellow or orange inside)	2350	5	0.2
V414J	Gave child any dark green leafy vegetables	2347	8	0.3
V414K	Gave child mangoes, papayas, other vitamin A fruits	2350	5	0.2
V414L	Gave child any other fruits	2351	4	0.2
V414M	Gave child liver, heart, other organs	2350	5	0.2
V414N	Gave child fish or shellfish	2349	6	0.3
V414O	Gave child food made from beans, peas, lentils, nuts	2351	4	0.2
V414P	Gave child cheese, yogurt, other milk products	2348	7	0.3
V414V	Gave child yogurt	2332	23	1.0
V469E	Times gave child powdered/tinned/fresh milk	381	1974	83.8
V469F	Times gave child infant formula	20	2335	99.2
M39	Number of times ate solid, semi-solid or soft food yesterday	2332	23	1.0
B4	Sex of child	2355	0	-
V404	Currently breastfeeding	2355	0	-
M5	Months of breastfeeding	2355	0	-
M34	When child put too breast	2319	36	1.5
BORD	Birth order number	2355	0	-
B0	Child is twin	2355	0	-
B11	Preceding birth interval (months)	1708	647	27.5
M18	Size of child at birth	2347	8	0.3
H11	Had diarrhoea recently	2355	0	-
V012	Respondent's current age	2355	0	-
V438	Respondent's height in centimeters (1 decimal)	1186	1169	49.6
V440	Height/Age standard deviation (respondent)	1186	1169	49.6
V445	Body Mass Index	1186	1169	49.6
V212	Age of respondent at 1st birth	2355	0	-
V714	Respondent currently working	2353	2	< 0.1
V106	Highest educational level	2355	0	-
V155	Literacy	2354	1	< 0.1
V130	Religion	2351	4	0.2
V190	Wealth index	2355	0	-
V136	Number of household members (listed)	2355	0	-
V137	Number of children 5 and under in household (de jure)	2355	0	-
V157	Frequency of reading newspaper or magazine	2355	0	-
V158	Frequency of listening to radio	2352	3	0.1
V159	Frequency of watching television	2354	1	< 0.1
M3	Type of delivery assistance	2352	3	0.1
M14	Number of antenatal visits during pregnancy	2328	27	1.1
M15	Place of delivery	2305	50	2.1
H1	Has health card	2354	1	< 0.1
M70	Baby postnatal check within 2 months	856	1499	63.7
M71	Time after delivery postnatal check took place	160	2195	93.2
M72	Person who performed postnatal checkups	162	2193	93.1
M73	Place baby was first checked	164	2191	93.0

V024	Region	2355	0	-
V025	Type of place of residence	2355	0	-
V040	Cluster altitude	2355	0	-
V113	Source of drinking water	2328	27	1.1
V115	Time to get to drinking water source (minutes)	2325	30	1.3
V116	Type of toilet facility	2326	29	1.2
V160	Toilet facility shared with other household	2296	59	2.5

In the DHS, a missing value (generally coded as 9, 99, 999, 9999, etc. depending on the variables number of digits) is defined as '*a variable that should have a response, but does not have a response - either because the question was not asked (due to interviewer error) or the respondent did not want to answer'.* The general rule for DHS data is that under no circumstances an answer should be made up and no imputation is assigned (Rutstein et al. 2006). Only for a few variables missing values are not accepted and an exception is made for imputation. These variables include: geographical variables such as region or place of residence, level of education for men and women and variables related to women's birth history. Another important missing response is the 'don't know' responses, coded as 8, 98, 998, 9998 etc. depending on the variables number of digits. Blank ('.') values mean *not applicable* for the respondent, either because the question was not asked in a particular country, or the question was not asked of this respondent due to the flow or skip pattern of the questionnaire (Rutstein et al. 2006).

Missing, blank and 'don't know' codes (if < 5% of the variable data) of variables which were used for calculating the complementary feeding indicators were handled according to the 2006 Guide to DHS Statistics, published by the DHS Program as part of the DHS Toolkit of methodology (Rutstein et al. 2006). Missing values of explanatory variables with < 5% missing values were excluded from analysis. If the variable entailed > 5% and < 20% of missing values, further analysis was done to investigate whether the values are missing at random or not. If they were not missing at random, analysis was done separately for different groups. If the variable entails > 20% of missing values, exclusion of this variable was considered.

Variables including > 20% missing values

Variables that entail > 20% missing values are: HW70, V496E V496F, B11, V438, V445, M70, M71, M72 and M73. The high number of missing values for HW70, V438 and V445 are caused by the subsample taken for anthropometric measurements. The DHS included an anthropometric component in which height and weight measurements of respondents and children under 5 in only a subsample of 50% of the households were collected. The high number of missing values for B11 is caused by the fact that 647 children were the firstborn child of the family and therefore had no preceding birth interval.

Due to the high number of missing values in the variables concerning postnatal care (M70, M71, M72 and M73), it was decided to exclude these variables from statistical analysis.

The high number of missing values in the variables V469E and V469F means that there is no available information on the number of non-breast milk feeds received by non-breastfed children.

As the complementary feeding indicator minimum meal frequency for non-breastfed children is defined as *'non-breastfed child received solid, semi-solid or soft food or milk feeds 4 times or more during the previous day'*, it was not possible to calculate the minimum meal frequency according the

WHO definition. Instead the indicator minimum meal frequency for non-breastfed children was only based on the number of times they consumed soft, semi-solid or soft foods on the previous day (variable M39), excluding the milk feeds.

The minimum acceptable diet for non-breastfed children was impossible to calculate as it is defined as: *'non-breastfed children who received at least two milk feedings and had at least the minimum dietary diversity score (not including milk feeds) and the minimum meal frequency during the previous day / all non-breastfed children'*. Therefore, the minimum acceptable diet was calculated for breastfed children only. However, the proportion of non-breastfed children in the sample was relatively small (7.4%) and made a small influence on the overall estimations of minimum meal frequency and minimal acceptable diet.

VARIABLES INCLUDING 5-20% MISSING VALUES

Not applicable.

VARIABLES INCLUDING < 5% MISSING VALUES

Variables with < 5% missing values that were used in calculating the WHO complementary feeding indicators were handled according to the 2006 Guide to DHS Statistics, published by the DHS Program as part of the DHS Toolkit of methodology. This Guide states that missing and don't know values for all specific foods have to be excluded from the numerators for all percentages, but included in the denominators. Missing and don't know values for breastfeeding are assumed 'not breastfeeding' (V404 = 0). Missing values of explanatory variables with < 5% of missing values were excluded from analysis.

APPENDIX III: FORMULAS FOR WHO INDICATORS

Table 9: WHO indicators and DHS variables needed

Indicator	Formula	DHS variables needed
Continued breastfeeding at 1 year (12-15 months)	Children (12-15 months) who received breast milk during the previous day / All children (12-15 months)	V404: Currently breastfeeding (yes/no)
Timely introduction of solid, semi-solid or soft food (6-8 months)	Infants (6-8 months) who received solid, semi-solid or soft foods during the previous day / All infants (6-8 months)	M39: Number of times ate solid, semi-solid or soft food yesterday
Minimum dietary diversity		
Non-BF (6-11 months)	Non-BF children (6-11 months) who received foods from ≥ 4 food groups during the previous day / All non-BF children (6-11 months)	See Appendix IV: DDS7-score
BF (6-11 months)	BF children (6-11 months) who received foods from ≥ 4 food groups during the previous day / All BF infants (6-11 months)	
Both (6-11 months)	Children (6-11 months) who received foods from ≥ 4 food groups during the previous day / All children (6-11 months)	
Non-BF (12-17 months)	Non-BF children (12-17 months) who received foods from ≥ 4 food groups during the previous day / All non-BF children (12-17 months)	
BF (12-17 months)	BF children (12-17 months) who received foods from ≥ 4 food groups during the previous day / All BF infants (12-17 months)	
Both (12-17 months)	Children (12-17 months) who received foods from ≥ 4 food groups during the previous day / All children (12-17 months)	
Non-BF (18-23 months)	Non-BF children (18-23 months) who received foods from ≥ 4 food groups during the previous day / All non-BF children (18-23 months)	
BF (18-23 months)	BF children (18-23 months) who received foods from ≥ 4 food groups during the previous day / All BF infants (18-23 months)	
Both (18-23 months)	Children (18-23 months) who received foods from ≥ 4 food groups during the previous day / All children (18-23 months)	
Non-BF (6-23 months)	Non-BF children (6-23 months) who received foods from ≥ 4 food groups during the previous day / All non-BF children (6-23 months)	
BF (6-23 months)	BF children (6-23 months) who received foods from ≥ 4 food groups during the previous day / All BF infants (6-23 months)	
Both (6-23 months)	Children (6-23 months) who received foods from ≥ 4 food groups during the previous day / All children (6-23 months)	
Minimum meal frequency **		
Non-BF (6-11 months)	Non-BF children (6-11 months) who received solid, semi-solid or soft foods 4 times or more during the previous day / All non-BF children (6-11 months)	V404: Currently breastfeeding (yes/no) M39: Number of times ate solid, semi-solid or soft food yesterday
BF (6-11 months)	BF children (6-8 months) who received solid, semi-solid or soft foods 2 times or more during the previous day + BF children (9-11 months) who received solid, semi-solid or soft foods 3 times or more during the previous day / All BF children (6-11 months)	
Both (6-11 months)	Non-BF children (6-11 months) who received solid, semi-solid or soft foods 4 times or more during the previous day + BF children (6-8 months) who received solid, semi-solid or soft foods 2 times or more during the previous day + BF children (9-11 months) who received solid, semi-solid or soft foods 3 times or more during the previous day / All children (6-11 months)	
Non-BF (12-17 months)	Non-BF children (12-17 months) who received solid, semi-solid or soft foods 4 times or more during the previous day / All non-BF children (12-17 months)	
BF (12-17 months)	BF children (12-17 months) who received solid, semi-solid or soft foods 3 times or more during the previous day / All BF children (12-17 months)	
Both (12-17 months)	Non-BF children (12-17 months) who received solid, semi-solid or soft foods 4 times or more during the previous day + BF children (12-17 months) who received solid, semi-solid or soft foods 3 times or more during the previous day / All children (12-17 months)	

Non-BF (18-23 months)	Non-BF children (18-23 months) who received solid, semi-solid or soft foods 4 times or more during the previous day / All non-BF children (18-23 months)	
BF (18-23 months)	BF children (18-23 months) who received solid, semi-solid or soft foods 3 times or more during the previous day / All BF children (18-23 months)	
Both (18-23 months)	Non-BF children (18-23 months) who received solid, semi-solid or soft foods 4 times or more during the previous day + BF children (18-23 months) who received solid, semi-solid or soft foods 3 times or more during the previous day / All children (18-23 months)	
Non-BF (6-23 months)	Non-BF children (6-23 months) who received solid, semi-solid or soft foods 4 times or more during the previous day / All non-BF children (6-23 months)	
BF (6-23 months)	BF children (6-8 months) who received solid, semi-solid or soft foods 2 times or more during the previous day + BF children (9-23 months) who received solid, semi-solid or soft foods 3 times or more during the previous day / All BF children (6-23 months)	
Both (6-23 months)	Non-BF children (6-23 months) who received solid, semi-solid or soft foods 4 times or more during the previous day + BF children (6-8 months) who received solid, semi-solid or soft foods 2 times or more during the previous day + BF children (9-23 months) who received solid, semi-solid or soft foods 3 times or more during the previous day / All children (6-23 months)	
Minimum acceptable diet ***		
BF (6-11 months)	BF children (6-8 months) who received solid, semi-solid or soft foods 2 times or more and who received these foods from ≥ 4 food groups during the previous day + BF children (9-11 months) who received solid, semi-solid or soft foods 3 times or more and who received these foods from ≥ 4 food groups during the previous day / All BF children (6-11 months)	See Appendix IV: DDS7-score
BF (12-17 months)	BF children (12-17 months) who received solid, semi-solid or soft foods 3 times or more and who received these foods from ≥ 4 food groups during the previous day / All BF children (12-17 months)	V404: Currently breastfeeding (yes/no)
BF (18-23 months)	BF children (18-23 months) who received solid, semi-solid or soft foods 3 times or more and who received these foods from ≥ 4 food groups during the previous day / All BF children (18-23 months)	M39: Number of times ate solid, semi-solid or soft food yesterday
BF (6-23 months)	BF children (6-8 months) who received solid, semi-solid or soft foods 2 times or more and who received these foods from ≥ 4 food groups during the previous day + BF children (9-23 months) who received solid, semi-solid or soft foods 3 times or more and who received these foods from ≥ 4 food groups during the previous day / All BF children (6-23 months)	

Non-BF = non-breastfeeding, BF = breastfeeding, both = non-breastfeeding + breastfeeding.

** According to the WHO, the minimal meal frequency for non-breastfed children is adequate when: 'non-breastfed child received solid, semi-solid or soft food or milk feeds 4 times or more during the previous day'. However, information on number of non-breast milk feedings contained > 80% of missing values. Therefore, in this study, we used the indicator for minimal meal frequency for non-breastfed children as follows: 'non-breastfed children who received solid, semi-solid or soft foods four times or more during the previous day / all non-breastfed children'.

*** This indicator is calculated only for breastfed children. This is because for non-breastfed children this indicator is defined as: 'non-breastfed children who received at least two milk feedings and had at least the minimum dietary diversity score (not including milk feeds) and the minimum meal frequency during the previous day / all non-breastfed children'. Due to the fact that data on minimum number of non-breast milk feedings were not available in the RDHS data, this calculation was not possible. However, the proportion of non-breastfed children was relatively small (5.3%) and made a small influence on the overall estimations of minimal acceptable diet

Appendix IV: Dietary diversity score (DDS-7)

Dietary diversity has been shown to be associated with increased nutrient adequacy of children in developed countries (Kant 1996; Moursi et al. 2008). To see whether the diet of children of 6-23 months of age in Rwanda is nutritiously adequate the minimal dietary diversity score is calculated, using the DDS-7 indicator. This indicator consists of 7 food groups, which are defined below. The bullets describe which variables of the 2010 RDHS can be used to indicate whether the child received food from the 7 different food groups.

1. Infant formula, milk other than breast milk, cheese or yogurt or other milk products;

- Gave child baby formula (V411A)
- Gave child tinned, powdered or fresh milk (V411)
- Gave child yogurt (V414V)
- Gave child cheese, yogurt, other milk products (V414P)

2. Foods made from grains, roots, and tubers, including porridge and fortified baby food from grains;

- Gave child bread, noodles, other made from grains (V414E)
- Gave child potatoes, cassava, or other tubers (V414F)
- Gave child fortified baby food (V412A)

3. Vitamin A-rich fruits and vegetables;

- Gave child mangoes, papayas, other vitamin A fruits (V414K)
- Gave child pumpkin, carrots, squash (yellow or orange inside) (V414I)

4. Other fruits and vegetables;

- Gave child any dark green leafy vegetables (V414J)
- Gave child any other fruits (V414L)

5. Eggs;

- Gave child eggs (V414G)

6. Meat, poultry, fish, and shellfish (and organ meats);

- Gave child meat (beef, pork, lamb, chicken, etc.) (V414H)
- Gave child liver, heart, other organs (V414M)
- Gave child fish or shellfish (V414N)

7. Legumes and nuts;

- Gave child food made from beans, peas, lentils, nuts (V414O)

APPENDIX V: CODEBOOK FOR RDHS 2010 VARIABLES

Original DHS variable name	Original RDHS variable code	Categories / range	Adjusted / newly composed variable name	Adjusted / new code	Continuous / categorical	Categories
Identification variables						
Case identification	CASEID	-	-	-	Continuous	-
Sample construction variables						
Date of interview (CMC)	V008	-	Age (in months)	V008_B3	Continuous	-
Date of birth (CMC)	B3	-				
Child is alive	B5	0 = no 2 = yes	-	-	Categorical	1 = child is alive 0 = child is not alive
Child lives with whom	B9	0 = respondent 1 = father 2 = other relative 3 = somewhere else 4 = lives elsewhere	Child lives with respondent	B9_1	Categorical	1 = respondent 0 = other
Index to birth history	MIDX	Range 1:6	Child is lastborn	MIDX_1	Categorical	1 = child is lastborn 0 = child is not lastborn
Dependent variables						
Height/age standard deviation (new WHO standards)	HW70	Range -600:600	Height-for-age (Z-score) (HW70 / 100)	HW70_con	Continuous	-
			Moderately stunting	HW70_cat	Categorical	1 = child is stunted (-2SD) 0 = child is not stunted (-3SD)
			Severely stunting	HW70_cat1	Categorical	1 = child is stunted (-3SD) 0 = child is not stunted (-3SD)
WHO indicator variables						
Gave child plain water	V409	1 = yes 0 = no	-	-	Categorical	1 = yes 0 = no
Gave child juice	V410	1 = yes	-	-	Categorical	1 = yes

		0 = no				0 = no
Gave child tinned, powdered or fresh milk	V411	1 = yes 0 = no	-	-	Categorical	1 = yes 0 = no
Gave child baby formula	V411A	1 = yes 0 = no	-	-	Categorical	1 = yes 0 = no
Gave child fortified baby food	V412A	1 = yes 0 = no	-	-	Categorical	1 = yes 0 = no
Gave child bread, noodles, other made from grains	V414E	1 = yes 0 = no	-	-	Categorical	1 = yes 0 = no
Gave child potatoes, cassava, or other tubers	V414F	1 = yes 0 = no	-	-	Categorical	1 = yes 0 = no
Gave child eggs	V414G	1 = yes 0 = no	-	-	Categorical	1 = yes 0 = no
Gave child meat (beef, pork, lamb, chicken, etc)	V414H	1 = yes 0 = no	-	-	Categorical	1 = yes 0 = no
Gave child pumpkin, carrots, squash (yellow or orange inside)	V414I	1 = yes 0 = no	-	-	Categorical	1 = yes 0 = no
Gave child any dark green leafy vegetables	V414J	1 = yes 0 = no	-	-	Categorical	1 = yes 0 = no
Gave child mangoes, papayas, other vitamin A fruits	V414K	1 = yes 0 = no	-	-	Categorical	1 = yes 0 = no
Gave child any other fruits	V414L	1 = yes 0 = no	-	-	Categorical	1 = yes 0 = no
Gave child liver, heart, other organs	V414M	1 = yes 0 = no	-	-	Categorical	1 = yes 0 = no
Gave child fish or shellfish	V414N	1 = yes 0 = no	-	-	Categorical	1 = yes 0 = no
Gave child food made from beans, peas, lentils, nuts	V414O	1 = yes 0 = no	-	-	Categorical	1 = yes 0 = no
Gave child cheese, yogurt, other milk products	V414P	1 = yes 0 = no	-	-	Categorical	1 = yes 0 = no
Gave child yogurt	V414V	1 = yes 0 = no	-	-	Categorical	1 = yes 0 = no
Drank from bottle with nipple yesterday/last night	M38	1 = yes 0 = no	-	-	Categorical	1 = yes 0 = no

Number of times ate solid, semi-solid or soft food yesterday	M39	Range 0:7	-	-	Continuous	-
Explanatory variables and covariates						
<u>Individual level (child)</u>						
Sex of child	B4	1 = male 2 = female	-	-	Categorical	1 = male 2 = female
Date of interview (CMC) Date of birth (CMC)	V008 B3	- -	Age (in months) categories	agecat3	Categorical	1 = 6-11 months 2 = 12-17 months 3 = 18-23 months
Breastfeeding initiation	M34	0 = immediately 100 = within first hour 101:198 = within first day 201:298 = after first day	Early initiation of breastfeeding (cat)	M34_cat	Categorical	1 = immediately 2 = within 1 hour 3 = after 1 hour
Currently breastfeeding	V404	1 = yes 0 = no	-	-	Categorical	1 = yes 0 = no
Duration of breastfeeding (months)	M5	Range 0:59 93 = ever breastfed, not currently breastfeeding (set to missing) 94 = never breastfed	Duration of breastfeeding (cat)	M5_cat	Categorical	1 = never breastfed 2 = < 6 months 3 = 6-12 months 4 = 13-24 months 5 = ever breastfed, not currently breastfeeding
Birth order number	BORD	Range 1:20	Birth order number (cat)	BORD_cat	Categorical	1 = first born 2 = second to fourth 3 = fifth or more
Child is twin	B0	0 = single birth 1 = 1st of multiple birth 2 = 2nd of multiple birth 3 = 3rd of multiple birth 4 = 4th of multiple birth 5 = 5th of multiple birth	Child is twin (cat)	B0_cat	Categorical	1 = single 2 = multiple
Preceding birth interval (months)	B11	Range 0:250	Preceding birth interval (cat)	B11_cat	Categorical	1 = no previous birth 2 = < 24 months 3 = ≥ 24 months

Size of child at birth (reported subjectively by the respondent)	M18	1 = very large 2 = larger than average 3 = average 4 = smaller than average 5 = very small	Size of child at birth (cat)	M18_cat	Categorical	1 = small 2 = average 3 = large
Had diarrhoea episode recently	H11	0 = no 1 = yes, last 24 hours 2 = yes, last two weeks	Had diarrhoea episode recently (cat)	H11_cat	Categorical	1 = no 2 = yes, last two weeks
Maternal/household level						
Respondent’s current age	V012	Range 15:49	Respondent’s current age (cat)	V012_cat	Categorical	1 = 15-24 years 2 = 25-34 years 3 = 35-49 years
Respondent's height in centimeters	V438	Range 500:2500	Respondent's height in centimeters (cat) – (V438 / 10)	V438_cat	Categorical	1 = < 150 cm 2 = 150-155 cm 3 = > 155 cm
Height/age standard deviation of the respondent**	V440	Range -600:600	Respondent is stunted (cat) – (V440 / 100)	V440_cat1		1 = yes 2 = no
Body Mass Index	V445	Range 1200:6000	Body Mass Index (cat) – (V445 / 100)	V445_cat	Categorical	1 = < 18.5 kg m^{-2} 2 = 18.5-24.9 kg m^{-2} 3 = ≥ 25 kg m^{-2}
Age of respondent at 1st birth	V212	Range 10:49	Age of respondent at 1st birth (cat)	V212_cat	Categorical	1 = < 20 years 2 = 20-29 years 3 = > 30 years
Respondent currently working	V714	0 = no 1 = yes	-	-	Categorical	0 = no 1 = yes
Highest educational level	V106	0 = no education 1 = primary 2 = secondary 3 = higher	Highest educational level (cat)	V106_cat	Categorical	0 = no education 1 = primary education 2 = secondary or higher education
Literacy	V155	0 = cannot read at all 1 = able to read only parts of sentence 2 = able to read whole	Literacy (cat)	V155_cat	Categorical	0 = cannot read at all 1 = able to read only parts of sentence 2 = able to read whole

		sentence 3 = no card with required language (missing) 4 = blind/visually impaired (0)				sentence
Religion	V130	1 = Catholic 2 = Protestant 3 = Adventist 4 = Muslim 5 = traditional 6 = no religion 96 = other	Religion (cat)	V130_cat	Categorical	1 = Christian 2 = Muslim 3 = other
Wealth index	V190	1 = poorest 2 = poorer 3 = middle 4 = richer 5 = richest	-	-	Categorical	1 = poorest 2 = poorer 3 = middle 4 = richer 5 = richest
Number of household members	V136	Range 1:17	Number of household members (cat)	V136_cat	Categorical	1 = 1-4 members 2 = 5+ members
Number of children 5 and under in household (*de jure**)	V137	Range 0:6	Number of children 5 and under in household (cat)	V137_cat	Categorical	1 = 1 child 2 = 2 children 3 = 3+ children
Frequency of reading newspaper or magazine	V157	0 = not at all 1 = less than once a week 2 = at least once a week 3 = almost every day	-	-	Categorical	0 = not at all 1 = less than once a week 2 = at least once a week 3 = almost every day
Frequency of listening to radio	V158	0 = not at all 1 = less than once a week 2 = at least once a week 3 = almost every day	-	-	Categorical	0 = not at all 1 = less than once a week 2 = at least once a week 3 = almost every day
Frequency of watching television	V159	0 = not at all 1 = less than once a week 2 = at least once a week 3 = almost every day	-	-	Categorical	0 = not at all 1 = less than once a week 2 = at least once a week 3 = almost every day

Health care level						
Type of delivery assistance	M3	A = doctor; B = nurse / medical assistant; C = midwife; D-F = country-specific health professional; G = traditional birth attendant; H = community health worker; I = community health mother and child; J = friend/relative; K = other; L-M = country-specific other	Type of delivery assistance (cat)	M3_cat	Categorical	1 = health professional 2 = other
Number of antenatal visits during pregnancy	M14	Range 0:40	Number of antenatal visits during pregnancy (cat)	M14_cat	Categorical	0 = none 1 = 1-3 visits 2 = 4+ visits
Place of delivery	M15	10-12 = home 20-29 = public hospital or health centre 30-36 = private hospital or clinic 96 = other	Place of delivery (cat)	M15_cat	Categorical	1 = health facility 2 = home / other
Health card for child	H1	0 = no card 1 = yes, seen 2 = yes, not seen 3 = no longer has card	Access to postnatal care (cat)	H1_cat	Categorical	1 = yes 2 = no
Community level						
Region	V024	1 = Kigali City 2 = South 3 = West 4 = North 5 = East	-	-	Categorical	1 = Kigali City 2 = South 3 = West 4 = North 5 = East
Type of place of residence	V025	1 = urban 2 = rural	-	-	Categorical	1 = urban 2 = rural
Cluster altitude	V040	Range 1072:2653	Cluster altitude (cat)	V040_cat	Categorical	1 = lowest

						2 = low 3 = high 4 = highest
Source of drinking water	V113	10 = piped water 11 = piped into dwelling 12 = piped to yard/plot 13 = public tap/standpipe 20 = tube well water 21 = tube well or borehole 30 = dug well (open/ protected) 31 = protected well 32 = unprotected well 40 = surface water 41 = protected spring 42 = unprotected spring 43 = river/dam/lake/ ponds/stream/canal/irrigation channel 51 = rainwater 61 = tanker truck 62 = cart with small tank 71 = bottled water 96 = other	Access to improved drinking water source (cat)	V113_cat	Categorical	1 = yes (piped water into plot, dwelling or yard, public tap/standpipe, borehole/tube well, protected dug well, protected spring, rainwater collection or bottled water) 2 = no (unprotected wells, unprotected springs, water provided by carts with small tanks, tanker truck-provided water and surface water taken directly from rivers, ponds, streams, lakes, dams or irrigation channels or other)
Time to get to drinking water source (roundtrip in minutes)	V115	Range 0:900 996 = on premises	Time to get to drinking water source (cat)	V115_cat	Categorical	1 = ≤ 30 minutes 2 = > 30 minutes
-	-		Access to safe drinking water	ASDW	Categorical	1 = no (no access to improved drinking water source or > 30 minutes to reach the source) 2 = yes (access to improved drinking water source and ≤ 30 minutes

						to reach the source or source on premises)
Type of toilet facility	V116	10 = flush toilet 11 = flush to piped sewer system 12 = flush to septic tank 13 = flush to pit latrine 14 = flush to somewhere else 15 = flush, don't know where 20 = pit toilet latrine 21 = ventilated improved pit latrine(vip) 22 = pit latrine with slab 23 = pit latrine without slab/open pit 30 = no facility 31 = no facility/ bush/field; 41 = composting toilet 42 = bucket toilet 43 = hanging toilet/latrine 96 = other	Access to improved sanitation facility (cat)	V116_cat	Categorical	1 = yes (flush toilet, flush to piped sewer tank, septic tank or pit latrine, pit toilet latrine, ventilated improved pit latrine (vip), pit latrine with slab, composting toilet) 2 = no (pit latrine without slab/open pit, no facility, bush/field, bucket toilet, hanging toilet/latrine, flush to somewhere else or don't know where, other)
Toilet facility shared with other household	V160	0 = no 1 = yes	-	-	Categorical	0 = no 1 = yes
-	-		Access to proper sanitation	APS	Categorical	1 = no (no access to improved sanitation facility or improved sanitation but shared) 2 = yes (access to improved sanitation facility and not shared)

Variables needed for analysis						
Cluster number	V001	Range	-	-	Continuous	-
Women's individual sample weight	V005	-	-	-	Continuous	-
Stratification used in sample design	V023	Range	-	-	Continuous	-

* *de jure* = (question only asked of) usual residents

** The NCHS/FELS/CDC only contains data for children up to the age of 18 years. For all women older than 18 years, the value of 215 months (17 years and 11 months) is used for their age, assuming that women are fully grown on the age of 18.

APPENDIX VI: RESULTS

Table 10: Individual, maternal / household and community level baseline characteristics of children aged 6-23 months, Rwanda 2010-2011.

Characteristic	Total sample (n = 2393)			APM subsample (n = 1181)			P-value
	N	%	Missing Values N	N	%	Missing Values N	
Individual level (child)							
Gender of the child							
Male	1184	49.5	-	591	50.0	-	0.5701
Female	1210	50.5		590	50.0		
Child's age in months							
6-11 months	838	35.0	-	416	35.2	-	0.8642
12-17 months	765	32.0		381	32.3		
18-23 months	790	33.0		384	32.5		
Stunting (HAZ <-2SD)							
Yes	464	39.3	1213	464	39.3	-	-
No	716	60.7		712	60.7		
Breastfeeding initiation							
Immediately	1597	67.8	36	798	68.6	18	0.6590
Within 1 hour	111	4.7		53	4.5		
After 1 hour	649	27.5		312	26.9		
Currently breastfed							
Yes	2221	92.8	-	1087	92.0	-	0.2372
No	172	7.2		94	8.0		
Birth order							
First born	653	27.3	-	336	28.4	-	0.3246
Second to fourth	1113	46.5		531	45.0		
Fifth or more	627	26.2		314	26.6		
Type of birth							
Single	2345	98.0	-	1157	98.0	-	0.9940
Multiple	48	2.0		24	2.6		
Preceding birth interval							
No previous birth	655	27.4	-	337	28.6	-	**0.0171**
< 24 months	322	13.5		178	15.1		
> 24 months	1416	59.1		666	56.3		
Size of child at birth							
Small	360	15.1	8	176	15.0	4	0.4683
Average	1011	42.4		486	41.3		
Large	1014	42.5		514	43.7		
Had diarrhoea episode recently							
No	1821	76.1	-	896	75.9	-	0.8518
Yes, last 2 weeks	572	23.9		285	24.1		
Maternal/household level							
Maternal age							
15-24 years	622	26.0	-	316	26.8	-	0.1915
25-34 years	1272	53.1		606	51.3		
35-49 years	500	20.9		259	21.9		
Maternal height							
< 150 cm	174	14.5	1192	174	14.7	1	-
150-155 cm	327	27.2		314	26.7		
> 155 cm	700	58.3		692	58.6		
Maternal BMI							
< 18.5 kg m^{-2}	64	5.3	1192	62	5.3	1	-
18.5-24.9 kg m^{-2}	950	79.1		934	79.1		
≥ 25 kg m^{-2}	187	15.6		184	15.6		

Respondent is stunted							
Yes	289	24.1	1192	286	24.3	1	-
No	912	75.9		894	75.7		
Maternal age at first birth							
< 20 years	656	27.4	-	317	26.8	-	0.7707
20-29 years	1678	70.1		833	70.5		
> 30 years	59	2.5		31	2.7		
Maternal working status							
Non-working	486	20.3	2	248	21.0	2	0.4318
Currently working	1905	79.7		931	79.0		
Maternal education							
No education	414	17.3	-	206	17.5	-	0.7818
Primary education	1769	73.9		867	73.4		
Secondary or higher education	210	8.8		108	9.1		
Maternal literacy							
Cannot read at all	623	26.0	1	309	26.2	1	0.3811
Able to read only parts of sent.	236	9.9		106	9.0		
Able to read whole sentence	1533	64.1		765	64.8		
Religion							
Christian	2316	96.9	3	1144	97.1	2	0.7078
Muslim	29	1.2		12	1.0		
Other	45	1.9		23	1.9		
Wealth index							
Richest	379	15.8	-	192	16.2	-	0.1192
Richer	442	18.5		207	17.6		
Middle	433	18.1		231	19.6		
Poorer	541	22.6		278	23.4		
Poorest	598	25.0		273	23.2		
Number of household members							
1-4 household members	973	40.7	-	496	42.0	-	0.2304
5+ household members	1420	59.3		685	58.0		
Number of children under 5 yrs							
One	940	39.4	10	457	38.8	4	0.7872
Two	1152	48.3		578	49.1		
Three or more	293	12.3		142	12.1		
Frequency of listening to radio							
Almost every day	0	-	3	0	-	3	0.6930
At least once a week	1503	62.9		743	63.1		
Less than once a week	645	27.0		322	27.3		
Not at all	242	10.1		113	9.6		
Frequency of watching TV							
Almost every day	0	-	1	0	-	1	0.3100
At least once a week	130	5.4		73	6.2		
Less than once a week	538	22.5		262	22.2		
Not at all	1724	72.1		845	71.6		
Frequency of reading newspaper or magazine							
Almost every day	0	-	-	0	-	-	0.4832
At least once a week	35	1.5		18	1.5		
Less than once a week	406	17.0		189	16.0		
Not at all	1952	81.5		974	82.5		
Health care level							
Antenatal clinic visits							
None	49	2.1	26	23	2.0	12	0.0834
1-3 visits	1446	61.1		742	63.5		
4+ visits	872	36.8		404	34.5		
Place of delivery							

Health facility	1900	81.1	51	934	80.9	27	0.8105
Home / other	442	18.9		220	19.1		
Type of delivery assistance							
Health professional	1882	78.7	3	923	78.2	-	0.4889
Other	508	21.3		258	21.8		
Access to postnatal care							
Yes	2073	86.7	1	1021	86.5		
No	319	13.3		160	13.5	-	0.8418
Community level							
Residence							
Urban	263	11.0	-	132	11.2	-	0.7579
Rural	2130	89.0		1049	88.8		
Geographical region							
Kigali city	217	9.1	-	102	8.6	-	0.7824
South	573	23.9		274	23.2		
West	651	27.2		330	28.0		
North	352	14.7		178	15.0		
East	600	25.1		297	25.2		
Cluster altitude							
Lowest	585	24.5	-	293	24.8	-	0.9702
Low	611	25.5		298	25.3		
High	603	25.2		297	25.1		
Highest	594	24.8		293	24.8		
Access to safe drinking water							
Yes	1178	49.8	29	583	50.0	15	0.9002
No	1186	50.2		583	50.0		
Access to proper sanitation							
Yes	994	42.7	63	481	41.6	27	0.3297
No	1336	57.3		673	58.4		

APM subsample = subsample for which anthropometric measurements were available.

* The high number of missing values is caused because the DHS took a subsample for which height and age measurements were collected. For the current study sample, this subsample consisted of 1181 children, which is 49.4% of the total study sample. For the mothers, 1201 (50.2%) values for height measurements were available. This is in line with the subsample of 50% of the households for which the RDHS 2010 collected anthropometric measurements of the household members.

Table 11: Breastfeeding and complementary feeding by age of children

	Age of the child (months)			
	6-8	9-11	12-17	18-23
	% 95% CI	% 95% CI	% 95% CI	% 95% CI
Exclusive breastfeeding or predominant breastfeeding	31.3 (26.5 ; 36.2)	5.0 (2.8 ; 7.2)	1.5 (0.6 ; 2.4)	0.9 (0.2 ; 1.5)
Complementary feeding	67.2 (62.3 ; 72.1)	91.5 (88.8 ; 94.3)	92.7 (90.8 ; 94.6)	85.1 (82.5 ; 87.8)

Table 12: Maternal education level of children that are exclusively breastfed or predominantly breastfed

	Age of the child (months)				
	6-8	9-11	12-17	18-23	6-23
Maternal education level	% (n)	% (n)	% (n)	% (n)	% (n)
No or primary education	96.9 (127)	95.2 (20)	100 (12)	85.7 (6)	96.5 (165)
Secondary education	3.1 (4)	4.8 (1)	- (0)	14.3 (1)	3.5 (6)
TOTAL	100 (131)	100 (21)	100 (12)	100 (7)	100 (171)

Table 13: Residence of children that are exclusively breastfed or predominantly breastfed

Residence	Age of the child (months) 6-8 % (n)	9-11 % (n)	12-17 % (n)	18-23 % (n)	6-23 % (n)
Urban	7.6 (10)	4.8 (1)	- (0)	14.3 (1)	7.0 (12)
Rural	92.4 (121)	95.2 (20)	100 (12)	85.7 (6)	93.0 (159)
TOTAL	100 (131)	100 (21)	100 (12)	100 (7)	171

Table 14: Food group consumption by Wealth Index score, cluster altitude and geographical region

	Children that received infant formula, milk other than breast milk, cheese or yoghurt etc.	Children that received foods made from grains, roots, and tubers.	Children that received vitamin A rich fruits and vegetables	Children that received other fruits and vegetables	Children that received eggs	Children that received meat, poultry, fish and shellfish (and organ meats)	Children that received legumes and nuts
	%	%	%	%	%	%	%
Wealth Index							
Poorest	8.2	63.2	26.8	60.8	1.6	13.4	65.1
Poorer	13.5	64.9	27.1	63.3	3.0	11.9	70.4
Middle	17.0	65.2	33.3	66.7	3.3	15.5	66.5
Richer	22.2	65.7	38.3	67.6	4.2	15.5	67.5
Richest	45.1	73.4	58.5	72.4	13.0	32.3	66.6
Cluster altitude							
Lowest	24.7	64.3	42.3	65.9	6.6	23.1	71.0
Low	19.0	62.1	37.5	66.9	4.6	18.8	66.2
High	17.1	73.9	35.2	69.3	4.7	18.2	69.8
Highest	17.0	63.7	25.8	59.9	2.1	7.3	62.0
Region							
Kigali	36.2	73.1	57.8	69.9	12.1	31.0	61.4
South	20.7	73.2	31.8	68.8	5.3	16.9	72.1
West	13.1	61.7	28.9	60.7	3.0	15.3	54.8
North	15.8	73.0	36.4	71.7	4.0	10.4	71.5
East	21.1	57.2	36.3	62.6	2.8	17.1	75.8

Table 15: Proportion of children achieving complementary feeding indicators by region.

	Age group	Kigali % CI	South % CI	West % CI	North % CI	East % CI
Continued breastfeeding	12-15	80.8 (68.3 ; 93.3)	98.3 (95.9 ; 100)	97.3 (94.8 ; 99.8)	95.1 (89.9 ; 100)	93.4 (88.5 ; 98.4)
Timely introduction CF	6-8	51.9 (33.4 ; 70.4)	72.2 (64.1 ; 80.3)	68.5 (59.6 ; 77.3)	61.1 (48.2 ; 73.9)	57.5 (46.0 ; 69.0)
Minimum dietary diversity	6-23	53.2 (38.1 ; 55.5)	33.4 (29.6 ; 37.3)	18.1 (14.2 ; 22.1)	30.3 (24.9 ; 35.6)	29.9 (25.6 ; 34.2)
Minimum meal frequency	6-23	54.0 (46.2 ; 61.8)	56.0 (52.0 ; 60.1)	42.4 (37.7 ; 47.1)	54.4 (48.7 ; 60.1)	50.8 (45.8 ; 55.8)
Minimum acceptable diet	6-23	37.7 (30.1 ; 45.3)	24.0 (21.0 ; 27.1)	12.8 (9.2 ; 16.3)	19.3 (15.0 ; 23.7)	20.1 (16.7 ; 23.5)
Stunting rate		24.0 (15.2 ; 32.7)	36.6 (30.9 ; 42.4)	42.8 (37.3 ; 48.3)	43.0 (34.4 ; 51.6)	40.9 (35.5 ; 46.4)

Table 16: Cox proportional hazard model with prevalence ratios for the association of each WHO indicator with **moderate stunting -2SD** (n = 1181)

Indicator	Crude PR*	(95% CI)	P value	Adjusted PR**	(95% CI)	P value
Continued breastfeeding at 1 year (12-15 months)	1.34	(0.57 ; 3.15)	0.5082	1.08	(0.44 ; 2.68)	0.8674
Timely introduction of solid, semi-solid or soft food (6-8 months)	0.95	(0.62 ; 2.67)	0.4576	0.98	(0.65 ; 2.81)	0.7256
<u>Minimum dietary diversity</u>						
Minimum dietary diversity for children 6-23 months	0.96	(0.81 ; 1.12)	0.5722	1.09	(0.93 ; 1.28)	0.2739
Minimum dietary diversity for children 6-11 months	0.86	(0.53 ; 1.39)	0.5345	1.16	(0.71 ; 1.90)	0.5484
Minimum dietary diversity for children 12-17 months	1.03	(0.80 ; 1.34)	0.8023	1.14	(0.88 ; 1.47)	0.3164
Minimum dietary diversity for children 18-23 months	0.92	(0.75 ; 1.12)	0.3764	1.03	(0.86 ; 1.25)	0.6950
<u>Minimal meal frequency</u>						
Minimal meal frequency for children 6-23 months	0.94	(0.82 ; 1.08)	0.3643	0.99	(0.87 ; 1.15)	0.9907
Minimal meal frequency for children 6-11 months	0.97	(0.66 ; 1.41)	0.8598	1.10	(0.76 ; 1.59)	0.6195
Minimal meal frequency for children 12-17 months	1.09	(0.86 ; 1.38)	0.4849	1.16	(0.91 ; 1.48)	0.2367
Minimal meal frequency for children 18-23 months	**0.82**	**(0.68 ; 1.00)**	**0.0498**	0.86	(0.70 ; 1.05)	0.1295
<u>Minimum acceptable diet</u>						
Minimum acceptable diet for children 6-23 months	0.90	(0.75 ; 1.08)	0.2734	1.06	(0.88 ; 1.28)	0.5126
Minimum acceptable diet for children 6-11 months	0.98	(0.58 ; 1.66)	0.9497	1.33	(0.79 ; 2.24)	0.2797
Minimum acceptable diet for children 12-17 months	0.98	(0.72 ; 1.34)	0.8895	1.16	(0.84 ; 1.61)	0.3769
Minimum acceptable diet for children 18-23 months	0.84	(0.67 ; 1.06)	0.1379	0.96	(0.76 ; 1.21)	0.7339

* Crude model adjusted for age and sex of the child

** Adjusted model for *continued breastfeeding at 1 year* adjusted for: sex child, age child, maternal age, wealth index, region and type of place of residence.
Adjusted model for *timely introduction of solid, semi-solid or soft food* adjusted for: sex child, age child, duration of breastfeeding, maternal age, maternal education, wealth index, region and type of residence.
Adjusted model for *minimum dietary diversity* adjusted for: sex child, age child, duration of breastfeeding, preceding birth interval, size of child at birth, maternal BMI, maternal education, wealth index, frequency of reading newspaper and watching television, region, type of residence, cluster altitude and access to safe drinking water.
Adjusted model for *minimal meal frequency* adjusted for: sex child, age child, maternal age, maternal education, wealth index, region, type of residence, access to safe drinking water.
Adjusted model for *minimum acceptable diet* adjusted for: sex child, age child, duration of breastfeeding, preceding birth interval, maternal age, maternal education, wealth index, frequency of reading newspaper and watching television, region, type of residence, cluster altitude and access to safe drinking water.

Table 17: Multiple linear regression model with β-parameter estimates and p-values for the association of each WHO indicator with **HAZ-scores** (n = 1181).

Indicator	Crude estimate*	(95 % CI)	P value	Adjusted estimate**	(95 % CI)	P value
Continued breastfeeding at 1 year (12-15 months)	-0.62	(-1.60 ; 0.36)	0.2170	-0.33	(-3.12 ; 2.25)	0.5035
Timely introduction of solid, semi-solid or soft food (6-8 months)	-0.06	(-1.69 ; 2.22)	0.7884	-0.10	(-0.53 ; 0.32)	0.6372
<u>Minimum dietary diversity rate</u>						
Minimum dietary diversity rate for children 6-23 months	0.09	(-0.11 ; 0.30)	0.3583	-0.10	(-0.30 ; 0.11)	0.3592
Minimum dietary diversity rate for children 6-11 months	0.15	(-0.24 ; 0.56)	0.4493	-0.10	(-0.50 ; 0.30)	0.6277
Minimum dietary diversity rate for children 12-17 months	-0.08	(-0.39 ; 0.23)	0.6196	-0.24	(-0.54 ; 0.07)	0.1270
Minimum dietary diversity rate for children 18-23 months	0.27	(-0.05 ; 0.60)	0.0971	0.07	(-0.22 ; 0.36)	0.6203
<u>Minimum meal frequency rate</u>						
Minimum meal frequency rate for children 6-23 months	-0.04	(-0.21 ; 0.13)	0.6379	-0.11	(-0.28 ; 0.06)	0.2037
Minimum meal frequency rate for children 6-11 months	-0.21	(-0.51 ; 0.10)	0.1905	**-0.32**	**(-0.62 ; -0.01)**	**0.0440**
Minimum meal frequency rate for children 12-17 months	-0.14	(-0.42 ; 0.13)	0.3081	-0.23	(-0.52 ; 0.07)	0.1321
Minimum meal frequency rate for children 18-23 months	0.25	(-0.03 ; 0.53)	0.0842	0.19	(-0.08 ; 0.47)	0.1650
<u>Minimum acceptable diet rate</u>						
Minimum acceptable diet rate for children 6-23 months	0.11	(-0.11 ; 0.33)	0.3183	-0.09	(-0.33 ; 0.14)	0.4287
Minimum acceptable diet rate for children 6-11 months	-0.08	(-0.55 ; 0.38)	0.7230	-0.37	(-0.85 ; 0.11)	0.1266
Minimum acceptable diet rate for children 12-17 months	-0.02	(-0.37 ; 0.33)	0.9032	-0.24	(-0.61 ; 0.12)	0.1951
Minimum acceptable diet rate for children 18-23 months	**0.37**	**(0.04 ; 0.71)**	**0.0293**	0.16	(-0.18 ; 0.50)	0.3426

* Crude model adjusted for age and sex of the child

** Adjusted model for *continued breastfeeding at 1 year* adjusted for: sex child, age child, maternal age, wealth index, region and type of place of residence.
Adjusted model for *timely introduction of solid, semi-solid or soft food* adjusted for: sex child, age child, duration of breastfeeding, maternal age, maternal education, wealth index, region and type of residence.
Adjusted model for *minimum dietary diversity* adjusted for: sex child, age child, duration of breastfeeding, preceding birth interval, size of child at birth, maternal BMI, maternal education, wealth index, frequency of reading newspaper and watching television, region, type of residence, cluster altitude and access to safe drinking water.
Adjusted model for *minimal meal frequency* adjusted for: sex child, age child, maternal age, maternal education, wealth index, region, type of residence, access to safe drinking water.
Adjusted model for *minimum acceptable diet* adjusted for: sex child, age child, duration of breastfeeding, preceding birth interval, maternal age, maternal education, wealth index, frequency of reading newspaper and watching television, region, type of residence, cluster altitude and access to safe drinking water.

Table 18: Continued breastfeeding, timely introduction of solid, semi-solid or soft foods, minimum dietary diversity, minimal meal frequency and minimum acceptable diet rates according to characteristics, Rwanda 2010 (n = 2393).

Characteristic	Continued breastfeeding at 1 year			Timely introduction of solid, semi-solid or soft foods			Minimum dietary diversity			Minimum meal frequency			Minimum acceptable diet		
	%	(95% CI)	P	%	(95% CI)	P	%	(95% CI)	P	%	(95% CI)	P	%	(95% CI)	P
<u>Individual level (child)</u>															
Gender of the child															
Male	95.7	(93.1 ; 98.2)	0.3354	66.0	(59.4 ; 72.5)	0.3574	28.3	(25.6 ; 31.0)	**0.1597**	50.5	(47.4 ; 53.6)	0.9267	20.0	(17.7 ; 22.3)	0.9275
Female	93.7	(90.6 ; 96.9)		61.5	(54.3 ; 68.7)		31.1	(28.1 ; 34.1)		50.7	(47.6 ; 53.7)		19.9	(17.4 ; 22.3)	
Child's age in months															
6-11 months							20.1	(17.3 ; 22.9)	**<0.0001**	43.1	(39.5 ; 46.6)	**<0.0001**	13.2	(10.9 ; 15.5)	**<0.0001**
12-17 months							33.1	(29.6 ; 36.6)		51.0	(47.3 ; 54.7)		21.1	(18.2 ; 24.0)	
18-23 months							36.6	(32.8 ; 40.4)		58.2	(54.3 ; 62.1)		26.0	(22.7 ; 29.3)	
Breastfeeding initiation															
Immediately	94.9	(92.5 ; 97.3)	**0.1904**	62.3	(56.4 ; 68.3)	0.6209	29.7	(27.1 ; 32.2)	**0.0808**	50.9	(48.2 ; 53.5)	0.6761	20.6	(18.5 ; 22.8)	**0.0432**
Within 1 hour	96.4	(89.2 ; 100)		64.4	(43.6 ; 85.3)		39.4	(29.1 ; 49.7)		53.9	(45.0 ; 62.9)		27.1	(18.5 ; 35.7)	
After 1 hour	98.2	(95.9 ; 100)		67.9	(59.0 ; 76.8)		27.8	(24.0 ; 31.6)		49.7	(45.7 ; 53.8)		17.4	(14.4 ; 20.3)	
Currently breastfed															
Yes				63.3	(58.3 ; 68.4)	-	28.5	(26.4 ; 30.6)	**<0.0001**	52.4	(50.0 ; 54.8)	**<0.0001**	20.4	(18.6 ; 22.2)	**0.0351**
No				100	-		45.4	(37.8 ; 52.9)		27.0	(19.8 ; 34.2)		13.9	(8.7 ; 19.1)	
Birth order															
First born	94.9	(91.0 ; 98.9)	0.6457	67.7	(58.7 ; 76.8)	0.4908	32.9	(29.0 ; 36.9)	**0.1340**	51.4	(47.5 ; 55.3)	**0.1379**	22.2	(18.9 ; 25.5)	0.2459
Second to fourth	95.4	(92.4 ; 98.4)		60.9	(53.7 ; 68.2)		28.6	(25.8 ; 31.4)		48.5	(45.3 ; 51.7)		18.9	(16.5 ; 21.2)	
Fifth or more	93.0	(88.4 ; 97.5)		64.8	(55.1 ; 74.6)		28.4	(24.6 ; 32.1)		53.4	(49.1 ; 57.7)		19.4	(16.0 ; 22.8)	
Type of birth															
Single	95.3	(93.4 ; 97.2)	**0.0078**	64.3	(59.3 ; 69.3)	**0.0319**	29.5	(27.4 ; 31.6)	0.2190	50.5	(48.2 ; 52.9)	0.5157	19.9	(18.2 ; 21.6)	0.6730
Multiple	73.7	(41.8 ; 100)		20.8	(0,00 ; 54.6)		40.9	(21.4 ; 60.5)		56.9	(37.8 ; 76.1)		23.3	(6.7 ; 40.0)	
Preceding birth interval															
No previous birth	95.0	(91.0 ; 98.9)	0.5190	67.7	(58.7 ; 76.8)	0.5081	32.9	(28.9 ; 36.9)	**0.0040**	51.4	(47.5 ; 55.3)	0.6232	22.3	(19.0 ; 25.6)	**0.0461**
< 24 months	91.3	(82.6 ; 99.9)		58.9	(45.4 ; 72.4)		34.7	(29.1 ; 40.2)		52.4	(46.8 ; 58.1)		22.7	(17.9 ; 27.5)	
> 24 months	95.2	(92.8 ; 97.6)		62.9	(56.6 ; 69.3)		27.1	(24.7 ; 29.5)		49.8	(46.9 ; 52.7)		18.2	(16.1 ; 20.3)	
Size of child at birth															
Small	97.1	(93.8 ; 100)	0.3387	60.0	(46.7 ; 73.2)	0.7874	28.9	(23.9 ; 33.9)	**0.0294**	51.2	(45.4 ; 57.0)	0.4384	19.6	(15.3 ; 23.9)	**0.1195**
Average	93.3	(89.7 ; 96.9)		64.2	(57.0 ; 71.4)		32.6	(29.5 ; 35.7)		51.9	(48.3 ; 55.4)		21.9	(19.2 ; 24.5)	
Large	95.0	(92.3 ; 97.8)		65.1	(57.8 ; 72.4)		27.2	(24.3 ; 30.0)		48.9	(45.7 ; 52.0)		18.1	(15.5 ; 20.6)	
Had diarrhoea episode recently															
No	93.9	(91.1 ; 96.6)	0.2590	61.2	(55.8 ; 66.6)	**0.0081**	30.0	(27.6 ; 32.4)	0.5998	50.9	(48.2 ; 53.5)	0.6369	20.5	(18.5 ; 22.5)	**0.1988**
Yes, last 2 weeks	96.6	(93.5 ; 99.7)		79.3	(68.6 ; 89.9)		28.8	(24.9 ; 32.7)		49.7	(45.4 ; 54.0)		18.0	(14.8 ; 21.2)	

Maternal/household level															
Maternal age		(92.2 ; 99.0)													
15-24 years	95.6	(91.5 ; 97.3)	0.8400	64.4	(55.2 ; 73.6)	0.5735	28.1	(24.3 ; 31.9)	0.3979	47.5	(43.4 ; 51.6)	**0.0407**	17.2	(14.1 ; 20.3)	**0.0243**
25-34 years	94.4	(89.0 ; 98.9)		62.0	(55.4 ; 68.5)		29.6	(26.8 ; 32.4)		50.2	(47.0 ; 53.4)		19.6	(17.2 ; 22.0)	
35-49 years	94.0			68.9	(58.4 ; 79.3)		32.1	(27.5 ; 36.6)		55.4	(50.7 ; 60.2)		24.1	(20.1 ; 28.2)	
Maternal height		(88.0 ; 100)													
< 150 cm	95.0	(86.3 ; 100)	0.8216	67.3	(50.1 ; 84.6)	0.9855	30.0	(23.4 ; 36.6)	0.9379	49.1	(41.5 ; 56.7)	**0.2083**	23.1	(17.3 ; 28.9)	0.3706
150-155 cm	93.2	(87.6 ; 96.2)		65.6	(54.7 ; 76.5)		29.5	(24.7 ; 34.4)		47.1	(41.6 ; 52.6)		18.1	(13.9 ; 22.3)	
> 155 cm	91.9			66.1	(57.3 ; 75.0)		30.6	(26.9 ; 34.2)		52.8	(48.8 ; 56.8)		20.7	(17.7 ; 23.8)	
Maternal BMI		(68.4 ; 100)													
< 18.5 kg m^{-2}	86.4	(91.8 ; 97.7)	**0.0404**	48.5	(17.3 ; 79.6)	0.4049	30.2	(18.5 ; 41.9)	**0.0105**	51.4	(38.1 ; 64.6)	0.9699	17.5	(7.8 ; 27.2)	**0.0562**
18.5-24.9 kg m^{-2}	94.8	(67.3 ; 98.1)		66.5	(59.3 ; 73.7)		28.2	(25.3 ; 31.2)		50.5	(46.9 ; 54.1)		19.2	(16.8 ; 21.7)	
≥ 25 kg m^{-2}	82.7			71.9	(53.5 ; 90.3)		40.1	(32.0 ; 48.2)		51.5	(43.6 ; 59.4)		27.2	(20.3 ; 34.0)	
Respondent is stunted		(92.2 ; 100)													
Yes	96.7	(87.8 ; 95.6)	**0.1600**	61.9	(48.0 ; 75.8)	0.4725	30.1	(25.0 ; 35.2)	0.9637	46.2	(40.2 ; 52.2)	**0.0803**	19.8	(15.3 ; 24.4)	0.7899
No	91.7			67.6	(60.0 ; 75.2)		30.2	(27.0 ; 33.4)		52.2	(48.6 ; 55.7)		20.6	(17.9 ; 23.2)	
Maternal age at first birth		(94.0 ; 99.7)													
< 20 years	96.8	(91.1 ; 96.5)	0.3544	64.9	(55.1 ; 74.7)	0.3189	26.0	(22.6 ; 29.3)	**0.0039**	47.9	(43.9 ; 52.0)	**0.0795**	17.6	(14.6 ; 20.5)	**0.0015**
20-29 years	93.8	(85.5 ; 100)		63.0	(57.4 ; 68.5)		30.7	(28.1 ; 33.2)		51.3	(48.5 ; 54.0)		20.3	(18.2 ; 22.3)	
> 30 years	95.0			90.6	(72.3 ; 100)		44.3	(31.4 ; 57.2)		61.1	(49.7 ; 72.5)		36.8	(24.4 ; 49.1)	
Maternal working status		(84.6 ; 95.4)													
Non-working	90.0	(93.8 ; 98.2)	**0.0175**	56.7	(45.8 ; 67.7)	**0.1646**	29.2	(24.8 ; 33.7)	0.8262	45.4	(40.2 ; 50.6)	**0.0270**	18.0	(14.5 ; 21.5)	0.2328
Currently working	96.0			65.4	(59.7 ; 71.0)		29.8	(27.4 ; 32.2)		52.0	(49.4 ; 54.6)		20.4	(18.5 ; 22.4)	
Maternal education		(88.0 ; 100)													
No education	94.0	(92.9 ; 97.6)	0.4586	60.7	(49.6 ; 71.8)	**0.1253**	16.8	(12.8 ; 20.8)	**<0.0001**	41.8	(36.7 ; 47.0)	**<0.0001**	9.9	(6.8 ; 13.0)	**<0.0001**
Primary education	95.2	(82.5 ; 98.1)		62.9	(57.1 ; 68.6)		29.7	(27.2 ; 32.1)		51.1	(48.4 ; 53.7)		20.2	(18.2 ; 22.1)	
Secondary or higher ed.	90.3			78.5	(65.8 ; 91.2)		55.7	(49.3 ; 62.0)		63.9	(57.4 ; 70.4)		37.8	(31.5 ; 44.2)	
Maternal literacy															
Cannot read at all	93.8	(88.9 ; 98.8)	0.9016	66.5	(57.9 ; 75.1)	0.7379	16.3	(13.1 ; 19.5)	**<0.0001**	43.2	(38.9 ; 47.6)	**<0.0001**	9.6	(7.1 ; 12.1)	**<0.0001**
Able to read parts of sent.	95.2	(98.8 ; 100)		59.8	(41.0 ; 78.6)		23.5	(18.0 ; 29.1)		47.5	(40.8 ; 54.3)		14.3	(9.8 ; 18.9)	
Able to read whole sentence	94.9	(92.4 ; 97.4)		63.2	(57.2 ; 69.2)		36.2	(33.4 ; 38.9)		54.1	(51.2 ; 57.0)		25.0	(22.8 ; 27.3)	
Religion															
Christian	94.9	(92.8 ; 97.0)	**0.1015**	63.6	(58.7 ; 68.6)	0.5090	29.7	(27.6 ; 31.8)	**0.1937**	50.4	(48.1 ; 52.8)	0.5060	19.9	(18.2 ; 21.6)	**0.1054**
Muslim	93.0	(78.9 ; 100)		45.3	(0.0 ; 100)		42.4	(25.5 ; 59.3)		60.7	(44.9 ; 76.5)		32.2	(17.1 ; 47.3)	
Other	81.7	(58.2 ; 100)		81.2	(54.0 ; 100)		22.9	(10.1 ; 35.7)		50.4	(35.7 ; 65.2)		13.3	(3.4 ; 23.2)	
Wealth index															
Richest	92.6	(87.5 ; 97.8)	**0.0100**	65.4	(53.8 ; 77.1)	**0.1908**	56.0	(50.6 ; 61.3)	**<0.0001**	58.0	(52.5 ; 63.4)	**0.0009**	39.7	(34.4 ; 45.0)	**<0.0001**
Richer	88.7	(81.4 ; 96.0)		61.3	(49.7 ; 73.0)		32.4	(27.7 ; 37.2)		56.4	(51.1 ; 61.8)		23.5	(19.2 ; 27.9)	
Middle	94.9	(90.5 ; 99.4)		55,3	(43.5 ; 67.2)		27.8	(23.3 ; 32.2)		47.1	(42.4 ; 51.9)		15.2	(11.8 ; 18.5)	
Poorer	99.3	(98.0 ; 100)		73.4	(64.0 ; 82.9)		22.7	(19.1 ; 26.3)		48.0	(43.3 ; 52.7)		14.0	(11.0 ; 17.0)	
Poorest	95.7	(92.0 ; 99.4)		62.0	(52.4 ; 71.6)		18.8	(15.3 ; 22.3)		46.5	(42.1 ; 50.9)		13.7	(10.7 ; 16.7)	

Number of household members															
1-4 household members	94.3	(90.9 ; 97.8)	0.8086	62.8	(55.1 ; 70.5)	0.7172	27.4	(24.1 ; 30.8)	**0.0614**	50.5	(47.2 ; 53.9)	0.9745	18.5	(15.9 ; 21.1)	**0.1576**
5+ household members	94.9	(92.3 ; 97.4)		64.7	(58.1 ; 71.3)		31.3	(28.8 ; 33.8)		50.6	(47.7 ; 53.6)		20.9	(18.8 ; 23.1)	
Number of children under 5 yrs															
One	94.6	(91.5 ; 97.7)	0.7021	63.7	(55.7 ; 71.8)	0.4423	33.0	(29.6 ; 36.5)	**0.0247**	50.5	(47.2 ; 53.8)	0.9980	21.7	(18.9 ; 24.4)	0.2325
Two	95.2	(92.4 ; 98.1)		66.3	(59.5 ; 73.1)		27.2	(24.4 ; 30.0)		50.5	(47.3 ; 53.7)		18.6	(16.2 ; 21.0)	
Three or more	92.4	(84.9 ; 99.9)		57.8	(45.6 ; 69.9)		29.0	(23.5 ; 34.6)		50.7	(44.4 ; 57.0)		19.6	(14.9 ; 24.2)	
Frequency of listening to radio															
Almost every day	0.0	-	0.2469	0.0	-	0.9972	0.0	-	**<0.0001**	0.0	-		0.0	-	**0.0068**
At least once a week	94.6	(91.9 ; 97.4)		63.8	(57.5 ; 70.2)		33.5	(30.8 ; 36.2)		52.7	(49.8 ; 55.6)	**0.0390**	22.0	(19.7 ; 24.3)	
Less than once a week	96.1	(93.1 ; 99.1)		63.8	(54.6 ; 72.9)		23.9	(20.5 ; 27.4)		46.8	(42.8 ; 50.7)		17.1	(14.2 ; 20.0)	
Not at all	89.3	(79.8 ; 98.9)		64.4	(49.0 ; 79.8)		22.1	(16.0 ; 28.1)		47.2	(40.0 ; 54.4)		15.0	(10.2 ; 19.9)	
Frequency of watching TV															
Almost every day	0.0	-	**0.1519**	0.0	-	0.9707	0.0	-	**<0.0001**	0.0	-	0.2292	0.0	-	**<0.0001**
At least once a week	87.2	(75.7 ; 98.7)		65.1	(48.9 ; 81.2)		63.1	(53.8 ; 72.4)		58.1	(49.7 ; 66.5)		43.0	(33.7 ; 52.3)	
Less than once a week	94.2	(90.0 ; 98.4)		62.9	(52.2 ; 73.6)		33.4	(28.8 ; 38.0)		51.4	(46.3 ; 56.5)		22.3	(18.3 ; 26.3)	
Not at all	95.4	(93.0 ; 97.9)		64.1	(58.3 ; 69.9)		26.1	(23.8 ; 28.3)		49.8	(47.1 ; 52.5)		17.5	(15.7 ; 19.3)	
Frequency of reading newspaper or magazine															
Almost every day	0.0	-	0.2578	0.0	-	0.9811	0.0	-	**<0.0001**	0.0	-	**0.1026**	0.0	-	**<0.0001**
At least once a week	83.6	(54.5 ; 100)		66.3	(34.7 ; 97.9)		61.4	(44.9 ; 77.8)		50.2	(32.8 ; 67.5)		35.7	(19.4 ; 51.9)	
Less than once a week	96.6	(93.5 ; 99.8)		63.1	(50.7 ; 75.5)		44.1	(38.7 ; 49.5)		55.8	(50.3 ; 61.4)		29.8	(24.8 ; 34.9)	
Not at all	94.5	(92.1 ; 96.8)		63.9	(58.4 ; 69.5)		26.1	(24.0 ; 28.3)		49.5	(47.0 ; 52.0)		17.6	(15.9 ; 19.3)	
Health care level															
Antenatal clinic visits															
None	100	-	-	87.7	(65.1 ; 100)	0.2903	20.2	(8.0 ; 32.4)	**0.0858**	40.4	(25.7 ; 55.1)	0.2661	15.9	(4.7 ; 27.0)	0.2277
1-3 visits	94.0	(91.2 ; 96.9)		62.4	(55.9 ; 69.0)		28.4	(25.9 ; 31.0)		50.1	(47.3 ; 52.9)		18.9	(16.8 ; 21.0)	
4+ visits	96.0	(93.5 ; 98.6)		66.0	(58.1 ; 73.9)		32.0	(28.7 ; 35.4)		52.0	(48.4 ; 55.6)		21.8	(18.8 ; 24.8)	
Place of delivery															
Health facility	94.7	(92.5 ; 97.0)	0.9321	61.6	(56.2 ; 67.0)	**0.0552**	31.4	(29.0 ; 33.9)	**0.0004**	50.9	(48.4 ; 53.5)	0.5773	21.4	(19.4 ; 23.4)	**0.0005**
Home / other	94.4	(88.2 ; 100)		74.7	(63.2 ; 86.2)		22.2	(18.0 ; 26.3)		49.3	(43.9 ; 54.7)		13.6	(10.2 ; 17.0)	
Type of delivery assistance															
Health professional	94.7	(92.4 ; 97.0)	0.9892	62.2	(56.7 ; 67.6)	**0.0992**	31.4	(28.9 ; 33.8)	**0.0009**	51.2	(48.7 ; 53.7)	0.3000	21.4	(19.4 ; 23.4)	**0.0009**
Other	94.6	(89.2 ; 100)		72.8	(62.0 ; 83.6)		23.4	(19.5 ; 27.2)		48.3	(43.3 ; 53.3)		14.6	(11.4 ; 17.7)	
Access to postnatal care															
Yes	94.2	(91.8 ; 96.5)	0.2631	63.7	(58.6 ; 68.8)	0.8197	29.6	(27.4 ; 31.9)	0.9245	51.0	(48.6 ; 53.4)	0.2720	20.2	(18.3 ; 22.1)	0.3920
No	97.3	(93.6 ; 100)		66.0	(46.9 ; 85.1)		29.9	(25.3 ; 34.5)		47.5	(41.4 ; 53.7)		18.1	(14.1 ; 22.2)	

Community level															
Residence															
Urban	89.7	(82.3 ; 97.1)	**0.0727**	62.6	(49.1 ; 76.1)	0.8492	51.0	(43.7 ; 58.4)	**<0.0001**	56.1	(49.7 ; 62.5)	**0.0792**	35.5	(28.8 ; 42.1)	**<0.0001**
Rural	95.3	(93.1 ; 97.5)		64.0	(58.6 ; 69.4)		27.1	(24.9 ; 29.3)		49.9	(47.4 ; 52.4)		18.0	(16.3 ; 19.8)	
Geographical region															
Kigali city	80.8	(68.3 ; 93.3)	**0.0003**	51.9	(33.4 ; 70.4)	**0.1034**	53.2	(44.5 ; 61.9)	**<0.0001**	54.0	(46.2 ; 61.8)	**0.0004**	35.7	(28.6 ; 42.7)	**<0.0001**
South	98.3	(95.9 ; 100)		72.2	(64.1 ; 80.3)		33.4	(29.6 ; 37.3)		56.0	(52.0 ; 60.1)		23.2	(20.3 ; 26.0)	
West	97.3	(94.8 ; 99.8)		67.7	(58.6 ; 76.8)		18.1	(14.2 ; 22.1)		42.4	(37.7 ; 47.1)		12.5	(9.0 ; 16.0)	
North	95.1	(89.9 ; 100)		61.1	(48.2 ; 73.9)		30.3	(24.9 ; 35.6)		54.4	(48.7 ; 60.1)		19.2	(14.8 ; 23.6)	
East	93.4	(88.5 ; 98.4)		57.1	(45.7 ; 68.5)		29.9	(25.6 ; 34.2)		50.8	(45.8 ; 55.8)		19.6	(16.3 ; 23.0)	
Cluster altitude															
Lowest	92.3	(87.6 ; 97.1)	0.5152	63.1	(52.7 ; 73.6)	0.3663	37.6	(32.8 ; 42.5)	**<0.0001**	53.4	(48.1 ; 58.7)	**0.0039**	25.4	(21.3 ; 29.5)	**<0.0001**
Low	94.3	(89.7 ; 98.9)		58.0	(48.0 ; 68.0)		32.7	(28.2 ; 37.3)		50.1	(45.3 ; 54.9)		22.6	(19.0 ; 26.1)	
High	95.4	(91.4 ; 99.3)		71.3	(61.8 ; 80.9)		31.0	(26.6 ; 35.4)		55.2	(51.0 ; 59.4)		20.6	(16.9 ; 24.4)	
Highest	96.7	(93.6 ; 99.9)		64.6	(54.9 ; 74.3)		17.5	(14.0 ; 21.0)		43.6	(39.1 ; 48.1)		11.2	(8.4 ; 14.0)	
Access to safe drinking water															
Yes	93.7	(90.4 ; 97.0)	0.4174	63.9	(56.8 ; 71.0)	0.9078	34.6	(31.6 ; 37.7)	**<0.0001**	53.8	(50.7 ; 56.9)	**0.0040**	24.3	(21.6 ; 26.9)	**<0.0001**
No	95.4	(92.7 ; 98.2)		63.3	(56.3 ; 70.4)		24.8	(22.2 ; 27.4)		47.4	(44.2 ; 50.7)		15.5	(13.5 ; 17.6)	
Access to proper sanitation															
Yes	95.0	(92.1 ; 97.9)	0.7151	61.3	(54.6 ; 67.9)	0.3232	32.6	(29.8 ; 35.4)	**0.0036**	53.5	(50.5 ; 56.5)	**0.0037**	22.1	(19.9 ; 24.4)	**0.0041**
No	94.2	(90.9 ; 97.5)		66.3	(58.7 ; 73.9)		26.6	(23.5 ; 29.6)		47.2	(43.8 ; 50.5)		17.3	(14.9 ; 19.8)	

Table 19: Possible determinants for not timely introducing solid, semi-solid or soft foods.

Characteristic	Unadjusted PR	95% CI	P	Adjusted PR	95% CI	P
Individual level (child)						
Gender of the child						
Female	1.00			1.00		
Male	0.87	(0.67 ; 1.13)	0.2959	0.76	(0.51 ; 1.13)	0.1751
Breastfeeding initiation						
Immediately	1.00			1.00		
Within 1 hour	0.95	(0.52 ; 1.74)	0.8764	0.42	(0.06 ; 3.05)	0.3909
After 1 hour	0.86	(0.62 ; 1.19)	0.3599	1.08	(0.71 ; 1.63)	0.7146
Birth order						
First born	1.00			1.00		
Second to fourth	1.20	(0.85 ; 1.69)	0.2970	1.27	(0.71 ; 2.28)	0.4236
Fifth or more	1.07	(0.74 ; 1.55)	0.7083	1.48	(0.66 ; 3.32)	0.3440
Type of birth						
Single	1.00			-		
Multiple	1.64	(0.51 ; 5.23)	0.4035			
Preceding birth interval						
No previous birth	1.00			1.00		
< 24 months	1.27	(0.82 ; 1.97)	0.2741	1.57	(0.83 ; 2.99)	0.1642
> 24 months	1.13	(0.82 ; 1.56)	0.4463	1.17	(0.64 ; 2.13)	0.6100
Size of child at birth						
Small	1.00			1.00		
Average	0.88	(0.60 ; 1.31)	0.5313	1.05	(0.54 ; 2.06)	0.8847
Large	0.87	(0.60 ; 1.28)	0.4765	1.08	(0.54 ; 2.16)	0.8228
Had diarrhoea episode recently						
No	1.00					
Yes, last 2 weeks	0.54	(0.32 ; 0.91)	**0.0207**	0.51	(0.25 ; 1.04)	0.0645
Maternal/household level						
Maternal age						
15-24 years	1.00			1.00		
25-34 years	1.09	(0.81 ; 1.46)	0.5733	0.99	(0.64 ; 1.53)	0.9603
35-49 years	0.87	(0.56 ; 1.33)	0.5129	0.89	(0.53 ; 1.52)	0.6751
Maternal height						
< 150 cm	1.00			1.00		
150-155 cm	0.93	(0.63 ; 1.36)	0.7007	1.02	(0.54 ; 1.94)	0.9412
> 155 cm	0.91	(0.66 ; 1.26)	0.5847	1.00	(0.55 ; 1.81)	0.9966
Maternal BMI						
< 18.5 kg m^{-2}	1.44	(0.78 ; 2.66)	0.2575	1.46	(0.81 ; 2.63)	0.2045
18.5-24.9 kg m^{-2}	1.00			1.00		
≥ 25 kg m^{-2}	0.78	(0.41 ; 1.51)	0.4624	0.84	(0.44 ; 1.61)	0.6065
Respondent is stunted						
Yes	1.00			1.00		
No	0.86	(0.64 ; 1.16)	0.3131	0.78	(0.50 ; 1.22)	0.2772
Maternal age at first birth						
< 20 years	1.00			1.00		
20-29 years	1.07	(0.79 ; 1.46)	0.6573	0.94	(0.61 ; 1.45)	0.7903
> 30 years	0.27	(0.04 ; 2.00)	0.2003	-		
Maternal working status						
Non-working	1.00			1.00		
Currently working	0.79	(0.58 ; 1.07)	0.1329	0.71	(0.48 ; 1.03)	0.0733
Maternal education						
No education	1.00			1.00		
Primary education	0.93	(0.69 ; 1.27)	0.6658	1.11	(0.66 ; 1.88)	0.6885
Secondary or higher education	0.55	(0.28 ; 1.07)	0.0763	0.49	(0.15 ; 1.57)	0.2288
Maternal literacy						
Cannot read at all	1.00			1.00		
Able to read parts of sent.	1.20	(0.72 ; 1.99)	0.4793	2.17	(0.91 ; 5.18)	0.0789
Able to read whole sentence	1.09	(0.81 ; 1.45)	0.5821	2.03	(0.92 ; 4.49)	0.0788
Religion						
Christian	1.00			1.00		

Muslim	1.52	(0.42 ; 5.43)	0.5205	1.84	(0.65 ; 5.23)	0.2507
Other	0.52	(0.13 ; 2.19)	0.3733	0.33	(0.04 ; 2.76)	0.3037
Wealth index						
Richest	1.00			1.00		
Richer	1.10	(0.70 ; 1.73)	0.6811	1.09	(0.53 ; 2.22)	0.8180
Middle	1.26	(0.83 ; 1.93)	0.2781	1.14	(0.59 ; 2.22)	0.6966
Poorer	0.77	(0.48 ; 1.24)	0.2785	0.59	(0.28 ; 1.25)	0.1655
Poorest	1.10	(0.72 ; 1.67)	0.6603	0.88	(0.45 ; 1.70)	0.6924
Number of household members						
1-4 household members	1.00			1.00		
5+ household members	0.93	(0.70 ; 1.24)	0.6348	0.90	(0.56 ; 1.44)	0.6451
Number of children under 5 yrs						
One	1.00			1.00		
Two	0.93	(0.69 ; 1.26)	0.6403	0.96	(0.57 ; 1.62)	0.8787
Three or more	1.16	(0.80 ; 1.67)	0.4419	1.50	(0.87 ; 2.58)	0.1413
Frequency of listening to radio						
At least once a week	1.00	(0.63 ; 1.60)	0.9941	0.88	(0.48 ; 1.63)	0.6813
Less than once a week	1.02	(0.61 ; 1.69)	0.9449	0.94	(0.47 ; 1.88)	0.8598
Not at all	1.00			1.00		
Frequency of watching TV						
At least once a week	0.98	(0.60 ; 1.61)	0.9285	0.86	(0.35 ; 2.12)	0.7403
Less than once a week	1.01	(0.73 ; 1.41)	0.9318	1.15	(0.71 ; 1.85)	0.5708
Not at all	1.00			1.00		
Frequency of reading newspaper or magazine						
At least once a week	0.94	(0.37 ; 2.40)	0.9788	1.21	(0.68 ; 2.16)	0.5181
Less than once a week	1.00	(0.69 ; 1.44)	0.8952	0.90	(0.31 ; 2.60)	0.8427
Not at all	1.00			1.00		
Health care level						
Antenatal clinic visits						
None	1.00			-	-	-
1-3 visits	3.06	(0.49 ; 19.1)	0.2308	-	-	-
4+ visits	2.76	(0.43 ; 17.7)	0.2821	-	-	-
Place of delivery						
Health facility	1.00			1.00		
Home / other	0.64	(0.39 ; 1.05)	0.0757	0.59	(0.28 ; 1.24)	0.1600
Type of delivery assistance						
Health professional	1.00			1.00		
Other	0.70	(0.45 ; 1.08)	0.1039	0.69	(0.36 ; 1.33)	0.2634
Access to postnatal care						
Yes	1.00			1.00		
No	0.95	(0.53 ; 1.68)	0.8478	1.02	(0.47 ; 2.19)	0.9630
Community level						
Residence						
Urban	1.00			1.00		
Rural	0.95	(0.64 ; 1.41)	0.8101	0.79	(0.39 ; 1.61)	0.5160
Geographical region						
Kigali city	1.00			1.00		
South	0.58	(0.36 ; 0.94)	**0.0266**	0.55	(0.27 ; 1.13)	0.1019
West	0.66	(0.41 ; 1.06)	0.0831	0.60	(0.29 ; 1.24)	0.1674
North	0.81	(0.49 ; 1.35)	0.4118	0.70	(0.30 ; 1.64)	0.4098
East	0.88	(0.55 ; 1.42)	0.6020	0.83	(0.44 ; 1.59)	0.5783
Cluster altitude						
Lowest	1.00			1.00		
Low	1.15	(0.79 ; 1.68)	0.4583	0.92	(0.52 ; 1.63)	0.7630
High	0.79	(0.50 ; 1.23)	0.2898	0.88	(0.48 ; 1.62)	0.6739
Highest	0.95	(0.64 ; 1.41)	0.8065	0.89	(0.50 ; 1.62)	0.7092
Access to safe drinking water						
Yes	1.00			1.00		
No	1.05	(0.80 ; 1.38)	0.7151	1.41	(0.95 ; 2.09)	0.0921
Access to proper sanitation						
Yes	1.00			1.00		
No	0.90	(0.69 ; 1.19)	0.4695	0.76	(0.50 ; 1.16)	0.2050

Table 20: Possible determinants for not meeting the minimum dietary diversity.

Characteristic	Unadjusted PR	95% CI	P	Adjusted PR	95% CI	P
Individual level (child)						
Gender of the child						
Female	1.00			1.00		
Male	1.04	(0.98 ; 1.10)	0.1622	1.08	(1.00 ; 1.16)	0.0510
Child's age in months						
18-23 months	1.00					
12-17 months	1.06	(0.98 ; 1.14)	0.1592	1.04	(0.94 ; 1.15)	0.4164
6-11 months	1.26	(1.18 ; 1.35)	**<.0001**	1.25	(1.14 ; 1.37)	**<.0001**
Breastfeeding initiation						
Immediately	1.00			1.00		
Within 1 hour	0.86	(0.73 ; 1.03)	0.0951	0.86	(0.68 ; 1.07)	0.1764
After 1 hour	1.03	(0.97 ; 1.10)	0.3729	0.99	(0.91 ; 1.08)	0.8695
Currently breastfed						
Yes	1.00			1.00		
No	0.76	(0.67 ; 0.88)	**0.0001**	0.83	(0.68 ; 1.01)	0.0590
Birth order						
First born	1.00					
Second to fourth	1.06	(0.99 ; 1.14)	0.0750	1.12	(1.01 ; 1.24)	**0.0382**
Fifth or more	1.07	(0.99 ; 1.15)	0.0942	1.13	(0.98 ; 1.31)	0.0819
Type of birth						
Single	1.00			1.00		
Multiple	0.84	(0.60 ; 1.17)	0.2956	0.98	(0.65 ; 1.50)	0.9354
Preceding birth interval						
No previous birth	1.00			1.00		
< 24 months	0.97	(0.89 ; 1.07)	0.5914	1.03	(0.90 ; 1.18)	0.6479
> 24 months	1.09	(1.02 ; 1.16)	**0.0140**	1.15	(1.03 ; 1.28)	**0.0126**
Size of child at birth						
Small	1.00			1.00		
Average	0.95	(0.88 ; 1.03)	0.1876	1.00	(0.89 ; 1.13)	0.9854
Large	1.02	(0.95 ; 1.11)	0.5578	1.10	(0.98 ; 1.23)	0.1062
Had diarrhoea episode recently						
No	1.00			1.00		
Yes, last 2 weeks	1.02	(0.96 ; 1.08)	0.5966	1.02	(0.94 ; 1.11)	0.6207
Maternal/household level						
Maternal age						
15-24 years	1.00			1.00		
25-34 years	0.98	(0.92 ; 1.04)	0.5026	1.00	(0.91 ; 1.10)	0.9794
35-49 years	0.95	(0.87 ; 1.03)	0.1770	0.97	(0.87 ; 1.08)	0.5202
Maternal height						
< 150 cm	1.00			1.00		
150-155 cm	1.00	(0.92 ; 1.08)	0.9469	1.05	(0.94 ; 1.17)	0.4202
> 155 cm	0.98	(0.93 ; 1.04)	0.5684	1.06	(0.96 ; 1.17)	0.2706
Maternal BMI						
< 18.5 kg m^{-2}	0.98	(0.83 ; 1.16)	0.8185	0.99	(0.85 ; 1.15)	0.8698
18.5-24.9 kg m^{-2}	1.00			1.00		
≥ 25 kg m^{-2}	0.84	(0.74 ; 0.96)	**0.0108**	0.93	(0.82 ; 1.05)	0.2180
Respondent is stunted						
Yes	1.00			1.00		
No	0.99	(0.93 ; 1.05)	0.6816	1.01	(0.96 ; 1.07)	0.6622
Maternal age at first birth						
< 20 years	1.00			1.00		
20-29 years	0.94	(0.89 ; 0.99)	**0.0205**	0.98	(0.92 ; 1.03)	0.3630
> 30 years	0.75	(0.60 ; 0.95)	**0.0171**	0.86	(0.69 ; 1.06)	0.1429
Maternal working status						
Non-working	1.00			1.00		
Currently working	0.99	(0.93 ; 1.07)	0.8544	0.96	(0.90 ; 1.03)	0.2788
Maternal education						
No education	1.18	(1.12 ; 1.25)	**<.0001**	1.11	(1.02 ; 1.20)	**0.0171**
Primary education	1.00			1.00		

Secondary or higher education	0.63	(0.54 ; 0,73)	**<.0001**	0.66	(0.53 ; 0.82)	**<.0001**
Maternal literacy						
Cannot read at all	1.00			1.00		
Able to read parts of sent.	0.91	(0.94 ; 0.99)	**0.0322**	1.08	(0.94 ; 1.24)	0.2801
Able to read whole sentence	0.76	(0.72 ; 0.81)	**<.0001**	0.96	(0.86 ; 1.07)	0.4467
Religion						
Christian	1.00			1.00		
Muslim	0.82	(0.61 ; 1.10)	0.1852	0.90	(0.70 ; 1.16)	0.3960
Other	1.10	(0.93 ; 1.30)	0.2828	1.08	(0.92 ; 1.28)	0.3459
Wealth index						
Richest	0.61	(0.53 ; 0.70)	**<.0001**	0.67	(0.55 ; 0.81)	**<.0001**
Richer	0.94	(0.85 ; 1.03)	0.1540	0.95	(0.83 ; 1.08)	0.3855
Middle	1.00			1.00		
Poorer	1.07	(0.99 ; 1.16)	0.0864	0.99	(0.89 ; 1.10)	0.8335
Poorest	1.12	(1.04 ; 1.21)	**0.0020**	1.05	(0.95 ; 1.16)	0.3553
Number of household members						
1-4 household members	1.00			1.00		
5+ household members	0.95	(0.90 ; 1.00)	0.0570	0.98	(0.92 ; 1.03)	0.3702
Number of children under 5 yrs						
One	1.00			1.00		
Two	1.09	(1.02 ; 1.15)	**0.0077**	1.07	(1.01 ; 1.14)	**0.0283**
Three or more	1.06	(0.96 ; 1.17)	0.2486	1.02	(0.92 ; 1.12)	0.7292
Frequency of listening to radio						
At least once a week	0.85	(0.78 ; 0.93)	**0.0003**	1.20	(1.04 ; 1.38)	**0.0112**
Less than once a week	0.97	(0.89 ; 1.07)	0.5530	1.13	(0.98 ; 1.31)	0.0916
Not at all	1.00			1.00		
Frequency of watching TV						
At least once a week	0.50	(0.39 ; 0.64)	**<.0001**	0.61	(0.44 ; 0.86)	**0.0043**
Less than once a week	0.90	(0.84 ; 0.97)	**0.0044**	0.98	(0.90 ; 1.08)	0.7326
Not at all	1.00			1.00		
Frequency of reading newspaper or magazine						
At least once a week	0.76	(0.69 ; 0.84)	**<.0001**	0.86	(0.74 ; 0.99)	**0.0333**
Less than once a week	0.52	(0.34 ; 0.80)	**0.0029**	0.86	(0.56 ; 1.32)	0.4881
Not at all	1.00			1.00		
Health care level						
Antenatal clinic visits						
None	1.00			1.00		
1-3 visits	0.99	(0.85 ; 1.15)	0.8488	1.04	(0.82 ; 1.31)	0.7742
4+ visits	0.94	(0.80 ; 1.09)	0.3952	1.07	(0.84 ; 1.36)	0.6014
Place of delivery						
Health facility	1.00			1.00		
Home / other	1.14	(1.07 ; 1.21)	**0.0001**	1.03	(0.94 ; 1.14)	0.5224
Type of delivery assistance						
Health professional	1.00			1.00		
Other	1.12	(1.05 ; 1.19)	**0.0004**	1.01	(0.92 ; 1.11)	0.8312
Access to postnatal care						
Yes	1.00			1.00		
No	0.99	(0.93 ; 1.07)	0.9387	1.08	(0.97 ; 1.21)	0.1574
Community level						
Residence						
Urban	1.00			1.00		
Rural	1.49	(1.28 ; 1.74)	**<.0001**	1.13	(0.92 ; 1.38)	0.2372
Geographical region						
Kigali city	1.00			1.00		
South	1.42	(1.17 ; 1.73)	**0.0004**	1.06	(0.83 ; 1.35)	0.6547
West	1.75	(1.45 ; 2.12)	**<.0001**	1.30	(1.03 ; 1.65)	**0.0309**
North	1.49	(1.22 ; 1.82)	**0.0001**	1.11	(0.87 ; 1.42)	0.4121
East	1.50	(1.23 ; 1.82)	**<.0001**	1.17	(0.92 ; 1.48)	0.1946
Cluster altitude						
Lowest	1.00			1.00		
Low	1.08	(0.97 ; 1.20)	0.1677	0.95	(0.84 ; 1.08)	0.4373
High	1.11	(1.00 ; 1.22)	**0.0491**	0.96	(0.84 ; 1.10)	0.5250

Highest	1.32	(1.21 ; 1.45)	**<.0001**	1.15	(1.02 ; 1.29)	**0.0209**
Access to safe drinking water						
Yes	1.00			1.00		
No	1.15	(1.09 ; 1.21)	**<.0001**	1.08	(0.99 ; 1.17)	0.0674
Access to proper sanitation						
Yes	1.00			1.00		
No	1.08	(1.02 ; 1.14)	**0.0080**	0.99	(0.92 ; 1.08)	0.9793

Table 21: Possible determinants for not meeting the minimum meal frequency.

	Unadjusted			Adjusted		
Characteristic	PR	95% CI	P	PR	95% CI	P
Individual level (child)						
Gender of the child						
Female	1.00			1.00		
Male	1.00	(0.93 ; 1.09)	0.9267	1.01	(0.89 ; 1.14)	0.9180
Child's age in months						
18-23 months	1.00			1.00		
12-17 months	1.17	(1.22 ; 1.52)	**<.0001**	1.18	(1.01 ; 1.39)	**<.0001**
6-11 months	1.36	(1.05 ; 1.31)	**0.0067**	1.46	(1.26 ; 1.69)	**0.0427**
Breastfeeding initiation						
Immediately	1.00			1.00		
Within 1 hour	0.94	(0.87 ; 1.14)	0.5056	0.87	(0.65 ; 1.18)	0.3673
After 1 hour	1.02	(0.93 ; 1.12)	0.6623	1.08	(0.95 ; 1.22)	0.2414
Currently breastfed						
Yes	1.00			1.00		
No	1.54	(1.38 ; 1.71)	**<.0001**	1.72	(1.46 ; 2.03)	**<.0001**
Birth order						
First born	1.00			1.00		
Second to fourth	1.06	(0.96 ; 1.17)	0.2346	1.04	(0.76 ; 1.42)	0.8029
Fifth or more	0.96	(0.85 ; 1.08)	0.4843	1.06	(0.74 ; 1.51)	0.7714
Type of birth						
Single	1.00			1.00		
Multiple	0.87	(0.56 ; 1.36)	0.5403	0.92	(0.58 ; 1.46)	0.7174
Preceding birth interval						
No previous birth	1.00			1.00		
< 24 months	0.98	(0.85 ; 1.13)	0.7591	1.13	(0.94 ; 1.36)	0.2032
> 24 months	1.03	(0.94 ; 1.13)	0.5015	1.28	(1.09 ; 1.51)	**0.0029**
Size of child at birth						
Small	1.00			1.00		
Average	0.99	(0.87 ; 1.15)	0.9941	1.02	(0.86 ; 1.22)	0.8017
Large	1.06	(0.93 ; 1.21)	0.3826	1.00	(0.83 ; 1.19)	0.9623
Had diarrhoea episode recently						
No	1.00			1.00		
Yes, last 2 weeks	1.02	(0.93 ; 1.13)	0.6352	0.94	(0.81 ; 1.08)	0.3907
Maternal/household level						
Maternal age						
15-24 years	1.05	(0.96 ; 1.16)	0.2936	1.21	(1.03 ; 1.42)	**0.0217**
25-34 years	1.00			1.00		
35-49 years	0.90	(0.79 ; 1.01)	0.0708	0.84	(0.71 ; 0.98)	**0.0270**
Maternal height						
< 150 cm	1.00			1.00		
150-155 cm	1.06	(0.95 ; 1.19)	0.2805	1.06	(0.89 ; 1.26)	0.5390
> 155 cm	0.95	(0.86 ; 1.04)	0.2829	0.96	(0.82 ; 1.13)	0.6407
Maternal BMI						
< 18.5 kg m^{-2}	0.98	(0.74 ; 1.30)	0.8994	1.01	(0.78 ; 1.32)	0.9383
18.5-24.9 kg m^{-2}	1.00			1.00		
≥ 25 kg m^{-2}	0.98	(0.83 ; 1.16)	0.8065	0.97	(0.82 ; 1.14)	0.6861
Respondent is stunted						
Yes	1.00			1.00		
No	0.95	(0.87 ; 1.03)	0.2335	0.92	(0.81 ; 1.04)	0.1938
Maternal age at first birth						
< 20 years	1.00			1.00		

20-29 years	0.94	(0.85 ; 1.03)	0.1527	0.95	(0.84 ; 1.08)	0.4197
> 30 years	0.75	(0.55 ; 1.01)	0.0604	0.82	(0.50 ; 1.35)	0.4314
Maternal working status						
Non-working	1.00			1.00		
Currently working	0.88	(0.79 ; 0.98)	**0.0185**	0.86	(0.75 ; 0.99)	**0.0405**
Maternal education						
No education	1.19	(1.07 ; 1.32)	**0.0009**	1.18	(1.02 ; 1.36)	**0.0242**
Primary education	1.00			1.00		
Secondary or higher education	0.74	(0.62 ; 0.88)	**0.0011**	0.76	(0.58 ; 0.98)	**0.0360**
Maternal literacy						
Cannot read at all	1.00			1.00		
Able to read parts of sent.	0.92	(0.79 ; 1.08)	0.3159	1.04	(0.82 ; 1.31)	0.7594
Able to read whole sentence	0.81	(0.73 ; 0.89)	**<.0001**	0.93	(0.78 ; 1.10)	0.3913
Religion						
Christian	1.00			1.00		
Muslim	0.79	(0.53 ; 1.19)	0.2616	0.95	(0.57 ; 1.56)	0.8250
Other	1.00	(0.74 ; 1.35)	0.9958	1.18	(0.83 ; 1.66)	0.3542
Wealth index						
Richest	0.80	(0.68 ; 0.93)	**0.0042**	0.85	(0.69 ; 1.04)	0.1158
Richer	0.82	(0.71 ; 0.95)	**0.0100**	0.85	(0.70 ; 1.04)	0.1210
Middle	1.00			1.00		
Poorer	0.98	(0.87 ; 1.11)	0.7841	0.97	(0.82 ; 1.14)	0.7175
Poorest	1.01	(0.90 ; 1.14)	0.8495	0.93	(0.78 ; 1.12)	0.4622
Number of household members						
1-4 household members	1.00			1.00		
5+ household members	1.00	(0.92 ; 1.09)	0.9746	1.01	(0.89 ; 1.16)	0.8385
Number of children under 5 yrs						
One	1.00			1.00		
Two	1.00	(0.92 ; 1.09)	0.9597	0.94	(0.82 ; 1.08)	0.3965
Three or more	1.00	(0.87 ; 1.15)	0.9805	0.77	(0.61 ; 0.96)	**0.0204**
Frequency of listening to radio						
At least once a week	0.91	(0.78 ; 1.05)	0.1963	0.99	(0.82 ; 1.19)	0.9115
Less than once a week	1.02	(0.87 ; 1.19)	0.8060	1.04	(0.85 ; 1.27)	0.7275
Not at all	1.00			1.00		
Frequency of watching TV						
At least once a week	0.83	(0.68 ; 1.03)	0.0876	1.05	(0.80 ; 1.38)	0.7199
Less than once a week	0.97	(0.86 ; 1.09)	0.5798	1.02	(0.88 ; 1.17)	0.8382
Not at all	1.00			1.00		
Frequency of reading newspaper or magazine						
At least once a week	0.99	(0.70 ; 1.40)	0.9439	1.37	(0.97 ; 1.93)	0.0738
Less than once a week	0.88	(0.77 ; 0.99)	**0.0467**	0.98	(0.81 ; 1.19)	0.8426
Not at all	1.00			1.00		
Health care level						
Antenatal clinic visits						
None	1.00			1.00		
1-3 visits	0.84	(0.66 ; 1.07)	0.1484	0.96	(0.64 ; 1.45)	0.8600
4+ visits	0.81	(0.63 ; 1.03)	0.0832	0.93	(0.62 ; 1.41)	0.7424
Place of delivery						
Health facility	1.00			1.00		
Home / other	1.03	(0.92 ; 1.16)	0.5853	1.02	(0.88 ; 1.19)	0.7566
Type of delivery assistance						
Health professional	1.00			1.00		
Other	1.06	(0.95 ; 1.18)	0.2910	1.04	(0.90 ; 2.21)	0.5658
Access to postnatal care						
Yes	1.00			1.00		
No	1.07	(0.95 ; 1.21)	0.2559	1.15	(0.97 ; 1.35)	0.1075
Community level						
Residence						
Urban	1.00			1.00		
Rural	1.14	(0.98 ; 1.33)	0.0947	0.95	(0.75 ; 1.19)	0.6347
Geographical region						
Kigali city	1.00			1.00		

South	0.96	(0.79 ; 1.16)	0.6389	0.80	(0.61 ; 1.04)	0.0927
West	1.25	(1.04 ; 1.51)	**0.0197**	0.93	(0.72 ; 1.20)	0.5617
North	0.99	(0.80 ; 1.22)	0.9333	0.74	(0.56 ; 0.99)	**0.0391**
East	1.07	(0.88 ; 1.30)	0.5071	0.84	(0.65 ; 1.08)	0.1694
Cluster altitude						
Lowest	1.00			1.00		
Low	1.07	(0.92 ; 1.25)	0.3771	0.95	(0.80 ; 1.14)	0.6060
High	0.96	(0.83 ; 1.11)	0.6018	0.80	(0.65 ; 0.99)	**0.0393**
Highest	1.21	(1.05 ; 1.39)	**0.0073**	1.05	(0.89 ; 1.24)	0.5788
Access to safe drinking water						
Yes	1.00			1.00		
No	1.13	(1.04 ; 1.24)	**0.0049**	1.17	(1.04 ; 1.32)	**0.0093**
Access to proper sanitation						
Yes	1.00			1.00		
No	1.12	(1.03 ; 1.23)	**0.0080**	1.06	(0.93 ; 1.20)	0.3706

Table 22: Possible determinants for not meeting the minimum acceptable diet.

Characteristic	Unadjusted PR	Unadjusted 95% CI	Unadjusted P	Adjusted PR	Adjusted 95% CI	Adjusted P
Individual level (child)						
Gender of the child						
Female	1.00			1.00		
Male	0.99	(0.96 ; 1.04)	0.9275	1.01	(0.96 ; 1.07)	0.6188
Child's age in months						
18-23 months	1.00			1.00		
12-17 months	1.07	(1.11 ; 1.24)	**0.0282**	1.05	(0.98 ; 1.14)	0.1829
6-11 months	1.17	(1.01 ; 1.13)	**<.0001**	1.16	(1.08 ; 1.24)	**<.0001**
Breastfeeding initiation						
Immediately	1.00			1.00		
Within 1 hour	0.92	(0.81 ; 1.04)	0.1632	0.88	(0.74 ; 1.06)	0.1814
After 1 hour	1.04	(0.99 ; 1.09)	0.0952	1.02	(0.96 ; 1.09)	0.4595
Currently breastfed						
Yes	1.00			1.00		
No	1.08	(1.02 ; 1.15)	**0.0126**	1.20	(1.10 ; 1.31)	**<0.0001**
Birth order						
First born	1.00			1.00		
Second to fourth	1.04	(0.99 ; 1.10)	0.0971	1.14	(1.05 ; 1.23)	**0.0011**
Fifth or more	1.04	(0.98 ; 1.10)	0.2522	1.19	(1.07 ; 1.32)	**0.0013**
Type of birth						
Single	1.00			1.00		
Multiple	0.96	(0.77 ; 1.19)	0.6961	1.06	(0.82 ; 1.36)	0.6614
Preceding birth interval						
No previous birth	1.01	(0.94 ; 1.08)	0.8949	0.92	(0.84 ; 1.01)	0.0919
< 24 months	1.00			1.00		
> 24 months	1.06	(0.99 ; 1.13)	0.0963	1.07	(0.98 ; 1.17)	0.1230
Size of child at birth						
Small	1.00			1.00		
Average	0.98	(0.92 ; 1.04)	0.4196	0.99	(0.91 ; 1.08)	0.8545
Large	1.02	(0.96 ; 1.09)	0.5052	1.05	(0.96 ; 1.14)	0.3056
Had diarrhoea episode recently						
No	1.00			1.00		
Yes, last 2 weeks	1.03	(0.99 ; 1.08)	0.1863	1.03	(0.96 ; 1.09)	0.4367
Maternal/household level						
Maternal age						
15-24 years	1.03	(0.98 ; 1.08)	0.2196	1.03	(0.97 ; 1.10)	0.3273
25-34 years	1.00			1.00		
35-49 years	0.94	(0.89 ; 1.01)	0.0695	0.94	(0.87 ; 1.02)	0.1395
Maternal height						
< 150 cm	1.00			1.00		
150-155 cm	1.02	(0.97 ; 1.08)	0.4420	1.09	(1.00 ; 1.20)	0.0509
> 155 cm	0.99	(0.95 ; 1.04)	0.6732	1.08	(0.99 ; 1.17)	0.0845
Maternal BMI						

< 18.5 kg m-2	1.02	(0.91 ; 1.16)	0.7123	1.03	(0.92 ; 1.15)	0.6014
18.5-24.9 kg m-2	1.00			1.00		
≥ 25 kg m-2	0.90	(0.82 ; 0.99)	**0.0373**	0.95	(0.87 ; 1.04)	0.2783
Respondent is stunted						
Yes	1.00			1.00		
No	0.99	(0.95 ; 1.03)	0.5553	1.03	(0.96 ; 1.10)	0.4488
Maternal age at first birth						
< 20 years	1.00			1.00		
20-29 years	0.97	(0.93 ; 1.01)	0.1247	0.99	(0.93 ; 1.05)	0.6546
> 30 years	0.77	(0.63 ; 0.93)	**0.0079**	0.76	(0.57 ; 1.03)	0.0775
Maternal working status						
Non-working	1.00			1.00		
Currently working	0.97	(0.92 ; 1.02)	0.2013	0.95	(0.89 ; 1.01)	0.1046
Maternal education						
No education	1.13	(1.08 ; 1.18)	**<.0001**	1.09	(1.03 ; 1.16)	**0.0063**
Primary education	1.00			1.00		
Secondary or higher education	0.78	(0.70 ; 0.86)	**<.0001**	0.78	(0.67 ; 0.91)	**0.0014**
Maternal literacy						
Cannot read at all	1.00			1.00		
Able to read parts of sent.	0.95	(0.89 ; 1.01)	0.0880	1.02	(0.91 ; 1.13)	0.7734
Able to read whole sentence	0.83	(0.80 ; 0.86)	**<.0001**	1.97	(0.89; 1.05)	0.4238
Religion						
Christian	1.00					
Muslim	0.85	(0.68 ; 1.06)	0.1439	1.04	(0.82 ; 1.33)	0.7458
Other	1.08	(0.96 ; 1.21)	0.1790	1.20	(1.07 ; 1.35)	**0.0016**
Wealth index						
Richest	0.71	(0.65 ; 0.78)	**<.0001**	0.76	(0.66 ; 0.87)	**<.0001**
Richer	0.90	(0.84 ; 0.97)	0.0040	0.92	(0.83 ; 1.01)	0.0881
Middle	1.00			1.00		
Poorer	1.01	(0.96 ; 1.07)	0.6184	0.98	(0.90 ; 1.05)	0.5179
Poorest	1.02	(0.96 ; 1.07)	0.5318	0.98	(0.91 ; 1.06)	0.6219
Number of household members						
1-4 household members	1.00			1.00		
5+ household members	0.97	(0.93 ; 1.01)	0.1520	0.98	(0.92 ; 1.05)	0.6170
Number of children under 5 yrs						
One	1.00			1.00		
Two	1.04	(0.99 ; 1.09)	0.0989	1.03	(0.97 ; 1.10)	0.2998
Three or more	1.03	(0.96 ; 1.10)	0.4422	0.97	(0.88 ; 1.08)	0.6256
Frequency of listening to radio						
At least once a week	0.92	(0.86 ; 0.98)	**0.0068**	1.10	(0.99 ; 1.22)	0.0640
Less than once a week	0.97	(0.91 ; 1.04)	0.4234	1.03	(0.92 ; 1.14)	0.6135
Not at all	1.00			1.00		
Frequency of watching TV						
At least once a week	0.69	(0.59 ; 0.82)	**<.0001**	0.85	(0.69 ; 1.04)	0.1217
Less than once a week	0.94	(0.89 ; 1.00)	**0.0316**	1.00	(0.93 ; 1.06)	0.9089
Not at all	1.00			1.00		
Frequency of reading newspaper or magazine						
At least once a week	0.78	(0.61 ; 1.07)	0.0554	1.10	(0.85 ; 1.42)	0.4695
Less than once a week	0.85	(0.79 ; 0.92)	**<.0001**	0.90	(0.81 ; 1.00)	**0.0428**
Not at all	1.00			1.00		
Health care level						
Antenatal clinic visits						
None	1.00			1.00		
1-3 visits	0.99	(0.86 ; 1.13)	0.8295	1.12	(0.87 ; 1.43)	0.3912
4+ visits	0.95	(0.83 ; 1.09)	0.4635	1.12	(0.87 ; 1.44)	0.3990
Place of delivery						
Health facility	1.00			1.00		
Home / other	1.10	(1.05 ; 1.15)	**<.0001**	1.02	(0.95 ; 1.10)	0.6360
Type of delivery assistance						
Health professional	1.00			1.00		
Other	1.09	(1.04 ; 1.14)	**0.0004**	1.01	(0.94 ; 1.08)	0.8588

Access to postnatal care						
Yes	1.00			1.00		
No	1.03	(0.97 ; 1.09)	0.3665	1.06	(0.97 ; 1.16)	0.1939
Community level						
Residence						
Urban	1.00			1.00		
Rural	1.27	(1.14 ; 1.41)	**<.0001**	1.09	(0.95 ; 1.26)	0.2166
Geographical region						
Kigali city	1.00			1.00		
South	1.19	(1.06 ; 1.34)	**0.0027**	0.98	(0.85 ; 1.14)	0.8215
West	1.36	(1.21 ; 1.53)	**<.0001**	1.11	(0.96 ; 1.27)	0.1694
North	1.26	(1.11 ; 1.42)	**0.0003**	1.02	(0.88 ; 1.18)	0.7926
East	1.25	(1.11 ; 1.40)	**0.0002**	1.05	(0.91 ; 1.20)	0.4936
Cluster altitude						
Lowest	1.00			1.00		
Low	1.04	(0.96 ; 1.12)	0.3255	0.95	(0.87 ; 1.03)	0.2183
High	1.06	(0.99 ; 1.14)	0.0935	0.95	(0.86 ; 1.04)	0.2534
Highest	1.19	(1.12 ; 1.27)	**<.0001**	1.06	(0.98 ; 1.14)	0.1421
Access to safe drinking water						
Yes	1.00			1.00		
No	1.11	(1.07 ; 1.16)	**<.0001**	1.07	(1.01 ; 1.13)	**0.0348**
Access to proper sanitation						
Yes	1.00			1.00		
No	1.06	(1.02 ; 1.10)	**0.0064**	1.03	(0.98 ; 1.09)	0.2645

PROTOCOL DOSE-TO-MOTHER DOUBLY LABELLED WATER METHOD

Standard Operating Procedure for the Assessment of breast milk intake, body composition and energy expenditure in lactating women and their babies.

DIVISION OF HUMAN NUTRITION

OCTOBER 2014

WAGENINGEN UR
For quality of life

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INTRODUCTION

Adequate nutrition during the first year in life is crucial for the development of a healthy child and the prevention of stunting at a young age. Appropriate breastfeeding practices play an important role in this first period of life. The World Health Organization (WHO) recommends exclusive breastfeeding for six months, followed by the introduction of appropriate complementary foods, while breastfeeding continues until two years of age or beyond (WHO, 2002; WHO, 2003). Exclusive breastfeeding means that the infant receives human milk without any additional food or drink, not even water. However, only limited information is available on the quantities of human milk consumed and the time of introduction of other foods into infants' diets. Quantitative data on breast milk intake is sparse and mostly based on test weighing (WHO, 2002; Prentice et al., 1994). This method is prone to errors due to the necessity to correct for water loss during the period of each feeding; to the numerous small feedings (e.g. at night-time); and to the intrusion of this method on the normal behaviour of both mother and infant (Da Costa et al., 2010).

Methods that make use of isotope dilution techniques have been developed over the last 20 years to improve the assessment of human milk intake and intake of water from sources other than human milk. The dose-to-mother doubly labelled water method provides a tool to objectively quantify breast milk intake averaged over a 2-weeks' time period without disrupting normal feeding behaviour. Normally, when using isotope dilution techniques to asses human milk intake, a fixed dose of deuterium oxide ($^{2}H_2{}^{16}O$) is orally administered to the mother, after which the enrichment of the dose is traced in the body water of both the mother and her infant. This method known as deuterium isotope dilution was first described by Coward (Coward et al., 1982). The method is only capable to measure breast milk intake. However, in addition to measure breast milk intake, the use of doubly labelled water ($^{2}H_2{}^{18}O$) allows us to also assess maternal body composition and maternal energy expenditure (IAEA, 2009). Doubly labelled water (DLW) is a solution of deuterium oxide ($^{2}H_2{}^{16}O$) with 18-oxide ($^{1}H_2{}^{18}O$). The method is safe in use and can be implemented in field settings, for instance in developing countries, without the need of high-tech equipment (Da Costa et al., 2010; IAEA, 2010).

The objective of this protocol is to provide a standard operating procedure (SOP) for the assessment of breast milk intake and maternal body composition / energy expenditure in mother-child pairs, by using the dose-to-mother doubly labelled water method.

THE DOUBLY LABELLED WATER DOSE-TO-MOTHER METHOD

The doubly labelled water dose-to-mother procedure that is used in this protocol is based on the Human Health Series No. 7 *'Stable Isotope Technique to Assess Intake of Human Milk in Breastfed Infants'* of the International Atomic Energy Agency (IAEA, 2010). However, because of the different isotope solution used in our protocol (DLW instead of Deuterium oxide) we combined this with the IAEA Human Health Series No. 3 for the *'Assessment of Body Composition and Total Energy Expenditure using the Stable Isotope Techniques'* (IAEA, 2009). By combining these methods the human milk intake, body composition and energy expenditure from either the mother and/or child can be assessed.

ASSESSMENT OF HUMAN MILK INTAKE

Calculation of human milk intake and intake of water from sources other than human milk is based on the two compartment steady state model (Shipley et al., 1972). This is illustrated in **Figure 1**. In the two compartment model, the mother's body water (V_m) is the first compartment and the baby's body water (V_b) is the second compartment. These two compartments are connected by the flow of milk from the mother to the baby (F_{bm}). In the steady state model, the total water input is equal to the total water output. In **Figure 1**, *F* signifies a flow of water. Conventionally, in compartmental models, the first letter after the *F* indicates where the flow goes to, and the second letter indicates where the flow is from, so that F_{bm} is the flow from the mother to the baby, i.e. human milk intake by the baby. Flows are also shown from the outside (*o*) to the mother (F_{mo}), i.e. the water she drinks, and from the mother to the outside, i.e. the water she loses from her body in urine, faeces, sweat and breath. Similarly, F_{bo} is the flow from the outside to the baby, i.e. water intake by the baby from sources other than human milk. The final flow is from the baby to the outside, F_{ob}, i.e. the water lost from the baby's body in urine, faeces, sweat, saliva and breath.

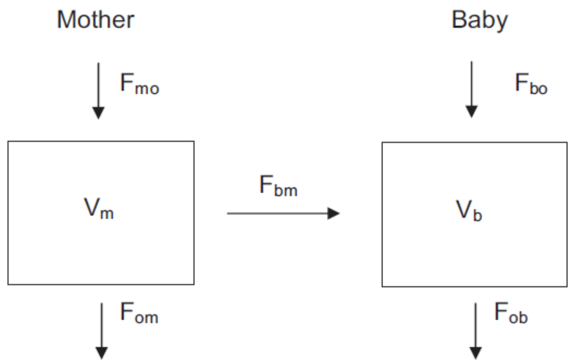

Figure 1*. Two compartment steady state model of water flow in a mother–baby pair. F = flow; m = mother; b = baby; o = outside; V = volume TBW; Vm = mother's TBW volume; Vb = baby's TBW volume; Fmo = from outside to mother; Fbo = from outside to baby (non-breast fluid intake); Fbm = from mother to baby (breast milk intake); Fom = from mother to outside; Fob = from baby to outside.*

Intake of human milk and water from sources other than human milk can be calculated by fitting the deuterium enrichment data to a model for water turnover in the mother and in the baby. An example is illustrated in **Figure 2**.

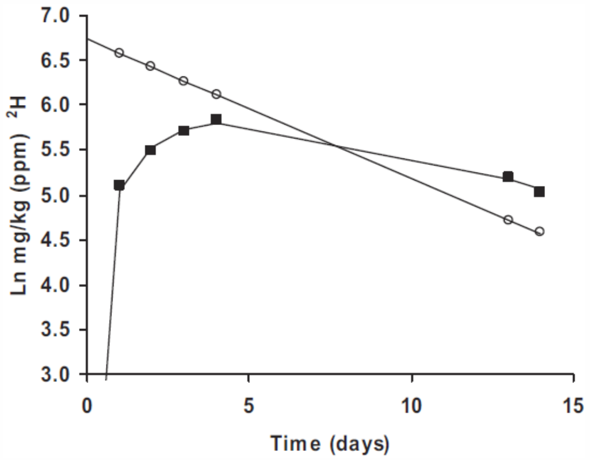

Figure 2. *Deuterium enrichment in the body water of a mother (○) and her baby (■).*

In the steady state, water turnover in the mother is given by a single exponential equation:

$$\frac{\mathrm{Em(t)}}{\mathrm{Em(0)}} = e^{-k}mm^{t}$$

where:

- $E_{m(t)}$ is the deuterium enrichment in the mother's body water at time t, in mg/kg or ppm; *t* is the time since the dose was taken, i.e. time post-dose in days;
- $E_{m(0)}$ is the deuterium enrichment in the mother's body water at time zero mg/kg (ppm), i.e. the y intercept of the isotope elimination curve (log/linear plot of enrichment of ^{2}H in body water versus time;
- k_{mm} is the fractional water turnover in the mother (kg/d), i.e. the gradient of the isotope elimination curve.

Data from the baby are fitted to the following multi-exponential model:

$$E_{b(t)} = E_{m(o)}\left(\frac{F_{bm}}{V_b}\right)\left(\frac{e^{-k}\,mm^{t} - e^{-(F_{bb}/V_b)t}}{(F_{bb}/V_b) - k_{mm}}\right)$$

Where:

- $E_{b(t)}$ is the deuterium enrichment in the baby's body water at time, t, in mg/kg (ppm);
- *t* is the time since the dose was taken by the mother, i.e. time post-dose in days;
- $E_{m(0)}$ is the deuterium enrichment in the mother's body water at time zero mg/kg (ppm), i.e. the y intercept of the mother's isotope elimination curve (log/linear plot of enrichment of ^{2}H in the mother's body water versus time);
- F_{bm} is the transfer of water from the mother to the baby via human milk (kg/d);
- V_b is the baby's total ^{2}H distribution space (kg). V_b is assumed to change linearly with initial and final values determined from the baby's weight (W, kg). $V_b = 0.84\ W^{0.82}$;
- k_{mm} is the fractional water turnover in the mother (kg/d), i.e. the gradient of the mother's isotope elimination curve (see Figure 2);
- F_{bb} is the total water loss in the baby (kg/d).

Curve fitting will be performed using the 'Solver' function in Microsoft Excel. 'Solver' uses non-linear regression to determine, by iteration, the value of the constants that gave the line of best fit through the data, i.e. to minimize the sum of the squares of the differences between observed and fitted values for mother and baby data combined. This procedure requires initial estimates for the unknown parameters ($C_{m(0)}$, F_{bm}, k_{mm} *and* F_{bb}) and, subsequently, refines them to converge on best fit values.

Maternal body water volume (V_m) can be calculated from the dose given, and $C_{m(0)}$ and maternal water intake can be estimated as:

$$\mathrm{F_{mo}} = \mathrm{V_m} \times k_{mm}$$

<u>Human milk intake by the baby</u> is calculated from the flow of water from the mother to the baby, assuming that human milk is 87.1% water (Holland et al., 1991).

$$M = F_{bm}/0.871 \text{ kg/d}$$

Measured human milk intake is usually expressed as g/d.

The baby's total intake of water includes water from the oxidation of milk solids (protein, fat and carbohydrate) and water from sources other than human milk. The total water input derived from human milk is F_m. Calculation of F_s (oral intake of sources other than milk) assumes that water input equals water output. Allowance must be made for the baby's growth (F_g) and for an increase in TBW during the two weeks of saliva sampling and the fact that water lost in the baby's breath and by transdermal evaporation (F_{ob}) is subject to isotopic fractionation, and for absorption of atmospheric water by the skin, mainly in the lungs (F_a). Water input ($F_m + F_a + F_s$) equals water output plus water from growth ($F_{ob} + F_g$); therefore: $F_s = F_{ob} + F_g - F_m - F_a$

The flow of water from the mother to the baby (F_{bm}) represents free water in milk and does not include water from the oxidation of milk solids (protein, fat and carbohydrate):

- Human milk is assumed to contain 87.1% water, 1.3% protein, 4.1% fat and 7.2% carbohydrate (Holland et al., 1991);
- The yield of water from 1 g of protein is 0.41 g, from 1 g of fat 1.07 g and from 1 g of carbohydrate 0.55 g.

Therefore, oxidation of milk solids gives about 9 g of water per 100 g of human milk. Total water input to the baby derived from human milk (F_m) is given by:

$$F_m = F_{bm} + 0.09M$$

Growth of the baby during the experimental period will result in a small change in the baby's deuterium distribution space, which is related to its TBW, and in this context is known as V_b. V_b is assumed to change linearly with initial and final values determined from the baby's weight (W, kg). $V_b = 0.84\mathrm{W}^{0.82}$.

Water gained during the experimental period, F_g, is given by:

$$F_g = \left(V_{b,day14} - V_{b,day0}\right)/14$$

Deuterium is lost from body water via breath and insensible routes via the skin (transdermal evaporation) more slowly than hydrogen, for the reasons described above; therefore, F_{bb} (total water loss in the baby) must be corrected for isotopic fractionation. Total water output from the baby, i.e. flow from the baby to the outside (F_{ob}), which includes water lost as urine, sweat, in faeces and in breath, includes a correction for isotopic fractionation. The isotopic fractionation factor for deuterium between water vapour and water liquid is 0.946 at 37ºC. It is assumed that 85% of the baby's water output is not fractionated and that the remaining 15% is fractionated by a factor of 0.946. Thus, the correction factor is 0.85 + (0.946 × 0.15) = 0.9919. F_{ob} is given by:

$$F_{ob} = F_{bb}/0.9919$$

For non-oral water intake in the infant (F_a), a correction factor is necessary for environmental water influx to the baby, which is composed of atmospheric water absorbed through the skin and the lungs. Alveolar exchange is the largest component. Non-oral water intake is estimated as 6.3% of total water intake (Wells et al., 1995). As total water intake is equal to total water output, F_a is given by:

$$F_a = 0.063(F_{ob} + F_g)$$

Oral water intake from sources other than human milk (F_S) is then calculated as:

$$F_S = F_{ob} + F_g - F_m - F_a$$

There is an error associated with the estimate of the baby's intake of water from sources other than human milk, because of the assumptions made in this calculation. This error (25 ± 62 mL/d) results in a small apparent intake of water from sources other than human milk in babies who are truly exclusively breastfed (Moore et al., 2007).

ASSESSMENT OF BODY COMPOSITION BY ESTIMATING TOTAL BODY WATER (TBW)

The mother's body composition is estimated from her TBW, which is measured by deuterium dilution. The calculations assume that the body is composed of fat and fat free mass (FFM). Fat mass (FM) is the difference between body weight and FFM. FFM can be estimated from TBW as follows. The volume of TBW is slightly less than the volume of distribution of the deuterium dose because some of the deuterium is sequestered in non-aqueous substances (mainly proteins) by a process known as non-aqueous exchange.

V_D is the volume of distribution of deuterium (also known as the dilution pool space). When the natural logarithm of deuterium enrichment in the mother's body water is plotted against time, the distribution is a straight line. V_D is calculated from the y intercept of the linear regression line through the data. The value of the y intercept is given the notation, $E_m(0)$ (enrichment of ^2H in the mother's body water at time zero):

V_D (kg) = deuterium oxide dose (mg) / $E_m(0)$ (mg/kg)

V_D must be corrected for non-aqueous isotopic exchange. Non-aqueous isotopic exchange for deuterium is assumed to be 4.1% of the pool space. TBW is, therefore, calculated by dividing V_D by 1.041:

TBW (kg) = V_D/1.041

The hydration of FFM in the body is remarkably constant between species, but is higher in infants than in adults. Here, we are only concerned with the mother. FFM in adults is assumed to be 73.2% water. This is known as the hydration of FFM. Thus:

FFM (kg) = TBW (kg)/0.732

FM is calculated as the difference between FFM and body weight:

FM (kg) = body weight (kg) – FFM (kg)
FM% = FM (kg)/body weight (kg) × 100

ASSESSMENT OF TOTAL ENERGY EXPENDITURE

In the DLW technique, the rate of carbon dioxide is measured. The method is based on the theory that after a dose of doubly labeled water ($^2H_2{}^{18}O$), the two isotopes equilibrate with the total body water and then are eliminated differentially from the body. Deuterium (^2H) leaves the body as water, while ^{18}O leaves the body as water (H_2O) and carbon dioxide (CO_2).

Deuterium elimination:	$rH_2O = TBW_{deuterium} \times k_H$	
^{18}O elimination:	$rH_2O + 2rCO_2 = TBW_{18\text{-}oxygen} \times k_O$	
Combining these, gives:	$rCO_2 = (0.5 \times (TBW_{avarage})) \times (k_O\text{-}k_H)$	[equation 1]

Where:

- $TBW_{avarage} = ((TBW_{deuterium}+TBW_{18\text{-}oxygen})/2)$, where $TBW_{deuterium} = V_D/1.041$ and $TBW_{18\text{-}oxygen} = V_O/1.007$.
- k_H and k_O are the fractional deuterium and ^{18}O turnover rates. When the deuterium and ^{18}O concentration is plotted as a natural logarithm against time, a straight line is observed. The ^2H and ^{18}O isotope turnover rates (k_H and k_O) can be calculated as the slope of the isotope elimination curves.

Isotope exchange with mainly protein ($^2H \leftrightarrow H$) and mainly phosphate ($^{18}O \leftrightarrow {}^{16}O$) increases the deuterium dilution space with 4.1% compared to TBW and increases the ^{18}O dilution space with 0.7% compared to TBW.

Incorporation of these factors into equation 1, it becomes:

$rCO_2 = (0.5 \times TBW) \times (1.007k_O – 1.041k_H)$ [equation 2]

After correction for isotope fractionation between body water and water vapour leaving the body, and between body water and carbon dioxide leaving the body, equation 2 can be modified to:

$rCO_2 = 0.455 \times TBW\ (1.007k_O – 1.041k_H)$ [equation 3]

Total energy expenditure can then be calculated as follows:

$TEE\ (kcal/d) = 22.4 \times rCO_2 \times (1.10 + 3.90/RQ)$

Where RQ is the respiratory quotient which is the ratio between the amount of CO_2 produced and O_2 consumed, which is assumed to be 0.85 in mixed diet.

PROCEDURE DOSE-TO-MOTHER DOUBLY LABELED WATER METHOD

The procedure of the dose-to-mother DLW method is summarized in **Figure 3**.

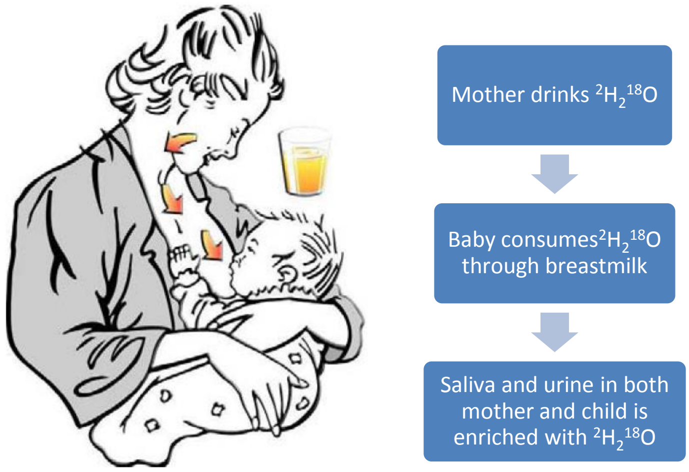

Figure 3. *Dose to mother technique with doubly labelled water for assessing human milk intake.*

DOUBLY LABELLED WATER DOSE PREPARATION AND STORAGE

The DLW dosage is based on body size in an effort to match the body water enrichments to the IRMS precision. Dosing more than the prescribed amount increases the cost of the dose, but does protect against under enrichment of ^{18}O and ^{2}H, which could lead to lost sample detection. Dosing less than the prescribed amount will reduce the precision of the energy expenditure measurement and increase the likelihood of having a final enrichment that is too low to pass quality control tests (IAEA, 2009). The prescribed dosage is based on a relative high water turnover rate of 5 L a day. This to ensure the precision of the last sample dosage. Assuming that the precision (± 1 SD) of analysis is about 1.5‰ (0.25 ppm) for deuterium and 0.15‰ (0.3 ppm) for ^{18}O, the optimal DLW dosage in adults contains 0.12 $g.kg^{-1}$ body water of 99 at.% deuterium labelled water and 1.8 $g.kg^{-1}$ body of 10 at.% ^{18}O water (IAEA, 2009). However, to be able to still detect the deuterium isotopes in the baby after 14 days, it is necessary to increase the dosage of 0.12 $g.kg^{-1}$ body water of 99 at.% deuterium labelled water to 0.3 $g.kg^{-1}$ body water of 99 at.% deuterium labelled water. Otherwise, the final enrichment of deuterium will be too low. Given that the dose is prescribed per unit of body water, an investigator must make estimates of TBW. This can be done assuming that 50% of the body weight in non-obese women is body water. Given these data, dosing per subject is subscribed in **Table 1**.

Table 1. DLW dose by weight mother.

Body weight (kg)	DLW dose (g)
< 60	60
60-70	70
70.1-80	77
80.1-90	85
>90	95

DOUBLY LABELLED WATER BATCH PREPARATION

The best way to prepare doubly labelled water samples is by making a DLW batch sufficient to your sample size. From the doubly labelled water batch you tap off the appropriate amount needed for an individual sample. The preparation of the doubly labelled water batch below is sufficient for the dosing of 5 subjects. Note that you need to prepare the doubly labelled water batch two days in advance. For the entire equipment list, see **appendix I**.

Dose requirements: ~ 1.8 g 10% enriched $H_2{}^{18}O$ per kg body water
~ 0.3 g 99% enriched $^2H_2O/D_2O$ per kg body water

The step-by-step dosage preparation:

- Weigh off 300 g 10% $H_2{}^{18}O$ in a 500 mL cylinder on a balance scale (0,1 g precise). Notate the weight precisely on the *DLW dosage datasheet* (see **appendix II**).
- Weight off 50 g 99% D_2O in a 100 mL cylinder on a balance scale (0.1 g precise). Notate the weight precisely on the *DLW dosage datasheet*.
- Mix the weighted $H_2{}^{18}O$ and D_2O amounts carefully in a 1L bottle. The bottle should be closed by a dispenser.
- Leave the bottle for 2 nights to allow full mixing of the water molecules.
- Shake the bottle two times per day.
- Collect 1.5 mL filtered (see individual dosage preparation) DLW mixture out of the batch into a 2 mL Sarsted cryovial with plastic pipette and close firmly. This sample will be used for diluted dose preparation (see **appendix III**).

INDIVIDUAL DOUBLY LABELLED WATER DOSAGE PREPARATION

- Code a 200 ml polyethylene bottle with the participant number.
- Place the polyethylene bottle without the cap (0.1 mg precise) on the weighing scale and tare the weighing scale.
- Dispense the needed individual double labelled water dose (see **table 1**) with the dispenser in a 250 mL plastic beaker.
- Aspirate the dispended amount in a 100 mL syringe by pulling the plunger back.
- The syringe must be held upside down.
- Attach the bacterial filter to the outlet of the syringe.
- Inject the content into the pre-labelled individual 200 mL polyethylene bottles with leak proof screw caps. Notate the weight of the filled polyethylene bottle (0.1 mg precise) on the *DLW dosage datasheet* before you put on the leak proof screw cap.
- Secure screw cap with parafilm.
- Store individual dose bottles in the refrigerator.

To ensure good hygiene and avoid cross-contamination, DLW dosages should not be stored in the same place as saliva & urine samples. When transporting doses to and from the field, separate boxes for DLW dosages and urine + saliva samples should be used.

INCLUSION AND EXCLUSION CRITERIA

Subjects are included in the study when:

- Female, apparently healthy
- Lactating, either exclusively or partially (at least three breastfeeds daily), during the entire study period
- If applicable, willing to cease expressing milk (pumping) or to give expressed milk during the entire study period
- Singleton and apparently healthy baby, between 2-4 months of age
- Full term pregnancy (>37 weeks)

Subjects are excluded from the study when:

- Suffering from kidney failure or malabsorption
- Suffering from congestive heart failure
- Being abroad or planning to travel during the study period (because of change water source)

MEASURING WEIGHT AND HEIGHT OR LENGTH

An accurate measure of the mother's body weight is required to estimate her body composition, which is based on the measurement of TBW. The mother's height is needed for the basic metabolic rate (BMR) and Body Mass Index (BMI) measurements. The mothers body weight needs to be measured on day 0 and 14. This is to ensure the weight didn't changed during the study period. When the body weight did change, drop-out or adaptations concerning energy expenditure needs to be considered! The mother's length can be measured twice on day 0 for an accurate measurement.

The babies weight and height needs to be measured both on day 0 and 14. The measurements can be done, according to the WHO growth references (WHO, 2006). In this way Z-scores can be calculated to determine stunting, wasting, underweight or overweight. The entire anthropometry procedures are described in **appendix IV**.

DOSE ADMINISTRATION

Baseline saliva samples must be obtained from both the mother and her baby before the consumption of DLW by the mother. A baseline urine sample from the baby is also taken. Detailed instructions for saliva and urine sampling are given in the sampling section.

Before the dosage consumption, the dose bottle should be inverted several times to avoid possible fractionation by condensation in the bottle. Make sure the whole bottle is mixed well, including condensation of the cap. This is because the condensation on the lid will be fractionated relative to the bulk liquid. The dose should be administered as described below:

- The bottle should not be opened until it is time for the dose to be consumed.
- The bottle number and the time the dose was taken should be noted on the *participant registration sheet* (see **appendix V**), the time must be notated very precisely (HH:MM:SS).
- Mothers should always drink the dosage through a straw to avoid spillage and to reduce immediate contamination in the mouth.
- Hereafter the bottle should be refilled with approximately 50 mL of drinking water.

- The second time, the bottle should be emptied by using the same straw to take up all the DLW. This procedure can be repeated. In this way no DLW is left in the bottle.

SALIVA AND URINE SAMPLING

The total equipment list for saliva and urine sampling can be found in **appendix 1.** The best time to collect the samples is around the breast feeding. Make sure the feeding takes place around the same time every collection day.

STEP-BY-STEP INSTRUCTION FOR SALIVA SAMPLING (MOTHER)

The saliva sampling from the mother can take place before, after or during a child feeding.

1) When collecting samples, it should be ensured that the mothers have not eaten or drunk anything for at least half an hour (30 minutes) before collection.
2) For the saliva sampling, mothers should be given a cotton wool ball to soak up saliva. She should be asked to move it around her mouth for 2 min or until sodden, **keeping her mouth closed while doing this to avoid fractionation.** Asking her to think about a favourite food increases salivation.
3) The plunger should be removed from a new 20 mL disposable syringe.
4) The mother should be asked to transfer the cotton wool to the front of her mouth and transfer it directly from her mouth into the body of the syringe.
5) The plunger should be replaced into the body of the syringe.
6) A sample storage vial should be labelled with the participant's identification number, date and time of collection.
7) The lid should be removed from the vial, and the syringe plunger used to extract saliva from the cotton wool into the sample storage vial.
8) If there is not at least 2 mL of saliva, the above steps should be repeated with a new cotton wool ball or swab.
9) The syringe, cotton wool and gloves should be discarded between participants. The sample vials or syringes should not be reused.
10) The saliva should be sampled at the baseline and then 1, 2, 3, 4, 13 and 14 d after the dose was taken by the mother, approximately at the same time of day on each occasion (± 1 hour). The participant's identification number as well as the date and time the sample was taken should be recorded on each vial.
11) Good records should be kept. All the dates and times of saliva collection should be recorded on the *participant registration datasheet* as well as on the collected samples.

STEP BY STEP INSTRUCTION FOR SALIVA SAMPLING (BABY)

The collection of saliva from the baby is different for steps 1-4 compared to the collection of the mother. The best time to collect saliva samples from the baby is before a feeding.

1) When collecting samples, make sure that it is at least 15 min since the baby was last fed, so that there is no residual milk or other foods in the baby's mouth. The saliva sampling can also be done before feeding.

2) In babies, saliva is sampled using a prepared cotton wool swab. Saliva should be collected by moving the swab around the baby's mouth until the cotton wool is sodden. Make sure the baby does not swallow the cotton wool. The time required for this will vary between babies. Patience is required. It may take several attempts to collect the required volume (minimum 2 mL).
3) The plunger from a new 20 mL disposable syringe should be removed.
4) The cotton wool from the swab should be removed and placed in the barrel of the 20 mL syringe. Step 5-11 same as mother.
5) Repeat the procedure when one cotton wool does not contains 2 ml of saliva. **Ensure the collection of saliva is repeated as soon as possible to avoid fractionation of the sample.**

STEP-BY-STEP INSTRUCTION FOR URINE SAMPLING (BABY)

It is not necessary to collect both urine and saliva from a baby. The decision for either urine or saliva depends, among other things, on the age of the child. Most studies make use of urine samples, which are easier to collect. However saliva samples are of better quality. Note that all the samples collected in one study should be the same. The best time period to collect urine is during or after a feeding.

1) Urine collection paths are placed in a clean dipper.
2) The paths should be placed as high as possible, closest to the urethra.
3) The dipper should be checked every 10 minutes for wetness.
4) If the baby urinated, the urine collection paths should be removed as soon as possible to reduce fractionation. Urine contaminated with faeces of faecal water cannot be used.
5) The urine collection paths should be placed in a plastic bag.
6) Cut a tip of the plastic bag.
7) The bag can be squeezed into a urine collection cup.
8) The collected urine can be decanted into the 5 mL sample storage vials.
9) The urine should be sampled at the baseline and then 1, 2, 3, 4, 13 and 14 d after the dose was taken by the mother, approximately at the same time of the day on each occasion (± 1 hour). The participant's identification number as well as the date and time the sample was taken should be recorded on each vial.
10) Good records should be kept. All the dates and times of saliva collection should be recorded on the *participant registration datasheet* as well as on the collected samples.

STORAGE OF SALIVA AND URINE SAMPLING

There will be a total of 7 samples from the mother and 7 samples from her baby. Saliva and urine sample vials from each mother-baby pair should be stored together.

Important points for the storage of saliva and urine samples are listed below:

- It is important to use good quality, screw capped containers for storage of saliva samples.
- Containers must be firmly closed to prevent loss of water by evaporation and cross-contamination between samples.

- Sample vials should be stored in sample vial boxes. To prevent cross-contamination each sample vials of both the urine and saliva should be covered with parafilm.
- The mother's and the baby's baseline samples should be placed in the same storage box
- The participant's identification number and sample time code should be written on the sample vails.
- To minimize bacterial growth, saliva and urine samples should be stored in a cool box or fridge until they can be transferred to a freezer at –20°C for storage until analysis.
- The saliva samples and urine samples should be stored in separate storage boxes. The 2ml saliva samples are stored in small boxes, the 5ml urine samples in large boxes.

To avoid contamination of samples:

- Samples and doses should never be stored together to avoid contamination.
- It should always be ensured that the cap of the sample bottles is tightly closed to avoid losses by evaporation and contamination by moisture from the atmosphere.

TIMELINE OF THE STUDY

An overview of the study timeline is shown in **figure 4.**

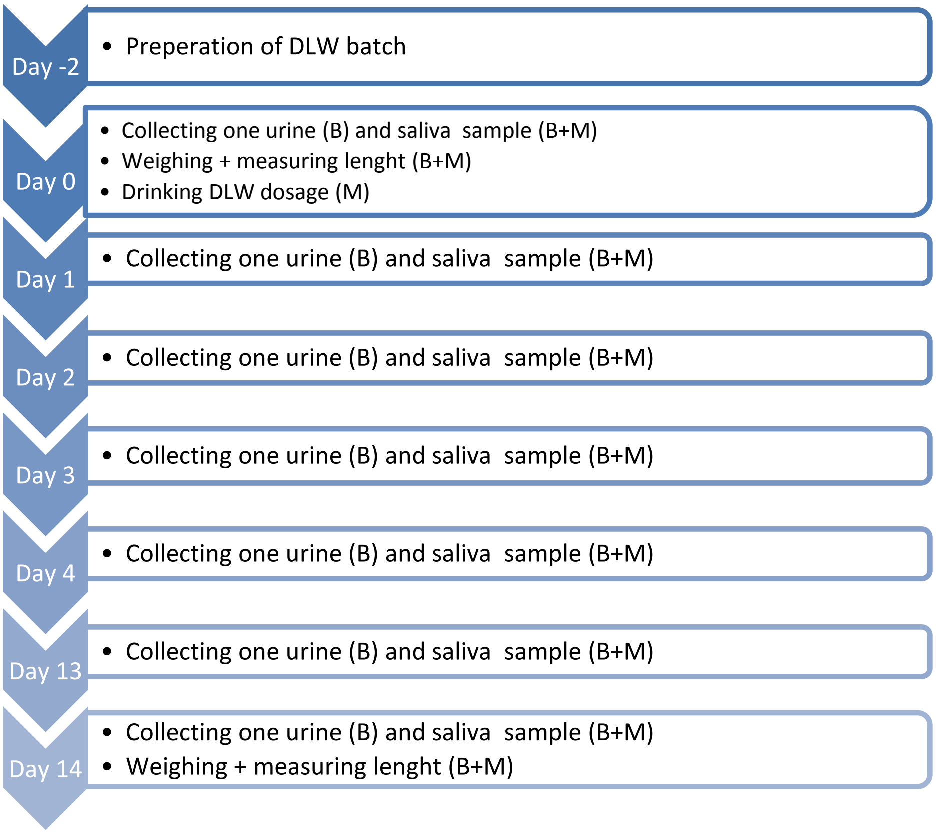

Figure 4. *Overview dose-to-mother doubly labelled water method.*

ANALYSIS OF THE ISOPTOPE ENRICHMENT BY IRMS

In order to measure the deuterium (^2H) and 18-oxygen (^{18}O) abundance in the samples, Isotope Ratio Mass Spectrometry (IRMS) is used. This technique is specifically designed for the measurement of mixtures of naturally occurring isotopes. Due to the nature of the molecules, the water is chemically converted to CO_2 and H_2 through the pyrolysis of water at 1500°C on a Hekatech High Temperature Pyrolysis unit and the gas is separated on GC-column ($H_2O + C \rightarrow H_2 + CO$). Afterwards, the $^{18}O/^{16}O$ and $^3H/^2H$ isotope ratios are measured on the respective molecules. The ratios are expressed in δ units of ‰.

PREPARATION OF THE SAMPLE CAPILLARIES

For the analyses by IRMS the collected urine and saliva samples need to be sealed in capillaries. It is really important to learn how to seal capillaries beforehand to avoid sample waste.

The sealing of the capillaries is done as follows:

- Fill the half of the capillary with urine or saliva till the mark.
- Rotate the capillary in your hands until the urine or saliva is centred in the tube.
- Place one end of the capillary between both hands.
- Seal the other end of the capillary using a blue flame burner.
- Watch your fingers keep a distance of 2 cm.
- Once the capillary is starting to melt, take the melted end with an tweezers.
- Rotate the capillary between your fingers until the melted glass collapses.
- Avoid heading up the content.
- Seal the other end of the capillary in the same way.
- The capillaries should not contain any air once sealed.
- If this is the case you have to repeat the procedure.
- The capillaries can be stored in clear daisy goblet with coloured visotubes. The coloured visotubes represent their own time code!
- Capillaries of mother-child pairs should be kept together.

The sealed capillaries are send to the lab in Groningen for further analysis. The deuterium (^2H) and 18-oxygen (^{18}O) abundance rates are entered into the *calculation data sheet* to calculate human milk intake, total body water and energy expenditure, see **appendix VI**.

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APPENDIX I: EQUIPMENT LIST

DLW batch preparation (5 dosages):

- ☐ 1000 mL flask, borosilicate 3.3 glass (VWR)
- ☐ 500 mL graduated cylinder (Schott, Duran)
- ☐ Weighing balance 0.01 G precise
- ☐ Bottle top dispenser varispencer plus, 100 mL (Eppendorf)
- ☐ 300 g oxygen-18 ($H_2^{18}O$) 10.5% (Centre of Molecular Research (CMR), Moscow, Russia)
- ☐ 50 g deuterium oxide D99.8% (Cambridge Isotope Laboratories, Tewksbury, United States)
- ☐ 2 mL cryovial (Sarstedt)
- ☐ 3 mL plastic pipette
- ☐ Printed batch label

DLW dosage preparation (per individual):	**Total Brinta-study:**
☐ 250 mL plastic beaker	5x
☐ 100 mL syringe (DB Plastipak)	1x
☐ Bacterial filter unit 0.2 µm FP 30/0.2 CA-S, (Whatman)	5x
☐ 200 mL polyethylene bottle	5x
☐ Screw cap for polyethylene bottle	5x
☐ Weighing balance 0.1 mg precise	1x
☐ Parafilm (Bemis, NA)	1 box
☐ Participant label	5x

Measuring weight and height (total study):	**Total Brinta-study:**
☐ Stadiometer	1x
☐ Head and footboard	1x
☐ Weighing scale 0.1 kg precise (mother)	1x
☐ Participant data sheet	1x

Collecting saliva sample mother (per sample) :	**Total Brinta-study:**
☐ Gloves	1 box
☐ Cotton wool balls	1 box
☐ 5 mL cyovails (Sarstedt)	35x
☐ Disposable 20 mL syringes	35x
☐ Participant label	5x
☐ Participant data sheets	5x

Collecting saliva sample baby (per sample):	
☐ Gloves	-
☐ Cotton wool swabs with extra cotton wool	-
☐ 5 mL cryovials (Sarstedt)	35x
☐ Disposable 20 mL syringes	35x

☐ Participant label	5x
☐ Participant data sheets	5x

Collecting urine sample baby (per sample):	**Total Brinta-study:**
☐ Gloves	-
☐ Diapers	35x
☐ Urine collection pads	35x
☐ Plastic bag	35x
☐ Scissors	1x
☐ Urine collection beaker	35x
☐ 5 mL cryovials (Sarstedt)	35x
☐ Participant label	5x
☐ Participant data sheets	5x

Sample storage:	**Total Brinta-study:**
☐ Cool box (chemical and food grade)	2x
☐ Freezer -20C	1x
☐ Cryovail sample storage box	2x
☐ Parafilm (Bemis, NA)	1x
☐ Sample label per storage box	2x

Preparation sample capillaries (per subject):	**Total Brinta-study:**
☐ Clear daisy goblet with coloured visotubes (Cryobiosystem)	5x
☐ 0.3 mL glass capillaries	105x
☐ Gas burner	1x
☐ Tweezer	1x

APPENDIX II: DLW DOSAGE DATASHEET

Date: ………………………………………………….

NAME of DATA COLLECTOR: ………………………………………………….

Participant number: ....

Dosage number:..

	(weight in 0.1 mg precise)
Weight of ± 300 g 10% $H_2{}^{18}O$ in a 500 mL cylinder	
Weight of ± 50 g 99% D_2O in a 100 mL cylinder	
Weight of the filled polyethylene bottle without the cap	

APPENDIX III: DILUTED DOSE PREPERATION

The preparation of the diluted dose is done as follows:

1. Tare analytical balance (0.1 mg accuracy; range 0-220 g) (=set zero).
2. Weigh a 200 mL polyethylene bottle to the nearest 0.1 mg: record weight (weight 1).
3. Add with an Eppendorf pipette: 400 uL of the DLW dose into the bottle: record weight (weight 2). Weight of dose for dilution (a) is: weight 2 – weight 1.
4. Add ~190 g of tap water to bottle: record weight (weight 3). Weight of tap water for dilution (W) is: weight 3 – weight 2.
5. Close bottle with screw cap and mix at least 15 times by inversion, leave it for one day at room temperature, remix by inversion the next day (it takes time to mix two types of water!).
6. Fill a 2 mL labelled Sarsted cryovial with the diluted dose from the bottle.
7. Prepare capillaries and store the cryovial with diluted dose at –20°C.
8. Prepare capillaries of tap water and store a cryovial with tap water at –20°C.

APPENDIX IV: MEASUREMENT OF WEIGHT AND LENGTH OR HEIGHT

MEASURING HEIGHT MOTHER

The height of the mother can be measured with a stadiometer (0.1 cm precise) as follows:

- Before measuring the accuracy of the stadiometer should be checked
- Height should be measured without shoes
- The mother should stand up right, with her heels touching the wall or vertical post of the stadiometer. Her knees should not be bend. See **figure 1**.
- The head should be positioned in the Frankfurt horizontal plane (ear and eye on the same line), looking straight ahead.
- Check the position in front and from the left side of the stadiometer
- The mother should inhale deeply and hold her breath during the measurement
- Make sure the body stays in the same position
- The headpiece should be lowered until it touches the top of the head with some pressure to compress the hair (if needed).
- Height should be measured twice
- Notate the height (0.1 cm precise) on the participant datasheet

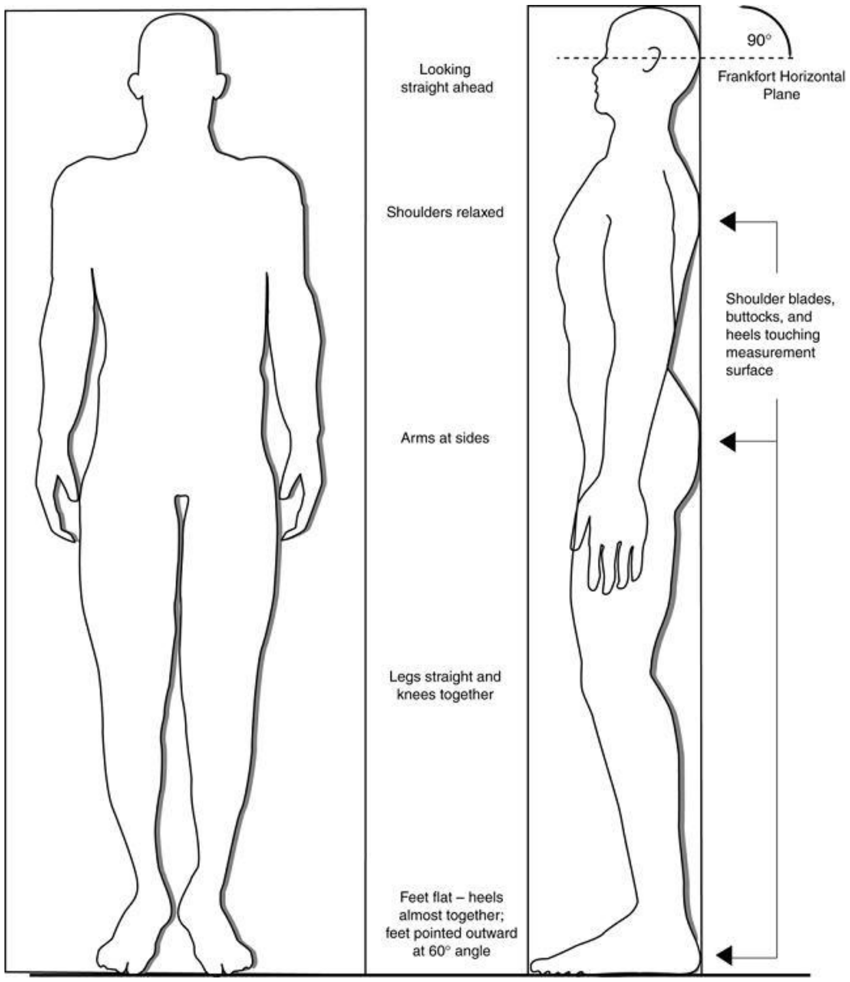


Figure 1 *Correct position of standing while measuring height with stadiometer.*

MEASURING LENGTH BABY

The height of the baby can be measured with a head-foot board or infantometer as follows:

- 2 people are needed to measure the length
- The baby lays down flat along the board with his head up
- 1 person should hold the head still and place it against the headboard, compress the hair (if needed)
- The other person should support the trunk of the baby. The shoulders should touch the board, the spine should not be arched and the knees should be pressed down firmly. See **figure 2**.
- Length should be measured twice to estimate mean length
- Notate the length (0.1 cm precise) on the participant datasheet

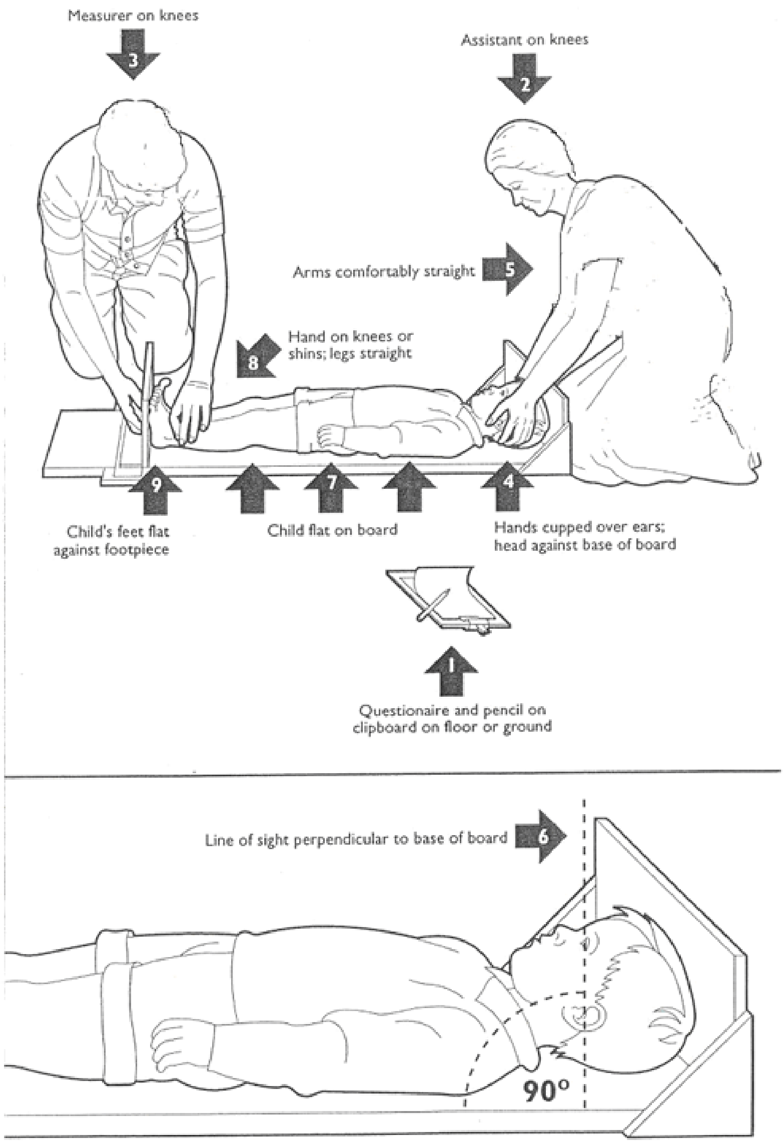


Figure 2. *Correct position of baby when measuring length with infantometer.*

MEASURING WEIGHT OF THE MOTHER AND THE BABY

The weight of the mother and the baby can be measured with an (electronic) weighing scale (0.1 kg precise) as follows:

- Before weighing always check the precision and accuracy of the scale.
- The mother should empty her bladder (and bowel) before weighing.
- Weighing should be done in minimal clothing and without shoes.
- If the mother does not want to take of her clothes, you can weigh the clothes afterward.
- First weigh the mother and the child together, by letting the mother hold her baby in her arms. The baby should be preferably weighed without clothing. If the temperature is low, a light blanket can be used.
- After weighing the mother and child together, the mother should be weighed alone.
- Weight of the baby = weight of the mother and baby together – weight of the mother alone.
- Do these measurements twice to estimate the mean weight.
- Notate the weight (0.1 kg precise) of both the mother and the baby on the *participant registration datasheet.*

APPENDIX V: PARTICIPANT REGISTRATION DATASHEET DLW METHOD

BRINTA Study Participant Data Sheet

	MOTHER	BABY
NAME		
STUDY ID		
DATE OF BIRTH		
BODY WEIGHT(KG) DAY (t=0)	Wt.1............. Mean=.......... Wt.2.............	Wt.1........... Mean=.......... Wt.2............
HEIGHT AND LENGTH (CM) (t=0)	Ht.1............. Mean=.......... Ht.2.............	Ht.1............. Mean=.......... Ht.2.............
BODY WEIGHT(KG) DAY (t=14)	Wt.1............. Mean=.......... Wt.2.............	Wt.1............. Mean=.......... Wt.2.............
HEIGHT AND LENGTH (CM) (t=14)	Ht.1............. Mean=.......... Ht.2.............	Ht.1............. Mean=.......... Ht.2.............
DATE OF BASELINE SAMPLING (t=0)		
TIME OF BASELINE SAMPLING (t=0)	S0:	S0: U0:
DOSE NUMBER		
DATE AND TIME DOSE TAKEN		
DATE OF SAMPLING (t=1)		
TIME OF SAMPLING (t=1)	S1:	S1: U1:
DATE OF SAMPLING (t=2)		
TIME OF SAMPLING (t=2)	S2:	S2: U2:
DATE OF SAMPLING (t=3)		
TIME OF SAMPLING (t=3)	S3:	S3: U3:

DATE OF SAMPLING (t=4)		
TIME OF SAMPLING (t=4)	S4:	S4: U4:
DATE OF SAMPLING (t=11)		
TIME OF SAMPLING (t=11)	S11:	S11: U11:
DATE OF SAMPLING (t=14)		
TIME OF SAMPLING (t=14)	S14:	S14: U14:

NOTE 1	
NOTE 2	
NOTE 3	
NOTE 4	

APPENDIX VI: CALCULATION DATA SHEET

The participant data sheets should be used as Excel files. In this way the needed formulas can be used to calculate TBW, energy expenditure and human milk consumption. The file can be requested at the Division of Human Nutrition of the Wageningen University. A print screen of the excel file is shown below.

	A	B	C	D	E	F	G	H	I	J	K	L
1	Instructions for use with Office 2010											
2	THIS SPREADSHEET IS FOR USE WITH IRMS DATA ONLY											
3	DO NOT CUT AND PASTE DATA: IT CORRUPTS THE FORMULAE. COPY AND PASTE MAY BE USED FOR DATES											
4	1) Rename spreadsheet: Human milk calcs "Study ID"											
5	2) Enter data in cells with green background											
6	3) Enter date (day/month/year) and time (hr:min) the dose was taken by the mother in cells B26 and B27											
7	3) If SOLVER is not already installed on your computer, click on the FILE tab, then on OPTIONS, ADD-INS.											
8	At the bottom of the page is "Manage" with EXCEL ADD-INS on a pull down menu. Click GO. Select SOLVER ADD-IN, then OK.											
9	4) Go to cell J61 (the Target Cell)											
10	5) Click on the DATA tab, SOLVER should be there. Click on SOLVER.											
11	6) The Solver parameters window opens, click on "Solve"											
12	This will determine the constants in cells F56:F59 which give the line of best fit to the mother's and baby's data											
13	7) The main outputs are human milk intake (J55) and intake of water from sources other than human milk (J60)											
14	8) The mother's body composition is in cells B58:B60											
15												
16	**Participant Study ID**	**template**										
17												
18	**MOTHER'S DATA**			**BABY'S DATA**								
19	Date of Birth	**31-aug-73**		Date of Birth	**23-mei-05**							
20	age	31	years	sex								
21	weight	**64.56**	kg	age	3.2	months						
22				start weight	**5.88**	kg						
23	**DOSE DATA**			final weight	**6.27**	kg						
24	Bottle number	**1**										
25	Weight D_2O (g) in bottle	**10.01**										
26	Date dose taken by mother	**29-aug-05**										
27	Time dose taken by mother	**10:00**										
28												
29	**(1) Data for mothers saliva**											
30							Deuterium			Deuterium		
31	Date	time	time since	Deuterium abundance		mean	enrichment	SD	CV (%)	enrichment calculated	mean sq error	
32			dose (days)	ppm	ppm	ppm	ppm xs	ppm xs		ppm xs	MSE	
33	**29-aug-05**	Baseline	0	**153.9**	**154.0**	153.9	0.0			336.7		
34	**30-aug-05**	**10:00**	1.00	**459.9**	**458.5**	459.2	305.3	1.03	0.22	300.3	24.7	
35	**31-aug-05**	**9:30**	1.98	**419.4**	**419.3**	419.4	265.4	0.03	0.01	268.5	9.5	
36	**1-sep-05**	**10:30**	3.02	**394.8**	**395.2**	395.0	241.1	0.28	0.07	238.4	7.4	
37	**2-sep-05**	**11:00**	4.04	**357.8**	**358.1**	357.9	204.0	0.26	0.07	212.1	66.0	
38	**11-sep-05**	**10:30**	13.02	**234.2**	**234.1**	234.2	80.2	0.11	0.05	76.0	17.5	
39	**12-sep-05**	**10:00**	14.00	**223.3**	**223.3**	223.3	69.4	0.06	0.03	68.0	1.9	

Informatie brochure BRINTA-studie

Brinta-study

Een studie naar de inname van borstvoeding door baby's tussen de 2 en 4 maanden.

WAGENINGEN UNIVERSITY
WAGENINGEN UR

2014

Afdeling:
Humane Voeding

Het onderzoeksteam van de Brinta-studie:

Dr. Ir. Alida Melse-Boonstra

Ir. Paul Hulshof

Roelinda Jonsgstra, Bsc

Nanette van der Spek , Bsc

Contactgegevens:

Afdeling Humane Voeding, bode 62

Roelinda Jongstra / Nanette van der Spek

Biotechnion (gebouw 307)

Bomenweg 2 6703 HD Wageningen

Roelinda.Jongstra@wur.nl / Nanette.vanderspek@wur.nl

06-24650859 / 06-30419498

Voorwoord

Deze brochure bevat informatie over het doel en de opzet van de BRINTA (BoRstvoeding INTAke) studie. In de brochure staat beschreven waarom de studie wordt uitgevoerd en wat wij van u als ‘mogelijke’ deelnemer verwachten.

Het onderzoek zal worden uitgevoerd door de afdeling Humane Voeding van de Wageningen Universiteit. De studie vindt plaats in november 2014. Deelname aan het onderzoek duurt 15 dagen. Voordat u besluit om samen met uw baby deel te nemen aan de studie dient u de brochure goed door te lezen.

Mocht u na het lezen van de brochure nog vragen hebben, neem dan gerust contact met ons op.

Hopelijk tot ziens!

Namens het onderzoeksteam,

Roelinda Jongstra & Nanette van der Spek

Achtergrond informatie

De BRINTA studie is een zogeheten pilot studie. Dit betekent dat het hoofddoel van de studie is om de methode te ontwikkelen. Dit wordt gedaan zodat de methode in de toekomst gebruikt kan worden bij andere studies.

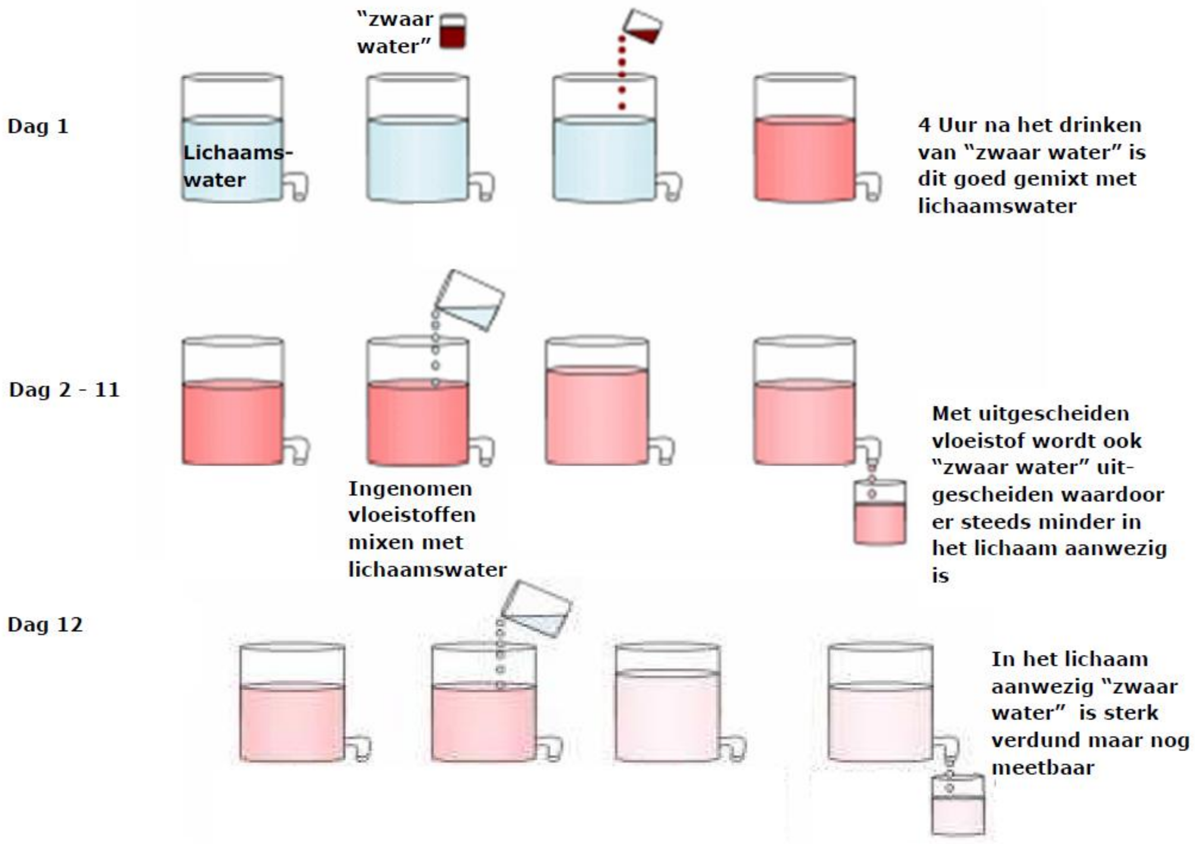
De methode die we gebruiken geeft antwoord op de volgende vragen:

- Hoeveel borstvoeding krijgt een baby gemiddeld binnen?
- Wat is de energie inname van een 2-4 maand oude baby die borstvoeding krijgt?
- Wat is de water/vet verdeling in het lichaam van de moeder?
- Wat is het energie verbruik van de moeder tijdens de studie periode?

Om deze vragen te kunnen beantwoorden maken we gebruik van de zogenaamde dubbel gemerkt water methode. Gewoon water bestaat uit 2 atomen waterstof en 1 zuurstof atoom. Bij dubbel gemerkt water zijn o.a. de waterstof atomen vervangen door deuterium atomen. Deuterium atomen zijn twee keer zwaarder dan waterstof atomen. Daarom noemen we het ook wel "zwaar water''. De dosis zwaar water die gebruikt wordt in het onderzoek is niet gevaarlijk voor de gezondheid. Tevens komt 'zwaar water' van nature in het menselijk lichaam voor.

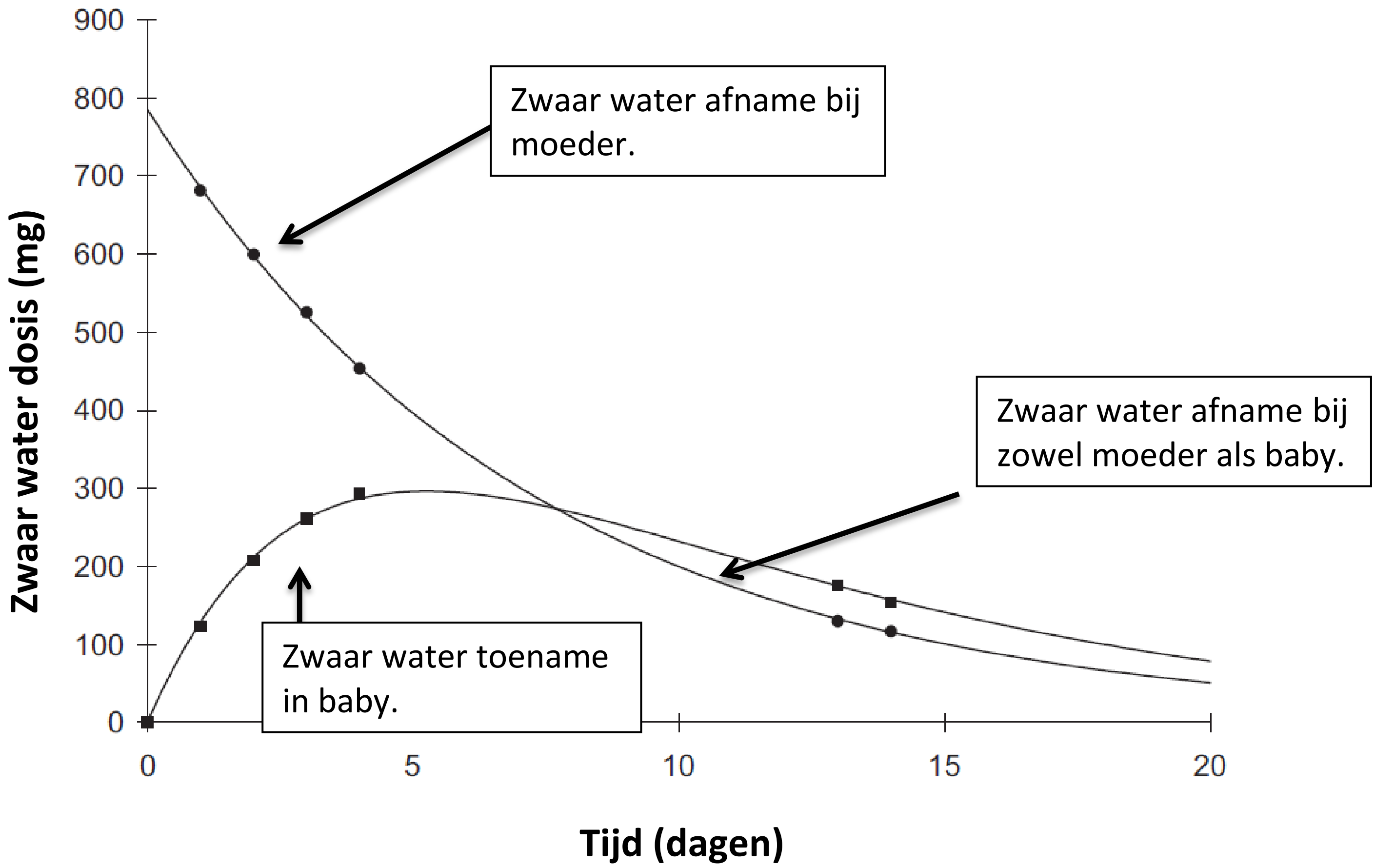
De helft van het menselijk lichaam bestaat uit water. Als een half kopje 'zwaar water' gedronken wordt, mengt zich dit water binnen 4 uur met het water dat al in het lichaam aanwezig is. Omdat de totale hoeveelheid lichaamswater vrij constant blijft, zal na iedere inname van vocht (koffie, thee, water, etc.) en vervolgens uitscheiding van het overtollige vocht met de urine, het in het lichaam aanwezige 'zwaar water' verdund worden. Over een periode van 12 dagen is de hoeveelheid 'zwaar water' in het lichaam al behoorlijk verdund maar nog steeds goed meetbaar. Na ongeveer 4 weken is er vrijwel geen extra zwaar water meer aanwezig in het lichaam. Vrijwel al het 'zwaar water' dat opgedronken is, is dan uitgescheiden.

Het principe van deze 'verdunningsmethode' wordt uitgelegd in **Figuur 1** onderaan de pagina. 'Zwaar water' is in de figuur rood gekleurd om de verdunningsmethode te verduidelijken. In werkelijkheid heeft zwaar water **geen** kleur.



Figuur 1: *De verdunningsmethode.*

De verdunningsmethode geldt **ook** bij moeders die borstvoeding geven. Het enige verschil is dat bij elke borstvoeding de baby ook een fractie van het zware water binnen zal krijgen. Na elke borstvoeding zal er dus meer zwaar water in het lichaam van de baby terecht komen. Dit zware water zal ook via de urine weer uitgescheiden worden. Na ongeveer 4 weken is al het opgedronken zware water bijna geheel uitgescheiden bij zowel de moeder als de baby. Dit principe wordt uitgelegd in **Figuur 2**.



Figuur 2. *Hoeveelheid zwaar water in moeder en kind gedurende de studie periode.*

Wat kunnen we door middel van deze methode vaststellen?

Door op verschillende tijden speeksel of urine van uw baby en speeksel van de moeder te verzamelen kunnen we een grafiek maken zoals in **Figuur 2**. Aan de hand van deze grafiek kunnen we nagaan hoeveel borstvoeding er in deze periode is gegeven. Aangezien borstvoeding een aardig constante voedingswaarde heeft (rond de 70 kilocalorieën per 100 ml) kunnen we de energie inname van de baby berekenen. Verder kan aan de hand van deze berekeningen bekeken worden of er naast de borstvoeding ook nog andere voedingsmiddelen zijn gegeven (water of bijvoeding).

Daarnaast kunnen we met de verzamelde speeksel monsters van de moeder ook een aantal dingen berekenen. Ten eerste is dat de water/vet verdeling in het lichaam. Hiervoor hebben we het lichaamsgewicht (kg) van de moeder en het totale lichaamswater (kg) nodig. Het totale lichaamswater wordt berekend aan de hand van de afname van zwaar water uit de grafiek. Met deze gegevens kan dan de water/vet verdeling berekend worden. Verder kan uit het verzamelde speeksel van de moeder vastgesteld worden hoeveel koolzuurgas er geproduceerd is. Met behulp van formules kan uit dit koolzuurgas berekend worden hoeveel energie er in de studieperiode (14 dagen) door de moeder is verbruikt.

Dit alles lijkt misschien heel ingewikkeld, maar daar merkt u als deelnemer gelukkig niks van. Hier nog even de belangrijkste punten van de methode op een rij:

- De dosis zwaar water die opgedronken zal worden (ongeveer half kopje) heeft geen kleur of smaak.
- Er komt van nature zwaar water in het lichaam voor.
- U merkt niet dat u zwaar water gedronken heeft.
- De hoeveelheid zwaar water in zowel moeder als baby zijn niet schadelijk voor de gezondheid.
- Na ongeveer 4 weken is het opgedronken zware water uit het lichaam van zowel moeder als baby verdwenen.

De BRINTA studie

Voor het onderzoek zijn we op zoek naar moeders met een baby tussen de 2-4 maanden waaraan borstvoeding gegeven wordt.

U komt **wel** in aanmerking voor het onderzoek als:

- U gezond bent;
- U bereidt bent gedurende het onderzoek (15 dagen) borstvoeding te blijven geven;
- Uw kindje is geboren na een volwaardige zwangerschap (>37 weken);
- Uw kindje gezond is.

U komt **niet** in aanmerking voor het onderzoek als:

- U last heeft van nier- of hartproblemen;
- U gedurende het onderzoek naar het buitenland gaat of vlak voor het onderzoek in het buitenland bent geweest;
- U een tweeling van 2-4 maanden heeft;

Verder mag u voor of tijdens de studie **niet** meedoen aan ander wetenschappelijk onderzoek.

Aanmelding

Voordat u mee mag doen aan de studie wordt aan de hand van een medische vragenlijst bepaald of u en uw kindje aan alle criteria voldoen. Door de medische vragenlijst ingevuld naar ons op te sturen kunt u zich aanmelden voor het onderzoek. Deze medische vragenlijst zal beoordeeld worden door het medisch team van de afdeling Humane Voeding van de Wageningen Universiteit. Als de medische vragenlijst is goedgekeurd kunt u deelnemen aan het onderzoek. Wij nemen hierover contact met u op.

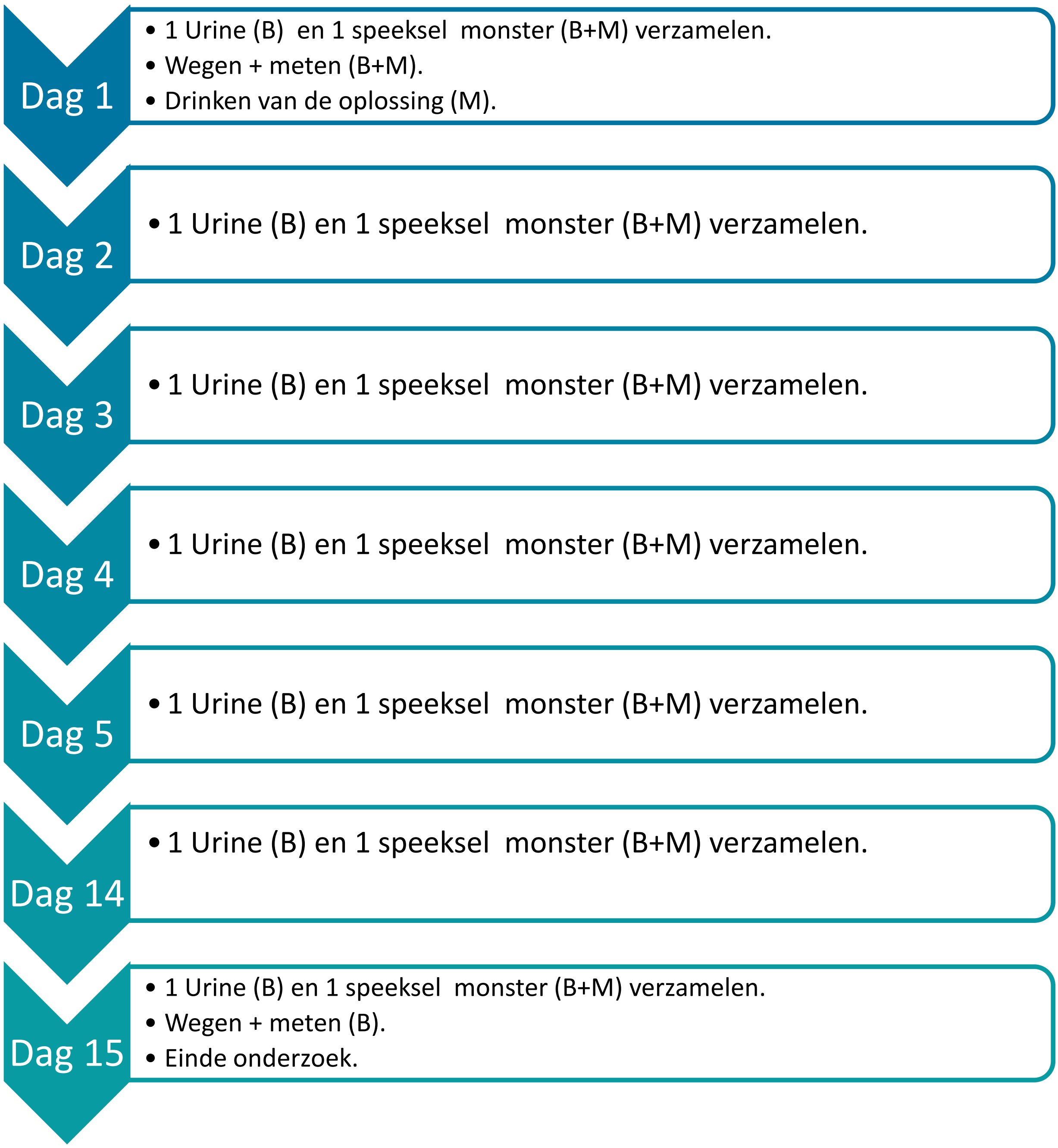
Toestemmingsverklaring

Indien u aan het onderzoek mee wilt doen, dient u een toestemmingsverklaring te ondertekenen. Hierin geeft u aan dat u voldoende geïnformeerd bent over het doel en de uitvoering van het onderzoek, dat u weet wat er van u verwacht wordt en dat u toestemming geeft voor deelname. De toestemmingsverklaring tekent u nadat u bent ‘goedgekeurd’ aan de hand van de medische vragenlijst en voordat de studie begint. Naast uw eigen toestemmingsverklaring dient er ook een toestemmingsverklaring voor uw kindje ondertekend te worden. Deze moet ondertekend worden door beide ouders.

Wat wordt er van u verwacht?

U drinkt op dag 1 eenmalig een dosis zwaar water (ongeveer een half kopje) met een rietje. Hierna worden er op verschillende tijdstippen speeksel (moeder en baby) en urine (baby) monsters verzameld. Voor de speeksel afname maken we gebruik van katoenbolletjes waar u op moet zuigen. Het volgezogen katoenbolletje zullen we in een spuit uitknijpen waardoor het speeksel verzameld kan worden. Voor de verzameling van speeksel bij uw kindje zullen we gebruik maken van katoenstaafjes, deze zullen in de mond geplaatst worden. Het kan zijn dat deze stap een aantal keer herhaald moet worden voordat we genoeg speeksel van uw kindje verzameld hebben. Mocht het niet lukken om op een dag speeksel van uw kindje te verzamelen dan gebruiken we alleen het urine monster. Voor de verzameling van urine maken we gebruik van een opvangstrip die in de luier geplaatst word. De opvangstrip zal elke 10 minuten op natheid gecheckt worden, waarna de strip wordt uitgeknepen en de urine verzameld kan worden. Het afnemen van de speeksel en urine monsters zal in totaal niet meer dan 30 minuten duren. In totaal zullen er 7 momenten zijn waarop speeksel en urine verzameld wordt. Verder zullen er op de eerste en laatste dag van de studie (1-15) de lengte en het gewicht van u en uw kindje opgemeten worden.

De gehele studie zal in de thuissituatie plaatsvinden. Dit betekent dat wij op afspraak de speeksel en urine monsters komen verzamelen. De exacte afnamemomenten staan weergegeven in **figuur 3**. Voor de afname van het speeksel is het van belang dat zowel u als uw kindje 30 minuten niet gegeten en of gedronken hebben. Het tijdstip van afname houden we zoveel mogelijk hetzelfde op alle dagen.



Figuur 3: *Tijdslijn BRINTA-studie, (B)= baby (M)=moeder*.

Wat krijgt u ervoor terug?

Bij deelname aan het onderzoek krijgt u een financiële vergoeding van €80,-. Mocht u eerder met de studie stoppen dan krijgt u een vergoeding conform uw bijdrage. Verder zullen we u informeren over uw persoonlijke onderzoeksresultaten, d.w.z. de inname van borstvoeding van uw kind en de lichaamssamenstelling en energieverbruik van de moeder. We hopen deze methode in de toekomst te gaan toepassen in landen waar veel ondervoeding voorkomt om daarmee de praktijk van borstvoeding beter in kaart te kunnen brengen. Met uw deelname levert u daarom niet alleen

een belangrijke bijdrage aan de wetenschap, maar mogelijk ook aan het oplossen van een maatschappelijk probleem.

VERDERE INFORMATIE

Stoppen met het onderzoek

Stoppen met het onderzoek mag altijd, u hoeft hier geen reden voor op te geven. Dit geld zowel voor u als voor uw kindje. De gegevens die tot dan toe zijn verzameld worden wel gebruikt in de resultaten van het onderzoek. Ook nadat u het toestemmingsformulier heeft ondertekend blijft u het recht behouden elk moment met het onderzoek te stoppen. Dit geld zowel voor u als voor uw kindje.

METC

Het onderzoek is goedgekeurd door de METC (Medisch Ethische Toetsing Commissie) van de Wageningen Universiteit. Dit betekent dat de studie aan alle medische en ethische eisen voor wetenschappelijk onderzoek met mensen voldoet.

Onafhankelijke arts

Voor ieder wetenschappelijk onderzoek wordt een onafhankelijke arts aangewezen. Een onafhankelijke arts is een arts die niet betrokken is bij de uitvoering van het onderzoek. De onafhankelijke arts kan door de deelnemers geraadpleegd worden voor vragen, die aan het onderzoek gerelateerd zijn en die de deelnemer niet aan de onderzoeker wilt stellen.

Voor de onderzoeken van de afdeling Humane Voeding is dit dr. J.J. van Binsbergen (arts te Brielle). Als u vragen heeft over het onderzoek die u niet met de onderzoekers wilt bespreken, kunt dr. van Binsbergen telefonisch bereiken door het telefoonnummer 0181 – 412155 te bellen op werkdagen tussen 8.00 en 10.00 uur. U krijgt een keuze menu te horen waarvan u 2 ‘voor overige zaken’ moet kiezen. De praktijkassistente noteert uw gegevens en dr. van Binsbergen zal contact met u opnemen.

U kunt uw vragen ook per e-mail stellen: j.vanbinsbergen@elg.umcn.nl

Graag duidelijk aan de praktijkassistente doorgeven of in de e-mail vermelden om welk onderzoek het gaat.

Verantwoordelijke arts

De verantwoordelijk arts in deze studie is Marco Mensink. Marco Mensink is als arts verbonden aan de afdeling Humane voeding van Wageningen Universiteit.

Risico's

Het onderzoek brengt geen risico's met zich mee. Eerdere onderzoeken met zwaar water bij moeders en hun 2-4 maanden oude baby's hebben geen schadelijke effecten of andere bijwerkingen gevonden.

Privacy

Bij wetenschappelijk onderzoek staat de privacy van de deelnemers hoog in het vaandel. U privacy wordt gewaarborgd door middel van een persoonlijk deelnemer nummer. Door dit nummer kan uw identiteit niet direct achterhaald worden. Verder zijn al uw gegevens vertrouwelijk en alleen beschikbaar voor de onderzoekers. In wetenschappelijke publicaties zullen persoonlijke gegevens niet vermeld worden. De verzamelde gegevens uit de studie worden voor een periode van maximaal 5 jaar opgeslagen. Hierna wordt alles vernietigd. Indien de gegevens voor een ander onderzoek gebruikt kunnen worden zal daar altijd weer toestemming voor gevraagd worden.

Bijdrage

Uw bijdrage is hard nodig om de studie tot een goed resultaat te brengen. Daarnaast krijgt u met uw bijdrage zelf een mooi overzicht van het energieverbruik van u en uw baby. Uw deelname draagt mogelijk bij aan een verbeterd inzicht in de inname van borstvoeding door baby's tussen de 2-4 maanden.

Meer weten?

Mocht u na het lezen van deze brochure nog vragen hebben, dan kunt u altijd contact opnemen met het onderzoeksteam. We danken u voor uw interesse in het onderzoek.