An investigation of factors associated with child stunting in northwest Rwanda: the role of care practices related to child feeding and health.

A thesis presented in partial fulfilment of the requirements for the degree of

Doctor of Philosophy

in

Nutritional Science.

College of Sciences

Massey University,

Palmerston North, New Zealand

Theogene Dusingizimana

2021

To

my loving wife

Laëtitia

and our children

Belicia

Estella

&

Josué

Abstract

Background: Stunting (height-for-age z-score < – 2 SD from the median of the WHO growth standards and a marker of chronic undernutrition) among children under 5 years is a public health challenge particularly in low- and middle-income countries, including Rwanda. Understanding the contributing factors is key for guiding future interventions and policies to address stunting.

Objective: This thesis aimed to investigate the factors associated with stunting among children aged 6–23 months of age in Rutsiro district, Rwanda, including the relationship between stunting and care practices related to child feeding and health.

Methods: A mixed-methods approach was used, consisting of an initial qualitative study followed by a cross-sectional survey. In the qualitative study, in-depth interviews with mothers (n= 24) were conducted to explore infant and young child feeding (IYCF) practices – *[Study 1]*. The qualitative study informed the development of a questionnaire which was used to collected data in a cross-sectional survey. In the survey, quantitative data at child-, maternal-, and household-level were obtained from 400 mother-child pairs. Child's anthropometric measurements were collected and used to determine child height-for-age z-scores (HAZ), which were used to define stunting. Data on infant and young child feeding (IYCF) and health practices were collected and used to construct an infant and child feeding practices index (ICFI) and a health practices index (HPI), respectively. Qualitative data on the use of multiple micronutrients powder (MNP) during complementary feeding were also collected during the survey. Multiple linear regression analysis was used to examine the association between HAZ and factors, including demographics, ICFI and HPI – *[Study 2]*. Content analysis and logistic regression analysis were carried out on qualitative and quantitative data, respectively, to examine factors related to access and use of multiple micronutrients powder (MNP) –*[Study 3]*.

Results: Mothers described two different food classification systems, based on modern nutrition knowledge about foods and on traditional beliefs about appropriateness of foods for young children. The traditional beliefs about foods, and the inability to recognize undernutrition/stunting, coupled with limited economic access to foods determines what foods children consume, and result in suboptimal IYCF practices, including limited diversity and amount of foods, and limited use of MNP. Results from the cross-sectional survey showed that 38% of the children were stunted (HAZ < – 2 SD). Maternal height, infant birth weight, and ICFI were positively associated with child HAZ. Conversely, child's age, sex (male), altitude, diarrhoea and upper respiratory infections in the previous 4 weeks were negatively associated with HAZ. No significant relationship was observed between HPI, household wealth index and child HAZ. Results also indicated that, compared with mothers of young children (6–11 months), mothers of older children (12–24 months) had significantly higher odds of using of MNP during complementary feeding. Similarly, mothers whose children participated in the food supplemental programme had significantly higher odds of using MNP, whereas increasing household hunger score was significantly associated with lower odds of using MNP.

Conclusions: In this setting, IYCF practices are suboptimal, and are associated with stunting. A tailored educational intervention designed to address existing beliefs and perceptions related to child feeding is required. Findings also indicate the need to facilitate mothers' implementation of appropriate practices through (child-sensitive) programmes that can enhance mothers' economic conditions and access to foods. The range of factors found to be associated with child HAZ suggests that a multi-sectoral approach is required to address stunting. Such approach should include interventions to improve health and nutrition of women before and during pregnancy to prevent prenatal growth restriction. Postnatally, interventions to promote optimal IYCF practices, particularly breast-feeding practices and dietary diversity should be coupled with measures to control infections.

Summary of Publications

Published articles

1. Dusingizimana, T., Weber, J., Ramilan, T., Iversen, P., & Brough, L. (2020). A qualitative analysis of infant and young child feeding practices in rural Rwanda. *Public Health Nutrition*, 1-10. doi:10.1017/S1368980020001081

2. Dusingizimana, T., Weber, J., Ramilan, T., Iversen, P., & Brough, L. (2020). An empirical study of factors associated with height-for-age z-scores of children aged 6−23 months in northwest Rwanda: The role of care practices related to child feeding and health. *British Journal of Nutrition,* 1-12. doi:10.1017/S0007114520004961

Article under review

A mixed-methods study of factors influencing access to and use of micronutrient powders (MNP) in Rwanda. Under review in *Global Health: Science and Practice* (Manuscript No: GHSP-D-20-004222R1)

Conference presentation

Dusingizimana, T., Weber, J. L., Ramilan, T., Iversen, P. O., & Brough, L. (2020). *Factors influencing access to and use of micronutrient powders (MNP) in rural Rwanda*. Abstract presented at the Micronutrient Forum 5th Global Conference: Connected 2020 (November 2–20, 2020) ~ Virtual presentation

Acknowledgements

First and foremost, I am very grateful to God Almighty for without His gift of life and blessings this thesis would not have been possible.

With immense gratitude, I would like to acknowledge financial support from the New Zealand Agency for International Development (NZAID) Programme that awarded me a scholarship for my PhD programme. My gratitude also goes to the University of Rwanda for granting me a study leave for the duration of my PhD programme.

I would like to express my sincere appreciation to my primary supervisor, Dr Louise Brough, and co-supervisors, Dr Janet L Weber and Dr Ramilan Thiagarajah. It was an absolute honour to do my PhD under your supervision. I am thankful for your support and guidance that made this intellectual but challenging journey possible. Your criticisms, which were always constructive and coupled with encouragement, improved my critical thinking, and nurtured my ability to conduct research independently. I greatly appreciate your patience and dedication to seeing me through the entire process.

I would also like to express my appreciation to Professor Per Ole Iversen, Oslo University, Norway, who has acted as my external supervisor. Having you in my supervisory team was invaluable. Your suggestions and critical comments on my research proposal, manuscripts, and thesis, as well as your encouragements throughout the entire PhD journey have significantly contributed to my success.

Prof Jane Coad is also appreciated for her encouragements and for reviewing my ethics applications.

I extend my appreciation to all mothers who participated in this study. Without you, this research would not have been possible. Thank you for welcoming me into your homes and for taking your time to share your views. Health centre managers, community health workers, and local leaders also helped me in various ways during my fieldwork and are appreciated.

I also take this opportunity to thank Paulin Ntirushwa and Jules Ihorere, for their assistance during my data collection. Jules and I ran into unforeseen challenges on several occasions, including unexpected downpour, which, many times caused floods and made roads impassable. Jules continued to assist me without complain, carrying my research equipment, which encouraged me especially when we had to walk long distances on a rough and hilly terrain.

I also acknowledge the help from my colleagues at the University of Rwanda, especially Aurelia Karayire for taking time to review and provide comments on the translations of my study instruments; and Maurice Mugabowindekwe for his help in creating the map of the surveyed area.

James Lee read and provided useful comments on the first draft of my qualitative paper. For that, I want to say thank you.

The support from the librarians, Chris Good and Jeff Philipps, is also greatly appreciated. I am thankful for the IT support from Tim O'Dea, as well as administrative support from Sharlene Lochore and Karen Pickering.

I also acknowledge the support from the International Student Support Officers, including Jamie Hooper, Saba Azeem and Micaella Moll, to name but a few. Thank you for making all my flights arrangements and for always being ready to offer support whenever I needed it.

The peer support and camaraderie of all my fellow PhD students, past and present, have been the fuel that helped me to overcome several challenges. Thank you, Lily Jia, and Marinea Marina. You have been helpful in many ways, and it was a great pleasure sharing an office with you. A special thank you to Lily and her husband, for offering me a place in their home and for making me part of their family during my first year. Lily, I will always remember all the times you or your husband came to pick me up from the bus stop, especially when it was raining during winter. I couldn't appreciate it enough. Other colleagues, including Ying Jin, Elizabeth Reynolds, Wei Chen, Katie Schraders

and Ciara Funnell are also appreciated for their constant motivation, care, and support. I have fond memories of each of you.

Many thanks also to friends from the Massey University African Students Club. Your company has been encouraging and made my stay in New Zealand an enjoyable experience.

Members of the Vision Church are gratefully appreciated. I grateful to Ps Dale and Rachel Meacheam, Ps Sam and Alison Livingston, the families of Dr Freddie Mbuba, Dr Adolph Nanguzgambo, Jayden Bay, and many others. Your company, encouragement, spiritual, and moral support helped me to find study-life balance, and to cope with the pressures of being a PhD student far away from my immediate family.

I will forever be indebted to my mum, brothers, sisters and other relatives for their encouragement, love, and support throughout my academic endeavours.

Last, but not least, I am truly grateful to my wife, Laëtitia. I cannot thank you enough for the tremendous support which kept me progressing even under tough times. Laetitia, your prayers, encouragement, and patience have been a solid foundation for my PhD journey. During my absence, you played the role of both mother and father, and, as always, you have shown your optimism and courage. Most notably, when the COVID-19 pandemic hit the country, being able to juggle the demand of our children and your work responsibilities as an essential health worker was beyond expectations. I am proud of you and I would like to say: '*Grand Merci et que Dieu te bénisse.'*

Table of Contents

List of Tables

List of Figures

List of Appendices

List of abbreviations

ANC	Antenatal care
aOR	Adjusted odds ratio
AUC	African Union Commission
CFSVA	Comprehensive Food Security and Vulnerability Analysis
CHW	Community health worker
CI	Confidence interval
COR	Crude odds ratio
DHS	Demographic and Health Survey
FAO	Food and Agriculture Organization
HAZ	Height-for-age *z*-score
HPI	Health practices index
ICFI	Infant and child feeding index
IQR	Interquartile range
IYCF	Infant and young child feeding
LMIC	Low- And Middle-Income Country
MNP	Multiple micronutrients powder
NEPAD	New Partnership for Africa's Development
NISR	National Institute of Statistics Rwanda
OFSP	Orange-fleshed sweet potato
SD	Standard deviation
SOSOMA	Soya Sorghum Maize
SPSS	Statistical Package for the Social Sciences
UN	United Nations
UNICEF	United Nations Children's Fund
URI	Upper respiratory infection
WFP	World Food Programme
WHO	World Health Organization

Chapter 1 General introduction

1.1 Background

Stunting – also referred to as *linear growth retardation or linear growth failure* – is the most common form of undernutrition among children under 5 years, especially in low- and middle-income countries (LMIC)[1]. Stunting is defined as a length/height-for-age *z*-score (L/HAZ) of < - 2 standard deviations from the median of the World Health Organization (WHO) reference population[2].

It is estimated that worldwide approximately 149 million (22%) of children under 5 years are stunted[3]. Two regions, i.e. South Asia and sub-Saharan Africa, account for the largest share of child stunting, with more than a half (55%) and over one-third (39%) of stunted children living in these regions, respectively[4]. Between 2000 and 2020, the number of stunted children declined, both globally, from 199.5 million to 149 million and, in South Asia, from 136.6 million to 78.2 million. In Africa, the proportion of stunted children has also marginally declined, but the actual number of affected children increased from 49.7 million to 57.5 million during the same period[3, 5]. Despite global efforts to reduce the number of stunted children, the progress has not been adequate to meet the global nutrition targets. It has been estimated that, at the current annual rate of stunting reduction (2.3%), there will be 130 million stunted children, 30 million above the global target of 2025[6].

Child stunting is increasingly gaining attention from governments and the international community as a result of an awareness of its negative health consequences as well as impact on national economies[7, 8]. Evidence shows that stunting is associated with increased morbidity and mortality among children under 5 years of age, diminished intellectual performance, low educational attainment, reduced work capacity and productivity and susceptibility to non-communicable diseases later in life[9-11]. Economic consequences of child undernutrition are related to health expenditures and the opportunity costs incurred in caring for sick children[12]. It is estimated that countries in

Africa and Asia lose up to 16.5% of their annual gross domestic product as a result of child undernutrition, including stunting[13].

In Rwanda, stunting affects 35% of children under 5 years of age[14]. Although there has been some progress in reducing stunting, estimates show that the current annual average reduction rate (4.5%) is below the required (5.2%) rate for Rwanda to achieve the World Health Assembly global nutrition targets of reducing the prevalence of stunting to 22% by 2025[15]. A recent analysis of data from 105 low-and middle-income countries (LMICs) showed that the usual reported prevalence of stunting at a national level may not always reflect the prevalence at subnational level, which masks the poorer nutritional status within country regions[16]. This is obvious in Rwanda, as evidenced by significant geographical disparities in stunting. For instance, stunting prevalence in nearly a half of the Rwanda's districts reaches as high as 40% to 54%[14], and the reasons for these disparities and the slow progress in reducing child stunting in Rwanda are not fully understood[17]. Although stunting is tied to poverty and food insecurity, available data show that even districts with a relatively low level of poverty have stunting prevalence of high (> 30%) or very high (> 40%) public health significance. Moreover, the data show that 25% of the stunted children in Rwanda are from households in the top two wealth quintiles[17], suggesting that stunting in Rwanda is not solely a result of poverty or food insecurity. Thus, there is a need to inquire into factors not related to income or food availability. The data also highlight the need to investigate the factors associated with child stunting in areas where the level of stunting is high, and the progress seems to be stagnated.

Evidence from LMICs shows that stunting generally begins during pregnancy and continues during the first 24 months after a child's birth[18, 19]. Thus, the period from conception to the child's second birthday (also referred to as the first 1000 days) has been identified as the window of opportunity for interventions to address child stunting[19]. The complementary feeding period, i.e. between 6–23 months, is particularly critical.

Studies conducted in Malawi and Cambodia showed that a half of the stunting occurs during this period[20], partly because the complementary feeding period coincides with the time when breastmilk is no longer sufficient to meet children's nutritional requirements, and the low nutrient density of the weaning foods[21]. In addition, the complementary feeding period is the time when children start exploring their home environment, which exposes them to pathogens that increase the risk of infections such as diarrhoea, which may reduce children's appetite and limit food intake and nutrient absorption[21]. Moreover, during the complementary feeding period, children depend on their caregivers for nourishment and care, which means that children's growth can be adversely affected by their caregivers' poor care practices[22]. Care refers to the practices and behaviours of caregivers that provide the food, health care, stimulation, and emotional support for children's healthy growth and development[23]. These practices, and the ways they are performed, may translate food and health care resources in child's wellbeing[23]. Although food quantity, quality and frequency often receive more attention, many practices related to how food is actually fed to children have significant influences on a child's nutrient intake[23]. For example, even if food is available in the household, caregivers still need to actively encourage children to eat the foods. Active feeding and encouragements are particularly important because young children may refuse foods due to poor appetite, which often results from illnesses or even monotonous diets[24]. In addition, caregivers' hygiene practices such as water boiling before use or child wastes disposal, can influence occurrence of diarrhoea in children, and eventually their nutritional status[25]. In light of the critical importance of the first 1000 days, more programmes and interventions focus on improving maternal health and nutrition during pregnancy, as well as infant and young child feeding (IYCF) practices and care practices during the complementary feeding period[18].

National surveys in Rwanda have consistently reported inadequate care practices during the complementary feeding period. For instance, the most recent Demographic and

Health Survey (DHS) report shows that only 57% of children aged 6−8 months are given complementary foods[26]. A recent survey also shows that, in 2018, only 34% of children aged 6−23 months were fed according to the recommended minimum frequency, whereas 40% met the recommended dietary diversity (i.e. consuming at least 4 food groups)[14]. Between 2010 and 2018, the proportion of children receiving acceptable diets, that is meeting the minimum meal frequency and minimum dietary diversity, remained unchanged at 17%[14], suggesting a lack of improvement in the overall IYCF practices during this period. Some studies suggested that suboptimal IYCF practices and health practices could be contributing to the high rates of child stunting in Rwanda[14, 27, 28]. However, little is known about the relationship between these practices and child stunting in Rwanda.

1.2 Aim and specific objectives of the thesis

The overall aim of this thesis is to identify the factors associated with stunting among children aged 6–23 months, with a particular emphasis on the role of care practices.

Specific objectives of the thesis are:

(1) To explore and gain an in-depth understanding of the factors influencing caregivers' infant and young child feeding practices.
(2) To assess and compare care practices related to child feeding and health between caregivers with non-stunted children and those with stunted children.
(3) To examine associations between child HAZ, a measure used to define stunting and other factors, including care practices related to child feeding and health.
(4) To identify potential areas of focus for future interventions to improve child nutritional status.

1.3 Thesis outline

The thesis is organized in 7 Chapters. It begins with an introduction (Chapter 1), which gives a general background of child undernutrition, introducing the problem and giving

the aims and objectives of the thesis. This is followed by a literature review (Chapter 2) of child undernutrition, its consequences and determinants, from a general perspective as well as Rwanda's nutrition context. Chapter 2 also gives a brief description of the study district and the research methodology.

The second Chapter is followed by three manuscripts, each of which presents results of three individual studies. The first study (Chapter 3) describes the findings of a qualitative study of the factors influencing infant and young child feeding practices in the study district. The findings from this study informed the development of a questionnaire used to collect data presented in the second and third studies. The second study (Chapter 4) investigates the factors associated with child HAZ, with a particular focus on care practices related to child feeding and health. The third study (Chapter 5) explored the factors influencing access to and use of multiple micronutrient powders (MNP). Both second and third studies were informed by findings from Chapter 3. Chapter 6 integrates and discusses key findings from Chapters 3, 4 and 5. The final section of Chapter 6 discusses the implications of findings and conclusions. The thesis is concluded with Chapter 7 outlining the strengths and limitations of the thesis, as well as recommendations for further research.

Each of the studies presented as Chapter 3, 4 and 5 was written following the guidelines of the scientific research journals in which the chapters were submitted. References all Chapters are numbered (Arabic numerical superscript) consecutively in the order in which they appear in the text, following the Vancouver style.

Chapters 3, 4 and 5 are not exact replications of the published/submitted versions. They have been formatted according to the University guidelines, and minor changes, including references to appropriate appendices have been included.

Chapter 2 Review of the literature

2.1 Child undernutrition

Child undernutrition is a collective term which may refer to stunting (height/length-for-age *z*-score below –2 SD of the WHO Child Growth Standards median), wasting (weight-for-height *z*-score below –2 SD of the WHO Child Growth Standards median), underweight (weight-for-age *z*-score below –2 SD of the WHO Child Growth Standards median), or micronutrient deficiencies also referred to as hidden hunger (e.g. minerals and vitamins deficiencies)[29]. Underweight includes both wasting and stunting.

Child stunting – the most common form of undernutrition among children, is a public health challenge, especially in the low- and middle-income countries (LMICs). The most recent estimates show that, globally, 149 million (22%) children under 5 years are stunted, 52 million (7.7%) are wasted, and 88.2 million (13%) are underweight [5, 30]. There is ample evidence of an increased risk of mortality due to infectious diseases such as diarrhoea and respiratory infections due to undernutrition[31]. It has been estimated that nearly half (45%) of annual deaths of children under 5 years are linked to child undernutrition, including stunting[1]. Most of these deaths occur in LMICs, especially in South Asia and sub-Saharan Africa[5], possibly because these two regions have the highest burden of childhood undernutrition.

Evidence shows that, in LMICs, linear growth faltering can begin *in utero*[32], partly due to inadequate maternal nutrition and care during pregnancy. Once a child is born, stunting increases for at least the first 24 months after birth[33]. The period from conception to 24 months of child age (the first 1000 days) has been recognized as the most critical “window of opportunity” for interventions to improve child growth and development[34]. The “window of opportunity” concept comes from evidence showing that interventions to prevent stunting in this period may have the greatest impact[35]; although evidence from cross-sectional and longitudinal data from LMICS shows that catch-up growth is also possible even after 24 months, including during puberty[34].

2.2 Consequences of child stunting

Child undernutrition is associated with short- and long-term consequences. In the short-term, stunting can result in increased risk of morbidity, mortality, and disability[36]. Studies have shown that stunted children are more susceptible to infections, particularly respiratory infections, and diarrhoea[37, 38]. A pooled analysis of data from 10 prospective studies in Africa, Asia and South America found a dose-response relationship between stunting and infections[31]. The study found that mildly stunted children (HAZ between –2 and < –1) were 1.55 times more likely to have respiratory infections and 1.67 more likely to have diarrhoea, compared to non-stunted children. Among severely stunted children (HAZ < – 3), the risk increased to 6.39 and 6.33, for respiratory infections and diarrhoea, respectively[31]. Ample evidence also shows that stunting during the period between conception and the second child's birthday (the first 1000 days) is associated with delayed cognitive development among children, which reduces their learning ability in school[9, 39].

As a result, stunted children have lower educational attainment, reduced physical work capacity and economic productivity late in life, which may lead to the intergenerational cycle of undernutrition and poverty[9, 40]. Moreover, stunted children are unlikely to achieve their full growth potential, and therefore mature into stunted adolescents and adults[22]. It has been estimated that one unit decrease in HAZ at 2 years of age is associated with 3.2 cm decrease in adult height[9]. Evidence also suggested that the consequences of stunting can extend into adulthood. Various hypotheses have proposed that stunting in early life is a risk factor for non-communicable diseases such as obesity and type-2 diabetes later in life[9]. This has raised concerns among some researchers who argued that, over the next several decades, the burden of non-communicable diseases might be substantially high in LMIC where the majority of stunted children live, especially given that these countries are also undergoing nutrition transition, characterized by shifts in diets (from traditional diet that is mainly plant-based and

minimally processed foods to highly processed, energy-dense, micronutrient-poor foods and drinks) and low physical activity patterns[41-44].

2.3 Determinants of child stunting

The UNICEF conceptual framework of the determinants of child undernutrition[45] is one of the most well-known frameworks used to study the determinants of child stunting. The framework was developed in 1990 and later adapted by Stewart *et al.* [12] (**Figure 2-1**) to reflect enhanced understanding of the determinants of stunting, including contexts of these determinants. According to Stewart *et al.,* stunting results from an overlap and complex interactions between four proximal factors, namely inadequate breast-feeding practices, infections, inadequate complementary feeding practices, and household and family factors[12].

Inadequate breast-feeding practices during the first 6 months, such as late initiation of breast-feeding, non-exclusive breast-feeding or not breast-feeding at all, result in inadequate intake of breastmilk, which deprives infants from getting enough energy and essential nutrients, as well as other protective components present in the breastmilk[46]. Consequently, an infant may become undernourished and more susceptible to undernutrition and infections, which can lead to poor growth and stunting[18]. Cross-sectional studies in Ethiopia (n= 622 children aged 0–59 months)[47] and India (n= 217 children aged 0–59 months)[48] found that children who were deprived of colostrum after delivery were >2 times more likely to be stunted than children who received colostrum. In a case-control study conducted in Ethiopia (n= 242 children aged 24–59 months), Fikadu *et al.* [49] also found that children whose mothers reported exclusive breast-feeding for the first 6 months were less likely to be stunted than those non-exclusively breastfed children. In Malawi, Kuchenbecker *et al.* [50] examined relationship between breast-feeding status and growth of infants (n= 196 aged 0–6 months) and found that infants who were exclusively breastfed had significantly higher HAZ than those who were not exclusively breastfed. However, exclusively breastfed infants in Kuchnebecker et

al.'s study, also had lower episodes of fever and/or diarrhoea, which suggests that the association of exclusive breast-feeding and child stunting may not be direct. Some studies found no association between breast-feeding and child stunting[51, 52]; whereas others reported lower HAZ among children who were exclusively breastfed between 0–5 months[53]. Jones et al. noted that, in cross-sectional surveys, lower HAZ among exclusively breastfed children could be due to the fact that researchers may classify some children as exclusively breastfed who may have received non-breast-milk liquids or foods prior to the survey[53]. Inadequate feeding practices during the complementary feeding period, i.e. from 6–23 months, can also contribute to child stunting. For instance, delayed introduction of complementary foods, insufficient diversity, and quantity of complementary foods results in inadequate nutrient intake, which in turn results in stunting[21, 54]. Several studies have shown that providing children with high quality and diverse complementary foods, and supplementing the diets with micronutrients, such as zinc and iron, can reduce the risk of stunting[55, 56].

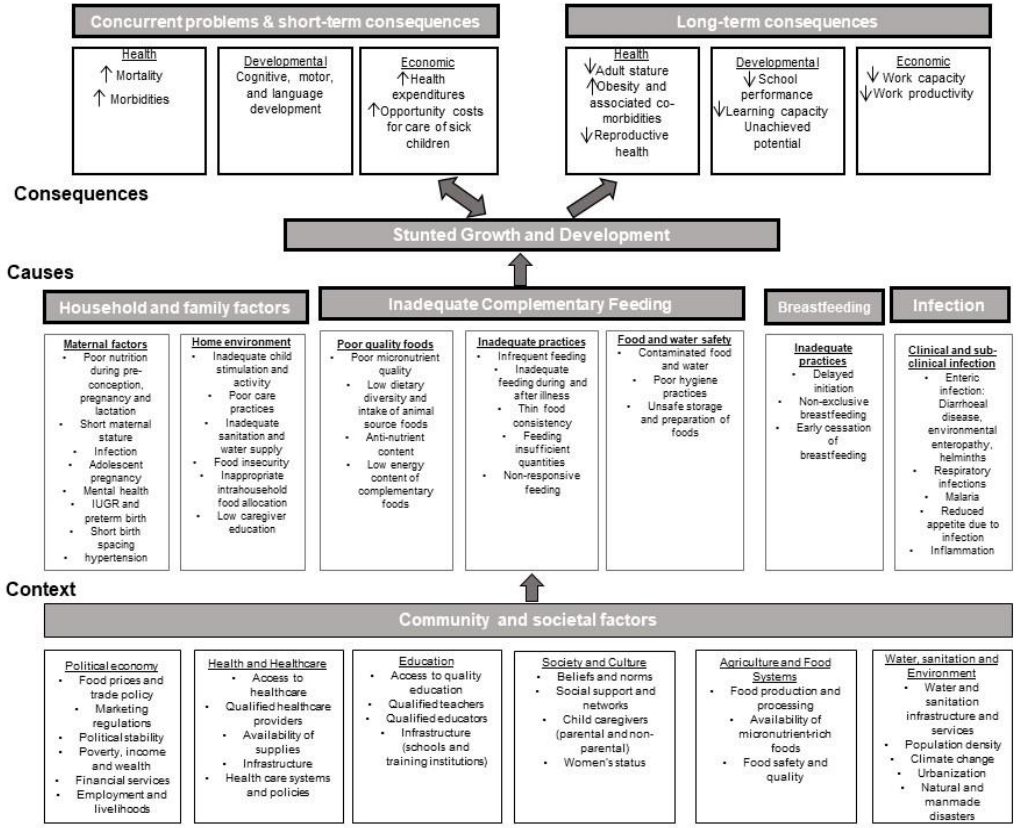

Figure 2-1 WHO conceptual framework on Childhood Stunting: Context, Causes, and Consequences, with an emphasis on complementary feeding. Reproduced from Stewart *et al.* [12] with permission from the publisher.

Using DHS data from 14 LMICs, Marriott *et al.* [57] found that, for children aged 6–8 months, consumption of iron-rich foods, meeting the WHO recommended minimum diversity and acceptable diet were associated with reduced risk of stunting. Some researchers demonstrated that the association between better feeding practices and better child HAZ may be mediated by maternal education[58]; although in Ghana, it was found that better feeding practices was positively associated with child HAZ, even in children from lower income households or from mothers with low (less than secondary) education[59].

In most disadvantaged populations, the adverse effect of inadequate complementary feeding practices on child's nutritional status is often compounded by infections due to consumption of contaminated foods or water [60]. It has been estimated that up 70% of diarrhoeal episodes in LMIC are attributed to contaminated complementary foods[61]. Parasitic infections have been found to be associated with diarrhoea, loss of appetite, intestinal mucosal damage, which reduce child food intake or interfere with nutrient absorption, leading to poor child growth[62, 63]. A pooled analysis of longitudinal data (n= 1393 children) from 9 countries found that the probability of stunting at 24 months of age increased by 2.5% per diarrhoeal episode, and that 25% of all stunting was attributable to having 5 or more diarrhoeal episodes before 24 months[64]. Another longitudinal study (n= 487 children aged 6–48 months) in Brazil also reported that HAZ significantly decreased in children who suffered from diarrhoea for 7 or more days over a period of 4 months[65]. With regard to complementary foods, observational studies conducted in West Africa have found that exposure to aflatoxin (a mycotoxin produced by the fungus *Aspergillus sp.*) through aflatoxin-contaminated foods, especially maize and groundnuts, has been associated with stunting[66, 67].

The household and family factors associated with stunting include unhealthy household environment (unclean water, poor hygiene, and sanitation)[18]. A study conducted in Peru

found that children aged 24 months living in households with the worst conditions for water source, water storage and sanitation had 54% greater frequency of diarrhoea and were 1 cm shorter than children from households with the best conditions[68]. Household and family factors also comprise maternal health (including mental health) and nutritional status before and during pregnancy which influence early processes of child growth and development. Maternal undernutrition (assessed by a body mass index <18kg/m^2) or maternal stunting (i.e. height < 145 cm) are associated with poor pregnancy outcomes, such as infant low-birth weight, which is a risk factor for stunting[69, 70]. Similarly, maternal infections such as malaria, helminths and HIV/AIDS during pregnancy contribute to intrauterine growth retardation, preterm birth (i.e. <37 weeks gestation) or low birth weight, all of which can contribute to child stunting[71]. Several studies have shown that infants with a low-birth weight (defined as birth weight <2500 g) are more likely to be stunted than those with normal weight[70, 72]. Household and family factors associated with child stunting also include care practices. According to Engle *et al.* [73], inadequate infant and child feeding practices that account for much of the nutritional deficiencies are not simply the result of lack of foods in the household. Rather, care practices related to how children are fed and cared for contribute significantly to children's nutrient intake, and consequently their nutritional status[73].

Stunting may also arise from a wide range of environmental, socio-cultural, political, and economic contextual factors[12, 46, 74], which influence the above-mentioned proximal factors.

Moreover, increasing evidence suggests that changes in the gut microbiota may be associated with stunted growth[75]. As highlighted by Robertson *et al.* [75], during early life, particularly from conception to 2 years, gut microbiota plays a role in immune, endocrine and establishment and maturation of developmental pathways. Therefore, it has been hypothesised that inadequate diet and environmental exposure to pathogens

due to poor water, hygiene, and sanitation, may disrupt the host-microbe-environment, contributing to deficit in child growth[75].

Although not captured in the above-mentioned conceptual framework, the literature suggests that child stunting can be partly attributed to genetic factors which determine individuals' size (small or tall)[76]. However, studies show that, in populations where undernutrition is common, much of the variability in child growth relates more to the difference in health and nutrition than to genetics[77] partly because, in such populations, environmental factors, including nutritional deprivation in early life, may not allow individuals to attain their genetic potential[78]. This is also supported by studies indicating that growth patterns of well-nourished healthy pre-school children are similar, irrespective of ethnic or geographical backgrounds[79, 80].

2.4 Child nutritional situation in Rwanda

2.4.1 A brief description of the country

Rwanda is a landlocked country located in East Africa. With a land surface area of 26,338 km^2 and a population of about 12 million people, Rwanda is one of the most densely populated countries (density= ~ 500 inhabitants per km^2) in Africa[81, 82]. Majority (80%) of the population is rural[83]. Agriculture is the backbone of the country's economy. It employs more than 80% of the population and contributes to > 30% of the country's gross domestic product (GDP)[84]. The major subsistence crops are cassava, beans, maize, banana plantain, Irish potato, sweet potato, and sorghum; whereas tea, coffee and pyrethrum are major cash crops[85]. While the agriculture sector constitutes the main economic activity for 80% of the labour force, landholdings are very small, with 50% of households cultivating, on average, less than 0.5 ha[86]. Administratively, Rwanda is divided into 5 provinces, namely, the City of Kigali, Northern, Southern, Eastern, and Western provinces. Each province is subdivided into districts (30 in total). Each district is subdivided into sectors, cells, and villages – the smallest administrative entities.

Over the recent years, the Rwandan government has shown a high-level of commitment to improve socio-economic conditions of the Rwandan population. According to the latest Integrated Household Living Conditions report, Rwanda's GDP has been growing at about 8% between 2001−2014, and the GDP per capita increased from US$ 211 in 2007 to US$ 718 in 2014[87]. Between 2000 and 2015, the proportion of Rwanda's population living in poverty fell from 58.9% to 38.2%[88]. Data also show that, over the last fifteen years, the life expectancy at birth increased from 48 years in 2000 to 68 years in 2012[89]. These achievements are attributed in part to the Rwanda's socioeconomic development, which resulted in improvement in health systems and coverage of healthcare interventions[90, 91]. However, despite these improvements in socioeconomic and health sectors, chronic undernutrition or stunting among children under 5 years of age remains widespread.

2.4.2 Child nutritional situation in Rwanda

The most recent national survey shows that the prevalence of stunting, underweight and wasting among children under 5 years of age was 35%, 12.6% and 2%, respectively[14]. These figures mark a significant improvement since 2000 when the prevalence of stunting, underweight and wasting were 48.3%, 25%, 7.7%, respectively (see **Table 2.1**). However, the national prevalence of stunting in Rwanda among children under 5 years of age remains greater than the average prevalence of stunting in LMICs (25%)[92]. The 2019 Global Nutrition Report indicated that Rwanda is on course to meet the global targets for wasting among children under 5 years, but is off course to meet the target for stunting[92]. While stunting prevalence is estimated at 35% at the national level, there are significant disparities in the prevalence of stunting across locations. For example, the prevalence of stunting is highest in rural areas (41%) compared to urban areas (24%)[26]. As highlighted in the background section, in 14 of the 30 Rwanda's districts, the prevalence of stunting exceeds the national average[14]. Whether there exist district-

specific factors causing the persistence of stunting in Rwanda remains largely unknown. Lack of disaggregated data on the determinants of undernutrition has been recognized as one of the gaps in accelerating progress to end child undernutrition in Rwanda[93]. Thus, this thesis intends to contribute to filling this gap by investigating the factors associated with child stunting in a district with the highest prevalence of stunting in Rwanda. Lack of disaggregated data may result in suboptimal allocation of resources to address stunting. For example, the 2015 Nutrition Stakeholders and Action Mapping report showed that the districts where core nutrition interventions, such as nutrition education, vitamin A supplementation and biofortification were being implemented in Rwanda, were not always the districts with the highest child stunting[94].

While stunting is the most common form of undernutrition among Rwandan children under 5 years of age, many of these children also suffer from anaemia – another form of undernutrition which is mainly caused by iron deficiency. According to the 2014/15 DHS report, 37% of children under 5 years were affected by anaemia in 2015[87]. Studies have shown that in LMIC many children suffer simultaneously from two or more forms of undernutrition. For example, in Ethiopia, Mohammed *et al.* [95] reported a 24% co-occurrence of stunting and anaemia in children aged 6–23 months. Gosdin *et al.* [96] reported 21% and 30% co-occurrence of stunting and anaemia in Indian and Peruvian populations, respectively. A recent pooled analysis of DHS data (n= 193065 children aged 6–59 months) collected between 2000–2015 from 43 countries, including Rwanda, found that 25% children suffers from both stunting and anaemia[97]. Based on the Rwanda's 2010 DHS data, these authors estimated that 17% of children under 5 years in Rwanda were affected by both stunting and anaemia. Recognizing the public health significance of undernutrition among young children, the Rwanda's National Food and Nutrition Policy calls for further strategies to solve the high prevalence of child stunting and high levels of anaemia among Rwandan children[98].

The consequences of child undernutrition in Rwanda have been highlighted in the 'Cost of Hunger' Study[99]. According to that study, undernutrition was associated with 22% of child deaths in 2012. The study also found that, in 2012, Rwanda lost 504 billion Rwandan francs (US$ 820 million) – an equivalent of 11.5% of Rwanda's total GDP – as a result of child stunting[99]. These data highlight the need for research to inform policies and interventions required to address child stunting in Rwanda.

2.4.3 Progress towards achieving national and global nutrition targets

While there has been some progress towards reducing undernutrition among children under 5 years of age in Rwanda over the past two decades, the reduction has not been adequate for Rwanda to achieve national and global nutrition targets. The data in Table 2.1 show that Rwanda is on-track to meet wasting reduction, but more actions are required to accelerate the progress and to achieve the targets for stunting and underweight. According to the 2018–2024 Rwanda's Health Strategic Plan[100], the new target is to reduce the number of stunted children to 19% by 2024. However, with only about 1 percentage point drop yearly between 2000 and 2018 (i.e. from 48.3% to 35%), the current reduction rate for stunting appears to be inadequate to achieve this target.

Table 2-1 Child undernutrition trends and targets in Rwanda, 2000−2018

	DHS 2000	**DHS 2005**	**DHS 2010**	**DHS 2014/15**	**CFSVA 2018**	**Targets [1]**
Stunting (%)	48.3	51.1	44.2	37.9	35	18
Underweight (%)	25	22.5	11.4	9.3	12.6	6
Wasting (%)	7	4	2.8	2.2	2	2
Anaemia (%) [2]	52	51.5	38.1	37	−	−

DHS, Demographic and Health Survey; CFSVA, Comprehensive Food Security and Vulnerability Analysis. Source of data: Institut National de la Statistique (NISR) & ORC Marco [101]; National Institute of Statistics of Rwanda (NISR) [Rwanda] *et al.* [102]; National Institute of Statistics of Rwanda (NISR) [Rwanda] *et al.* [26]; Ministry of Health [Rwanda] [103].

[1] National target set to be achieved between 2010 and 2018.

[2] Anaemia data are not available from the CFSVA. (–) denotes that there no national targets for anaemia.

Also, it has been estimated that currently Rwanda requires an annual average reduction rate of 5.2% to achieve the World Health Assembly global nutrition targets of reducing the prevalence of stunted children to 22% by 2025[15]. Overall, these data highlight the need for further actions to tackle child undernutrition in Rwanda.

2.5 Factors associated with child stunting in Rwanda

Most of the available data on factors associated with child stunting in Rwanda come from national survey data, including the Comprehensive Food Security and Vulnerability Analysis (CFSVA) surveys, and the Demographic and Health Surveys (DHS). Based on data from the DHS, researchers have found that socioeconomic factors, such as household wealth index, food insecurity, and lack of or low maternal education, are strong predictors of child stunting in Rwanda[104, 105]. Child stunting in Rwanda has also been found to be associated with maternal-level factors, such as short stature, low BMI, age (being older than 35 years) and having multiple births; and child-level factors, including age, low birth weight, and being of a male sex[104, 106-108].

Some studies have also examined the relationship between child stunting and access to health care services in Rwanda. These studies have produced inconsistent results. For example, using the 2005 DHS data, Chunling *et al.* [109] found no significant association between stunting among children (age: 6–24 months; sample size not specified) and enrolment in community-based health insurance or *Mutuelles de Santé*[1] (a proxy for access to health care services). Based on the 2010 DHS data (n= 1061), the same researchers found that the odds of stunting significantly reduced by 40% among children (aged 6–24 months) who were enrolled in community health insurance compared with

[1] In Rwanda, *Mutuelles de Santé* is a community-based health insurance scheme which provides health insurance for informal sector. It is subsidized by the government or its development partners to enable poor and vulnerable groups access the minimum service package, including nutrition 110. Antunes A, Saksena P, Elovainio R *et al.* (2009) *Health Financing Systems Review of Rwanda: options for universal coverage*. Geneva: World Health Organization and Ministry of Health, Rwanda.

children who were not enrolled[109]. Other researchers used travel time/distance from household to the nearest health facility as a proxy for access to health care services and examined its relationship with child height-for-age (HAZ). In one study using the 2010 DHS data (n= 931 children under 5 years of age), travel time to health facility was found to be inversely associated with child HAZ[111]; while another study, which was based on the 2014/15 DHS data (n= 1467 children under 2 years of age), found no significant association was observed between the distance (from a household cluster and the nearest health facility) and child HAZ[112]. While access to health care services is important, it is possible that other factors that are more important such as diet, and health practices, which have not been controlled for in all the above studies. The inconsistent results may also be due to the use of the same DHS data sets but different measures of access to health care services (e.g. Aoun *et al.* [111] and Chunling *et al.* [109]) or different DHS data sets and different measures (e.g. Aoun *et al.* [111] and Uwiringiyimana *et al.* [112]). Another limitation of the latter two studies is also the potential of under- or over-estimation of the actual travel time/distance since no one of the studies used real-time data on travel time/distance.

Two studies (one case-control study and a cross-sectional study) also conducted in Rwanda examined the relationship between hygiene and sanitation and the risk of stunting among children under 2 years of age. In the case-control study (n= 2787 children) conducted in nine districts of Rwanda, Lung'aho *et al.* [27] found that, compared to children in households with piped water into their dwellings, the (unadjusted) odds of stunting was significantly higher among children in households that obtained drinking water from other sources such as public tap, ponds, rivers, and streams. In the cross-sectional study which involved 4600 children from Rusizi district, southwest Rwanda, Sinharoy *et al.* [113] found that the risk of stunting was significantly lower among children whose caregivers reported having access to improved source of drinking water,

adequately treating drinking water, and having an improved sanitation facility. While improved water, sanitation and hygiene may protect children from stunting through reduction of infections and exposure to harmful germs[114], the studies by Lung'aho et al. and Sinharoy et al. have some limitations. For example, the association between stunting and the type of drinking water source reported by Lung'aho et al. was based on unadjusted models (bivariate analysis) which do not account for how other factors could have influenced stunting. For instance, it is possible that households with piped water into their dwelling also had access to better income and better complementary foods which could have protected their children from stunting. In addition, while Sinharoy et al. performed a multivariate analysis which adjusted for child's age, maternal education, and household wealth status, these researchers did not adjust for factors such as dietary patterns, child illness, maternal height, etc. that are known to influence child nutritional status and may be associated with sanitation.

A cross-sectional study conducted in Musanze district, Northern province, Rwanda, found that exclusive breast-feeding and use of deworming in the past 6 months were independently associated with child HAZ among children (n= 138) aged 5–30 months[115]. Using cross-sectional data from 1228 children under 5 years, Matsiko [116] also examined sex-specific factors associated with child stunting in Rwanda. They found that feeding cereal-based porridge as the first complementary foods (as opposed to cow's milk) was a significant predictor of stunting among boys, whereas discontinuing breast-feeding before 24 months predicted stunting among girls. However, a longitudinal study (n= 485, age at baseline 6–12 months; three measurements 2–3 months apart) found that, although males had statistically significantly lower HAZ than girls, there was no statistically significant difference in feeding practices by sex[117].

Other factors that have been hypothesized to be contributing to the persistence of stunting among children under 5 years in Rwanda include inappropriate care practices,

such as suboptimal feeding practices. In 2012, the CFSVA survey reported a high prevalence (60%) of stunting among children under 5 years of age in the northern agricultural zone – a region that is considered the breadbasket of Rwanda[118]. The regression analysis in the same survey found that inappropriate feeding practices was among predictors that could explain high stunting in the region. The analysis looked at individual foods consumed by children and found that consumption of cereal porridge and beans was associated with significantly higher prevalence of stunting, whereas consumption of dairy products was associated with significantly lower prevalence of stunting among children aged 12–23 months[118]. It would have been more insightful had the analysis included other measures of dietary adequacy such as dietary diversity.

The hypothesis that inappropriate care practices may be contributing to high child stunting in Rwanda also arises from the observations of high prevalence of stunting even among children in well-off households with better access to foods. For example, the 2015 DHS found that 21% of stunted children were from households in the highest wealth quintile[26]. The 2018 CFSVA survey reported 25% stunting prevalence among children from food secure households, compared with 48% and 62% in moderately and marginally food insecure households, respectively[14]. The same survey report suggested that, besides food insecurity, other household-level factors such as inadequate child feeding practices, may be contributing to stunting. The aforementioned cross-sectional study conducted by Lung'aho *et al.* [27] also reported 41% stunting prevalence among children from households in the highest wealth quintile, compared with 50% in the lowest wealth quintile. The same authors also found that in households with access to public taps (considered as improved drinking water source), children were 3 times more likely to be stunted, compared to children in households with piped water. Although their analysis has some limitations, as highlighted earlier, the authors speculated that these

results could be due to inadequate hygiene practices, such as improper water handling and storage, and poor hand washing practices[27].

Care practices range from child feeding practices, hygiene and home health practices to caregiver's responses that support a safe, healthy, and stimulating environment for a growing child[24]. Care practices have been recognized as one of the underlying determinants of child nutritional status, along with food security and health care[24, 45]. According to Engle[23], good care practices translate food security and health care resources into child's wellbeing, growth and development. According to den Hartog *et al.* [119], much of the variation in nutritional status of children from different households living in the same environment can be attributed to differences in caregivers' practices and behaviours within these households. This is because caregivers' practices related to what, when, and how to feed their children influence child's dietary intake[73]. In addition, caregivers are the first responders to child illness, so their perception of the severity of child illness and their promptness to seek appropriate treatment will influence the health status of the child[120]. Studies have shown that in countries where poverty is high and food availability is unstable, positive care practices can soften the deterioration in child nutritional status caused by poverty and food insecurity[59, 121].

Using Rwanda's 2015 DHS data, the 2017 Global Nutrition Report indicates that Rwanda has the highest rates of exclusive breast-feeding (87%) in the world[13]. However, some studies conducted in rural areas of Rwanda found that approximately half of infants aged 0–5 months are not exclusive breastfed[115, 116]. The cause of apparent discrepancy could be very high exclusive breast-feeding in some parts of the country and lower in others, or it could be due to methodological differences. In addition, even if exclusive breast-feeding is relatively high, child feeding practices during the complementary feeding period, i.e. from 6–23 months, are inadequate. **Table 2.2** shows data on some of the indicators which are often used to assess infant and young child feeding (IYCF)

practices. The data show that, in 2018, only 34% of children 6–23 months met the recommended minimum meal frequency, 40% met the recommended minimum dietary diversity, and only 17% of children met the minimum acceptable diet (i.e. meeting both the recommended minimum dietary diversity and minimum meal frequency). Further, the data show that the number of children meeting the minimum acceptable diet has not changed between 2010 and 2018, indicating lack of improvement in the overall IYCF practices.

Table 2-2 Percent of Rwandan children 6–23 months achieving the WHO recommended infant and young child feeding practices

Infant and young child feeding practices	2010	2015	2018
Children 0–5 months			
Exclusive breast-feeding	84.7	87.3	82.5
Children 6−23 months			
Child achieves minimum meal frequency	50.8	47.3	34.2
Child receives minimum 2 milk feedings / day (non-breastfed)	24.4	34.8	–
Child achieves minimum dietary diversity	25.8	30.1	39.9
Achieves minimum acceptable diet	16.8	18.6	17.0

For breastfed children, minimum meal frequency is 2 times children aged 6–8 months and 3 times for those aged 9–23 months. For non-breastfed children, minimum meal frequency is 4 times per day. Minimum dietary diversity means consuming at least 4 food groups. Minimum acceptable diet combines both minimum dietary diversity and minimum meal frequency. Non-breastfed children must receive at least 2 milk feedings per day to have a minimum acceptable diet (in addition to having a minimum meal frequency and dietary diversity)[122].

(−) indicator not reported.

Source: National Institute of Statistics of Rwanda [14]; National Institute of Statistics of Rwanda (NISR) [Rwanda] *et al.* [26]; National Institute of Statistics of Rwanda (NISR) [Rwanda] *et al.* [102]

Although research is limited on the factors that may be contributing to the lack of improvements in IYCF practices in Rwanda, there is some evidence suggesting that mothers have limited understanding of appropriate IYCF practices during the complementary feeding period. For example, a qualitative study (n= 28) conducted in Nyanza district, southern province of Rwanda, researchers found that cooking oil was withheld from young children's foods because of the concerns among mothers about

possible negative effects on cardiovascular health of children[123]. A nationwide study on Knowledge, Attitudes and Practices among caregivers (n= 2000; child age: 0–6 years) reported that 36% of the caregivers fed their children once or twice a day, partly because caregivers applied adults' eating schedules to young children[124]. Research is needed to identify factors that may be contributing to current child feeding practices in Rwanda.

The aforementioned national surveys have reported estimates and proportions of children who (don't) meet the recommended indicators of feeding practices; however, these surveys provide limited insights into "how" children are fed and "what" influence their mothers/caregivers feeding practices. Studies conducted in Nigeria, Africa, found that mothers were concerned that an earlier (between 6−12 months) introduction of some solid foods (e.g. pounded yam) could result in the child becoming "heavy", which mothers considered as an unhealthy state (i.e. a heavy child is "heavy to pick up", "sick" or "inactive"[125]. In Guatemala, Izurieta & Larson-Brown[126] reported that calorie- and protein-rich foods such as meat and whole beans were regarded as adult foods and were given only if the child asked or if mothers deemed it necessary. In their review of 18 ethnographic studies on complementary feeding, Pelto *et al.*[127] describes how factors such as parental beliefs and expectations, sociocultural determinants influence the type and amount of foods given to children. Such information is needed for Rwanda as it can contribute to our understanding of why children in Rwanda are not achieving the recommended indicators, which can inform the design of targeted interventions.

The Rwandan Food and Nutrition Policy states that suboptimal feeding patterns observed in Rwanda may be due to household food insecurity, but poor feeding and care practices are also at play; and that poor feeding practices may explain the high rates of child stunting[98]. This raises questions which this thesis seeks to explore: "Do mothers with non-stunted children care for their children differently than those with stunted children?" And if yes, "what are the care practices that can distinguish between mothers

with non-stunted and those with stunted children?" or "how significant is the influence of care practices given other factors?"

2.6 An overview of the study area and research methodology

2.6.1 A brief description of the study area

The research reported in this thesis was conducted in Rutsiro district, one of the 7 districts of the western province of Rwanda (**Figure 2-2,** L). Rutsiro district is one of the most remote districts, located 140 km from the Kigali capital. Data shows that access to infrastructure such as electricity, roads and markets is limited. For example, only one-fourth (20.7%) of households in Rutsiro district use electricity as the main source of lighting; whereas eighty-two percent of the households have access to an improved water source[128]. However, compared with the 2012 data (< 1% and 60% access to electricity and improved water source, respectively)[129], these figures represent a significant improvement. While the national average travel time to access a health facility is about 60 minutes, the average travel times to the nearest health facility in Rutsiro district is more than 90 minutes. In villages without markets in this district, the average travel time to the nearest market is 145 minutes (compared to 86 minutes national average)[14].

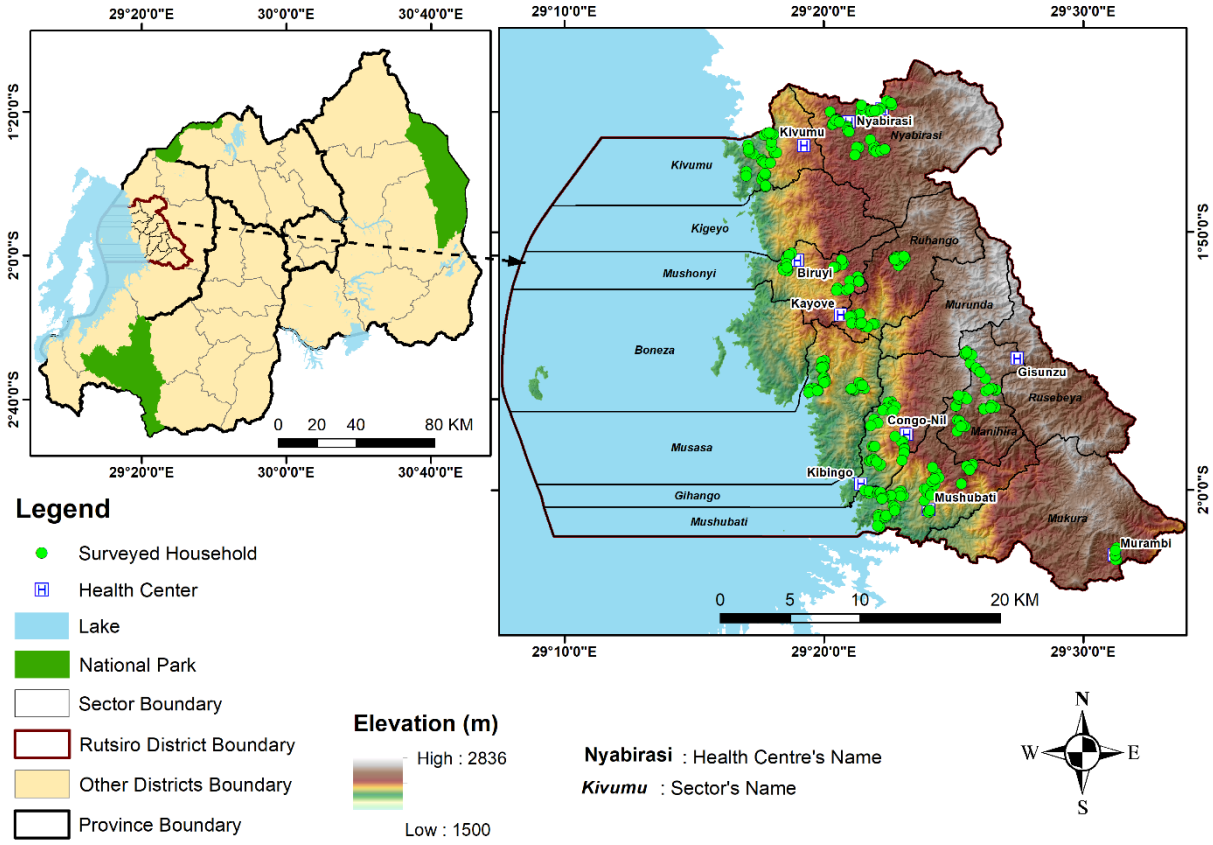

Figure 2-2 Map of Rwanda (L) and Rutsiro district (R) indicating surveyed households (green circles).

According to the most recent Integrated Household Living Conditions survey, 51% of the Rutsiro district residents were considered poor in 2015 (i.e. they were unable to afford to buy a basic basket of food and non-food essentials), whereas 24% were classified as extremely poor (i.e. their total consumption for food and non-food was below the food poverty line)[87]. Moreover, Rutsiro district is disproportionately affected by food insecurity. In 2018, 62% (compared to 18.7% national average) of the households in Rutsiro had inadequate food consumption, that is, they had limited or no access to the minimum food needs and had high (65–75%) or very high (>75%) food costs as share of household expenditure. Rutsiro district has the highest prevalence of stunting, and recently it has increased from 46% in 2015 to 54% in 2018[14].

2.6.2 Research methodology

To achieve the objectives of this thesis, a mixed-methods approach was used. Mixed-methods approach is characterized by integrating different research methods/data/analyses in order to maximize their contributions to the achievement of research objectives[130, 131]. In this thesis, qualitative and quantitative methods were applied in sequence. In the first phase, qualitative methods were used to collect and analyse qualitative data from a purposive sample of mothers recruited from one sector – Gihango (**Figure 2-2**). Qualitative findings informed the development of a household survey questionnaire, which was used in the second phase to collect (quantitative and qualitative) data from a large and random sample of mothers recruited across nine sectors of the district (**Figure 2-2**).

The first phase was descriptive and exploratory, which aimed to gain in-depth understanding of the factors influencing infant and child feeding practices in the study area. In-depth interviews were conducted with a sample (n= 24) of mothers of children aged 6–24 months. Interviews were conducted in Kinyarwanda at the participants' homes. They were audio-recorded, transcribed verbatim, and translated in English. Thematic analysis[132] was employed to identify, analyse, and report patterns and themes within the data. The analysis was guided by a biocultural model[133]. The biocultural model recognizes the influence of physical, socio-economic, and cultural environments on child feeding. The details of the qualitative methods applied and results from the first phase are reported in Chapter 3.

The themes identified through qualitative analysis in the first phase informed the development of a survey questionnaire, which was used to collect data in the second phase. This means that, during the questionnaire development, questions were formulated to expand on topics that mothers introduced during the first phase, including breastfeeding practices (i.e. the age at which mothers introduced complementary foods

to their children), food restriction when children suffered from diarrhoea, and the use of multiple micronutrients powders (MNP) during complementary feeding.

In the second phase, a structured survey questionnaire (**Appendix 14**) was used to collect quantitative data from a random sample of 400 mother-child pairs. In this phase, quantitative data were collected on infant and child feeding practices and on health practices. The quantitative data collected also included anthropometric and demographic data at child- and maternal-level, as well as data on household food security, location, and socio-economic status. Concurrently, qualitative data were collected from a sub-sample (n= 234 mothers) on the use of MNP during complementary feeding. The survey questionnaire included an open-ended question which allowed collection of qualitative data on the use of MNP. The open-ended question (and probes to obtain additional information) was directed to mothers who had not used MNP in the previous 7 days and those who never used MNP. Different methods of analysis were applied to the data collected in the second phase. Quantitative methods (i.e. descriptive statistics and multiple linear regression analysis) were used to explore the research questions and to address the second and third objectives of this thesis. The details of the quantitative methods and the results are reported in Chapter 4. Further, a combination of qualitative methods (i.e. content analysis) and quantitative methods (i.e. logistic regression) was used to analyse both qualitative and quantitative data from the second phase in order to explore the factors that influence access to and use of multiple micronutrient powders. The details of these methods and the results are reported in Chapter 5.

The details for research methodology for this thesis is illustrated in **Figure 2-3.**

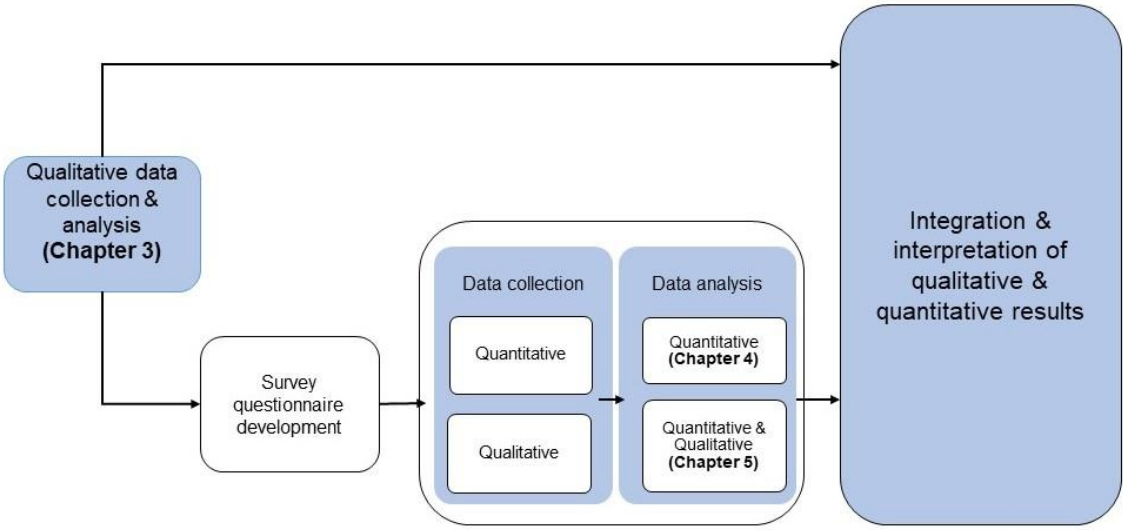

Figure 2-3 Mixed methods approach used for this thesis

Chapter 3 A qualitative analysis of infant and young child feeding practices in rural Rwanda

Data show that infant and young child feeding (IYCF) practices in Rwanda are less than optimal. The qualitative study presented in this chapter aimed to gain an understanding of IYCF practices and factors influencing them. The chapter is based on Paper I, entitled "A qualitative analysis of infant and young child feeding practices in rural Rwanda"; which has been published in the journal of *Public Health Nutrition*.

This chapter is not an exact replication of the published version. It has been formatted according to the Massey University guidelines, and minor changes, including references to appropriate appendix have been included in the thesis.

This chapter is been published as:

Dusingizimana, T., Weber, J., Ramilan, T., Iversen, P., & Brough, L. (2020). A qualitative analysis of infant and young child feeding practices in rural Rwanda. Public Health Nutrition, 1-10. doi:10.1017/S1368980020001081

3.1 Abstract

Evidence shows that inappropriate infant and child feeding (IYCF) practices contribute to poor child growth in low-and middle-income countries. Data from national surveys in Rwanda show that IYCF practices are less than optimal. It is important to understand the contributing factors and to identify gaps that need to be addressed. This study aimed to explore and gain an in-depth understanding of the factors influencing child feeding practices among rural caregivers in Rwanda. In-depth semi-structured qualitative interviews were conducted with a purposive sample of mothers (n= 24 age 24–42 years) with children aged 6−23 months from Rutsiro district, western province, Rwanda. Interviews were audio-recorded, transcribed verbatim and coded. Data were analysed inductively using thematic analysis. We identified five key themes: (i) breast-feeding practices and role in food supply; (ii) family vs. children's food preparations; (iii) food classification systems and their influence on child feeding decisions; (iv) child feeding during diarrhoeal episodes; and (v) influence of poverty on child feeding practices and childcare. Mothers' infant and young child feeding decisions are informed by both information from health workers and from traditional/own knowledge. Navigating through this information sometimes creates conflicts which results in less than optimal child feeding. A nutrition educational approach that is cognisant of maternal perceptions should be employed to improve child feeding practices. Efforts to improve child feeding practices must be complemented by programmes that enhance household economic opportunities and access to foods.

Key words – child feeding, perceptions, undernutrition, qualitative analysis, Rutsiro, Rwanda.

3.2 Introduction

Undernutrition among children under 5 years of age remains a global public health concern. Globally, 150.8 million (22.2%) of children under 5 years of age are stunted (i.e. low height-for-age)[1], a marker of chronic undernutrition. Chronic undernutrition in childhood increases risk of morbidity and mortality, impaired growth and cognitive development, poor school performance, reduced economic potential as well as the risk of chronic illness in adulthood. It has been estimated that undernutrition is associated with 45% of deaths among children under five[2], and more than 90% of these deaths occur in sub-Saharan Africa and South Asian countries.

Rwanda has significantly improved maternal and child health. The maternal mortality ratio fell from 1071 per 100 000 live births in 2000 to 210 per 100 000 live births in 2015 [3]. Under-five child mortality fell from 152 per 1000 live births in 2005 to 50 per 1000 live births in 2015. However, child undernutrition remains a serious public health concern in Rwanda. The most recent data from Rwanda estimated that, 35% of children under 5 years of age are stunted[4]. Although the prevalence of undernutrition among Rwandan children under 5 years has declined over the past two decades from 48% in 2000 [5] to 35% in 2018[4], the rate of reduction has not been enough to achieve the national targets of reducing stunting prevalence from 44% (2012) to 18% (2018)[6]. This calls for more efforts to reach the national nutrition targets.

Evidence suggests that undernutrition in low- and middle-income countries, particularly in Africa and Asia, is linked to poor infant and young child feeding (IYCF) practices[7, 8]. To improve child nutrition, the WHO recommends exclusive breast-feeding for the first 6 months, after which age appropriate, safe, nutritionally adequate, and responsive complementary feeding should commence[9, 10]. In Rwanda, the prevalence of exclusive breast-feeding for the first 6 months is high (87%)[3], but complementary feeding at 6-23 months remains sub-optimal. The national reports show that the number of children 6-

23 months old who meet the recommended minimum acceptable diet in terms of sufficient diversity and frequency of feeding has remained the same between 2010 and 2018 (17%)[3, 4]. This suggests gaps in optimal IYCF practices. Although poverty and food insecurity are often considered the main determinants of undernutrition [4], studies in Rwanda[11], and elsewhere[12] have reported high rates of child stunting even in the richest households. The authors suggested that cultural factors, inadequate knowledge and feeding behaviours could be limiting children from getting adequate diets[12].

Past studies on the risk factors underlying child undernutrition in Rwanda have mainly focused on socioeconomic and demographic factors[13-16]. Other studies[17-19] examined the influence of access to health care on child stunting. These studies have used quantitative approaches that do not provide detailed information on IYCF practices from a local sociocultural context. While qualitative research on IYCF practices in Rwanda is limited, studies in other countries show that a qualitative approach can provide valuable insights on the drivers of IYCF practices which can help inform the development of more culturally relevant interventions[20, 21]. A qualitative study conducted in one Rwandan district to explore the drivers of caregivers' food choices, found that local perceptions about certain foods limited mothers from feeding children locally available foods[22]. However, participants in that study were from urban and peri-urban populations whose feeding practices may not reflect the practices in rural areas where the majority of undernourished children live. The present study was thus designed to contribute to the limited information on IYCF practices in rural Rwanda. The primary objective of this study was to explore and gain in depth of understanding of the factors influencing IYCF feeding practices in rural Rwanda from mothers' perspectives.

3.3 Methods

Setting

This study was conducted in Rutsiro District, Northwest of Rwanda; approximately 140 km from Rwandan capital city, Kigali. The Rutsiro district is one of Rwanda's rural districts

with the highest prevalence of child stunting (54%) among children under 5 years[4]. The district population is largely rural (~98%) and subsistence farming and traditional rearing of animals are the primary livelihood activities[23]. The main subsistence crops are maize, beans, banana plantain, cassava, sweet and Irish potatoes. Data from national statistics show that 51.4% of the district population are poor and 24% live in extreme poverty (i.e. the poorest)[24]. Administratively, Rutsiro district is divided into 13 sectors. Each sector is divided into cells and each cell is divided into villages (a village is the lowest administrative unit in Rwanda). This study was conducted in Gihango sector from December 2017 to January 2018. Gihango sector was selected based on the study objectives. Although the sector was deemed to have a relatively good crop diversity compared to other sectors, it was the sector with the second highest number of children under 5 years of age with acute malnutrition (at the time the study was conducted). Additionally, the sector was accessible to the researcher.

Study design

This study was intended to be descriptive and exploratory. A descriptive qualitative methodology was used to explore IYCF practices among mothers. The study was conceptualized within the context of high prevalence of child undernutrition and inadequate IYCF practices among children 6–24 months in Rwanda. The study design draws from a biocultural model[25], which focuses on physical, socioeconomic and cultural environments that influence child feeding.

Participant selection and sample size

The selection of participants was designed to capture information-rich cases in order to obtain in-depth understanding of IYCF practices[26]. A purposive sample of 24 mothers with children 6–24 months old were identified in 4 villages using lists of eligible mothers compiled from growth monitoring records with the assistance of the village community health workers (CHWs). Mothers were eligible if: 1) they had a child aged 6–24 months

old; 2) had lived in the area for at least 6 months; 3) their child was apparently healthy; and 4) the mother was in the first or second lowest socio-economic group as per the Rwandan government classification. Approximately half of the eligible mothers from each list were selected. As we aimed for diverse perspectives on IYCF practices, attempts were made to include young and older mothers with children at different age stages. The interviewer approached the mothers to explain the aim of the study, confirm eligibility and invite her to participate in the study. Two mothers were not at home; all mothers spoken to agreed to participate. Recruitment ceased when data saturation had been reached, i.e. no new information was generated[27].

Data collection

Data were collected through in-depth interviews using a semi-structured interview guide (**Appendix 13**). The guide consisted of a set of open and closed questions, and the major topics covered were: (i) child feeding practices, including breast-feeding, complementary feeding and type of foods given/not given to young children and reasons for these choices, (ii) challenges related to child feeding, (iii) health practices, and (iv) childcare arrangements. To ensure clarity of the questions, community health workers from the study settings and a Rwandan nutritionist were consulted during the development of the interview guide. The interview guide was first developed in English, translated into Kinyarwanda (the local language) and then back translated into English by a Rwandan nutritionist. The final Kinyarwanda version was refined after back translation to maintain the original English meaning. Prior to data collection, the interview guide was pre-tested with six women from another community, and adjustments were made accordingly. Interviews were conducted by the first author, who is fluent in Kinyarwanda, and had prior experience in qualitative research methods and data collection in rural Rwanda. Interviews were conducted in the participants' homes. To ensure confidentiality, the data were anonymized by assigning an identification number to each record, transcript and field notes. Each interview lasted 30−60 minutes and was

audio-recorded. During the interview, specific questions or probes were asked to the mothers to seek further clarifications if necessary[28]. Field notes were also taken and later used for data triangulation. The notes also provided a means to clarify the interviewer's thoughts, which helped to minimize the bias during data analysis[29]. The authors held online meetings throughout the data collection to review preliminary findings. These meetings allowed us to review questions at the time of data collection and to develop new aspects of the questions[30].

This study received ethical approval from the Massey University Human Ethics Committee (reference: SOA 17/67) and the Institutional Review Board of the University of Rwanda's College of Medicine and Health Sciences (reference: 003/CMHS IRB/2017). A permission to collect data was also obtained from the Rutsiro District Public Health Office. This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving human subjects were approved by the Massey University Human Ethics Committee and the Institutional Review Board of the University of Rwanda's College of Medicine and Health Sciences. Written informed consent was obtained from all participants. Each participant received US $10 to compensate for their time.

3.4 Data analysis

The recorded interviews were transcribed verbatim in Kinyarwanda, and then translated into English. Transcripts were checked against the interview records and triangulated with field notes taken during each interview. The data were manually coded by the first author (TD). Analysis was performed inductively following the steps outlined by Braun & Clarke[31] for thematic analysis. Briefly, the first author read all the transcripts multiple times to familiarize himself with the data. An initial list of descriptive codes and relevant quotes pertaining each code were generated from a sub-sample of transcripts (*n* 5). The codes were then reviewed and discussed by the three authors (TD, LB, JW). Final codes

were agreed upon, which were applied to all subsequent transcripts. New codes that emerged from the subsequent transcripts were integrated into the final list of codes. Final codes were reviewed again, organized in a table, grouped into categories and then into themes using a pattern and focused coding method[32]. Quantitative data including demographic characteristics were analysed using Microsoft Excel. In presenting the data, relevant verbatim quotes were used to aid data interpretation. Methods and findings are reported as per the consolidated criteria for reporting qualitative research (COREQ) checklist (Supplemental Table – **Appendix 1**)[33].

3.5 Results

Participants and sample characteristics

Mean age of our study respondents was 30 years (range 24−42) (**Table 3.1**). Mean age of children was 16 months (range 6−22). Eighty-three percent (*n* 20) were married. The median household size was 5 (range 3−9); about a half (*n* 10) had two or three children under 5 years old. Self-reported child illnesses in the previous two weeks included diarrhoea (50%), fever (33%), and other illness (58%) (e.g. respiratory infections, eye and skin infections). All children had received all vaccines appropriate for their age.

Table 3-1 Characteristics of mothers and children (*n* 24) interviewed in the present qualitative study on infants and young child feeding practices in Gihango sector, Rutsiro District, Rwanda, December 2017–January 2018

Characteristics	Mean	SD	Frequency	%
Child's age (months)	16.1	4.7		
Mother's age (years)	30.5	5.0		
Household size	4.8	1.6		
Child's age group				
6−11 months			6	25
12−17 months			8	33
18−22 months			10	42
Child's sex				
Female			15	63
Males			9	37
Child's illness in the past 2 weeks				
Diarrhoea			12	50
Fever			8	33
Other illnesses			14	58

Characteristics	Mean	SD	Frequency	%
Mother's age group (years)				
≤ 25			3	12
26−30			6	25
31−34			6	25
≥ 35			9	37
Number of children (parity)				
1 child			7	29
2−3 children			11	46
4−5 children			6	25
Marital status				
Married			20	83
Unmarried			4	17
Mother's education				
None			3	13
Some primary			20	83
Some secondary			1	4
Health seeking practices				
Possession of community-based health insurance			20	83
Child fully immunized			24	100
Child taken to growth monitoring (last month)			18	75

Breast-feeding practices and role in the food supply

Nearly all mothers reported that they exclusively breastfed for the first 6 months. Only two mothers reported giving their children foods before 6 months, but they pointed out that giving child foods before 6 months was contrary to the recommendations. Our data indicate that mothers knew the recommended age for introduction of complementary foods. Breast-feeding is regarded as a child's rights, a sign of love, and a way to improve mother-child emotional bond, in addition to source of nutrition/goodness.

Prolonged breast-feeding is also a strategy to deal with anxiety experienced by some mothers who have insufficient food to feed their children. One mother with five children explained her choice to reserve food for the older non-breastfed child because the youngest child had a back-up option – the breast milk.

> 'If possible, she will breastfeed until 4 years. You cannot refuse to breastfeed a child. Breastmilk has something that is beneficial for child. And for us who are

poor, even if you don't have foods but breastfeed your child, the child feels that you are closer, which creates and maintain good relationship between you and your child.' **Participant 12, 38 years, child 11 months.**

'She [youngest child] eats when there is enough food. Because, as a mother, you tell yourself, at least she will get something from her mother's breasts. So, the little food that is there is reserved for her older sibling.' **Participant 11, 35 years, child 14 months.**

Most mothers mentioned that their children started receiving foods or fluids other than breastmilk between 6−7 months. The first and most common complementary food reported by all mothers was thin porridge. Sorghum flour is most commonly used to make the porridge. Mothers desired to give their children a more nutritious porridge made from a commercial mixed-grain cereal flour (locally known as SOSOMA) and they knew ingredients such as soya flour and milk could be used to prepare a nutritious porridge for their children. However, many mothers said that SOSOMA and most of these ingredients were not affordable. At around 8 months, children start to receive modified family foods. Fruits, biscuits and Irish potatoes are the foods that are procured specifically for young children.

Family vs. children's food preparations

We engaged mothers in discussion about how they prepared foods for their family and children. Mothers first described how they prepared family meals, and then how these foods were fed to young children. The narratives indicate that a typical family meal usually contains two major components: (i) a staple/starchy component (e.g. cassava, sweet potatoes, and taro) and (ii) a legume (often beans) and/or vegetables. The two components are usually boiled in one pot in a mixed dish – locally known as *"imvange."* When cooked separately, the starchy component is often served with a stew/sauce made

from vegetables and/or beans. Sometimes, groundnut powder is added to flavour the stew/sauce. Mothers with economic means buy small dried fish (*indagara*), soya flour and cooking oil to add to the stew/sauce. The narratives suggest that, regardless of whether the two components were cooked together or separately, the starchy component is viewed as adult foods, and may not be given to young children below 2 years because it is considered too "hard" for them. Instead, children are given vegetables (except cabbage), porridge, beans, sauces or stews. If the starchy component was ever fed to the child, the child would be given a trivial amount. Irish potatoes are an exception because they can be easily mashed into soft foods.

> 'When I have cooked cassava and beans in a mixed dish for us adults, I also have to look for vegetables. I cook them together, and then I mash these vegetables and beans to feed her. Normally a child like this should eat soft foods. If there are no beans, we add [to the family pot] some vegetables for her.' **Participant 5, 42 years, child 21 months.**

> 'When we [adults] eat sweet potatoes, he [child] eats vegetables and tops up with porridge. **Participant 8, 39 years, child 17 months.**

Mothers are encouraged by health professionals to have a side pot (locally known as *agakono k'umwana*) for young children[34]. We asked mothers about this practice. Our data suggest that the practice is not a common practice. Rather, the preparation of children's foods in a side pot is used as a compensatory mechanism when the child was sick or has lost weight.

> 'I usually prepare her food in a side pot when she isn't in a good health. When she is well, I cook all the food in one [family] pot. I know she is not well when I take her to the growth monitoring site and they tell me that she lost weight' **Participant 18, 32 years, child 19 months.**

Food classification systems and their influence on child feeding decisions

Mothers had two distinct food classification systems that influence their feeding decisions. In the first classification system, mothers classified foods into three broad categories based on what nutrients the foods bring to the body. In their narratives, over three quarters of the mothers use the "balanced diet" concept to refer to a meal that contains the three categories of foods: "*body building foods*", "*energy foods*" and "*disease protective foods*." Some mothers said that a balanced diet provides vitamins, while others gave reasons why it was important to feed their children a balanced diet: "so that a child gets all nutrients."

> 'Well, they teach us that a child should be given body building foods, disease protective foods and energy foods. Vegetables are disease protective; Irish potatoes are among the starchy foods and I know that milk is also good for a child. Banana is also important.' **Participant 3, 24 years, child 18 months.**

In the second classification system, mothers classified foods into three categories, namely *hard, soft,* and *oily/fatty foods* primarily based on physical characteristics. Foods such as cassava, sweet potatoes, maize grains, banana plantain and taro, are referred to as *hard foods* and, therefore not suitable for children below 2 years of age. Mothers also described *soft foods* as foods with a soft or watery consistency such as thin porridge or vegetables (except cabbage), cassava leaves, sauces and stews. Other foods were referred to as *oily foods* because they are regarded as containing oil. Examples of *oily foods* included cow's milk, avocado, vegetable cooking oil, and two flours – groundnut flour and soya flour – that might seem at first to be surprising candidates for inclusion in the oily food category.

In their narratives, mothers made statements which suggested conflicts between the two classification systems.

‘Sweet potatoes and taro are things you can’t give your child. In my opinion, sweet potatoes and taro are foods that provide energy for adults. But children can get that energy from vegetables and some other supplementary foods. Those other foods [sweet potatoes/taro] are for adults.’ **Participant 6, 28 years, child 18 months**

‘Hard foods are like cassava and sweet potatoes. Would you say that your child has eaten when you have fed him/her sweet potato? No, it does not contain any nutrients. Perhaps if you have peeled it, added some vegetables… that is when you can say: I have fed my child a balanced meal.’ **Participant 2, 33 years, child 7 months.**

‘A child is not eating well…, that means feeding her unbalanced diet. Like giving her those energy foods while she is still young and yet those kinds of foods provide her with nothing that can help her body.’ **Participant 10, 32 years, child 15 months**

Contrary to the *hard foods*, mothers had a strong preference for feeding *soft foods* and they considered these foods as the most suitable for young children.

‘She [child] cannot eat cassava. This one needs soft foods. It is because she does not have teeth to chew cassava.’ **Participant 1, 35 years, child 13 months.**

‘When we are lucky and manage to get sweet potatoes, because it is a hard food and she cannot eat it, she just breastfeeds, or we give her some vegetables.’ **Participant 4, 25 years, child 16 months.**

A few mothers said that preparing *hard foods* in a different way would allow the child to eat these foods.

> ‘Cassava…? Yes, it is also possible. You can chop them, add some vegetables, but then you need to make the food very soft. What is bad is cooking them in a mixed dish like we usually do, and just feed the child like that. When they [cassava] are soft, I think there is no problem.’ **Participant 2, 33 years, child 7 months.**

While soft foods are considered the most suitable for young children, these foods have a watery consistency that, according to some mothers, makes them unsuitable to mix with the micronutrients sprinkles which mothers receive through the home fortification programme. Some mothers felt it was against the recommendations if they added micronutrients sprinkles (*Ongera*) to the soups and stews that they usually feed their children.

> ‘There are even something called *Ongera* that they give us. We add it to foods that are not hot. But we don’t add it to those soft foods like soups. They told us that we must not mix *Ongera* with soft foods.’ **Participant 3, 24 years, child 18 months.**

Child feeding during diarrhoeal episodes

> ‘If you take your child to health centre every time she/he has diarrhoea, then you will spend your whole life at the health centre.’ **Participant 11, 35 years, child 14 months.**

This statement illustrates how frequently children from the study area are experiencing diarrhoea. Some mothers mentioned that diarrhoea lasted several days up to a week. There was a common belief among participants that eating sweet potatoes causes worms – a term which is also used to denote diarrhoea. Other mothers attributed diarrhoea to child developmental stages such as child learning to walk, stand alone or teething. While *soft* and *oily foods* are the most preferred food for young children, many

mothers avoid these foods when their children have diarrhoea because of the perceptions that these foods loosen stools and worsen diarrhoea.

> ‘When she has diarrhoea, I don’t give foods with a lot of soup… Foods mixed with groundnut or soya flour. I can’t even give her milk. It is because those foods contain a lot of oil. Those foods loosen stools and increase diarrhoea. Diarrhoea is not oil friendly.’ **Participant 21, 30 years, child 10 months**

> ‘Normally sweet potatoes cause worms (diarrhoea). Even us adults, when you eat them two times, the worms get activated. So, if you keep feeding your child sweet potatoes, the child will end up malnourished.’ **Participant 8, 39 years, child 17 months.**

> ‘They [community health workers] warned me saying that sweet potatoes cause “*bwaki”* (malnutrition).’ **Participant 18, 32 years, child 19 months.**

Instead, some mothers feed their children thick foods in attempt to stop diarrhoea.

> ‘When a child has diarrhoea, I just stop those soft foods that I usually give him. I stop them and give him thick foods. I try to cook for him *Mazizi* and *Kamara* [green banana varieties]. When I do that, diarrhoea stops. I don’t know how this works, but I guess they [green banana] are not quick to get out of the body.’ **Participant 11, 35 years, child 14 months.**

Influence of poverty on child feeding practices and childcare

Poverty and lack of employment opportunities were mentioned by many of the mothers as the main challenges facing the mothers in their feeding practices. Most mothers highlighted that these challenges translated into lack of nutritious foods and fewer meals for their children. Less than a half of the mothers mentioned that they could afford 3 meals a day while others mentioned providing 1 or 2 meals a day.

> ‘Honestly I can’t lie; many times they [children] spend the whole day without eating. I wake up in the morning and then go work for food. So, they eat when I am back in the evening.’ **Participant 18, 32 years, child 19 months.**

The narratives indicate that, poverty not only limits mothers’ access to foods, but it also has an impact on other aspects of childcare. For example, some mothers mentioned that chances to get a farm employment are limited for a breast-feeding mother. Thus, to increase chance to get a job, some mothers leave their children under the care of young siblings; though they doubted their caregiving capacity.

> ‘When you find a job at the road construction site, you just leave the child with her older siblings. But when you are back, you may find that they [older siblings] have eaten the food you left for the child. And you get back feeling tired and not even being able to take care for the child.’ **Participant 10, 32 years, child 14 months.**

3.6 Discussion

In many cultures, child feeding decisions are taken by mothers[35], and most of these decisions result from complex interactions between many factors, including mothers’ cultural beliefs and perceptions, resources and support available to the mothers as well as child health status and characteristics [36, 37]. Understanding these factors in a local context is a key step towards improving complementary feeding practices [20].

Our results show that mothers have a good understanding of and positive attitude towards exclusive breast-feeding for the first 6 months. Mothers also believed that a child should be breastfed together with complementary feeding for as long as possible. The prevalence of exclusive breast-feeding up to 6 months is high in Rwanda (87%)[3]. The benefits of breast-feeding on maternal and child health outcomes are well documented[38, 39]. Thus, the positive attitudes of mothers about exclusive breast-feeding presents an

opportunity to promote and sustain child breast-feeding in Rutsiro District. However, further investigation is warranted to assess if the positive attitude towards breast-feeding results from lack of adequate food resources.

In this study, we found that mothers have two systems of food classification which influence their feeding decisions. The first classification system, by which mothers classify foods into 3 categories: “energy foods”, “body building foods” and “disease protective foods”, is widely used by health professionals in Rwanda[40] to teach caregivers child feeding. This suggests that mothers had been exposed to and learned nutrition messages. The second classification system reflected mothers’ perceptions about the ability of young children to eat the foods or the perceived effects of the food on children’s health especially in the presence of diarrhoea. This finding is supported by earlier studies[41-43] showing that caregivers in different contexts and cultures classify food differently, and that child feeding is conceptualized around caregivers’ food classification systems[43].

In relation to child feeding, our data indicate a disconnect between the two classification systems used by mothers. While mothers frequently used the concept of “balanced diet” to suggest diet diversity, conflicting beliefs were identified. For example, some mothers viewed starchy staples (classified under energy foods category) as adult foods, while others doubted whether these staples have nutrients that are beneficial for young children. We found that child feeding decisions are largely influenced by the mothers’ traditional/own knowledge about foods and their suitability to young children. These findings suggest that young children may be deprived or given insufficient amount of staple foods such as cassava, sweet potatoes, green banana, and hence limiting children’s dietary diversity and energy intake. It is logical if mothers do not provide children with foods that they perceive to be harmful. However, where these decisions are

based on misperceptions it calls for an improved effort to address alternative beliefs held by mothers.

While studies on maternal perceptions and beliefs around IYCF practices are limited in Rwanda, studies from other African countries have documented maternal and cultural perceptions that limited children from consuming locally available foods. For example, in Ethiopia, it was found that vegetables and meat or other animal source foods were not given to young children due to the perceptions that they are difficult to digest and cause stomach illness[44]. Paul *et al.*[45] also found that, in Tanzania, children were not given fish because of the perceptions by mothers that fish cause tooth decay. In the present study, a few mothers felt that changes in how cassava or sweet potatoes are traditionally prepared could allow children eat these staples. Possibly these mothers fed children with these foods. In a previous study conducted in Nyanza district, South province of Rwanda, Lee *et al.*[22] found that, although their study households (*n* 28, child age range: 10−47 months) had purchased and eaten sweet potato several times in the past 7 days, sweet potato was completely absent from the 24 hour recall of their children's diet. Thus, if mothers are to maximize the diets of their children using foods that are within their reach, nutrition educators should work with mothers to identify acceptable methods of food preparations that can be used to prepare staple foods in a way that is appropriate for young children.

We also explored mothers' feeding practices during diarrhoea. Research shows that mothers adopt different care practices due to beliefs about children's illness, with implications on child's nutrition[37]. In the present study, we found that mothers have a strong preference for soft/thin foods in the absence of diarrhoea, because of the perceptions that young children up to 2 years cannot eat hard foods. In the presence of diarrhoea, mothers avoid soft foods because of perceived adverse effects of these foods on child diarrhoea. In the context of the study setting where diarrhoea may be common

in children, avoidance of foods during diarrhoea is likely to reduce children's food intake[46, 47], and to precipitate nutritional deficiencies[48, 49]. Interestingly, some mothers reported preparing thick foods (e.g. thick porridges) for children with diarrhoea and two of them reported using oral rehydration solution in attempt to stop diarrhoea. Our findings encourage further research to better understand the practices and motivations of mothers who adopt positive practices during child illness. Once these are understood and trialled, it could help in formulating clear nutrition educational messages that promote existing positive practices[50].

Our findings also suggest that current feeding practices have implications for other nutrition programmes. For example, in Rwanda, caregivers with children 6−23 months receive micronutrient sprinkles (locally known as Ongera) as part of the government's home fortification programme to prevent stunting and anaemia. Caregivers are expected to add these micronutrients to children's semi-solid or solid foods before consumption[34, 51]. The instructions of using the micronutrients sprinkles are that mothers should mix the product with semi-solid or solid foods[34]. However, mothers considered the consistency of complementary foods that they usually feed their children was inappropriate to mix with the micronutrients, suggesting that the children may not be receiving the recommended dose of the micronutrients. Moreover, the widely held belief that sweet potato is not suitable for young children is likely to interfere with the consumption of the vitamin-A rich sweet potato variety that is currently being promoted in Rwanda[52]. Thus, our findings underline the importance of understanding local contexts in which nutrition programmes take place.

Finally, poverty and food insecurity appeared to be significant barriers to appropriate child feeding practices. This may not be surprising given the high level of household poverty (51.4%)[24] and food insecurity (49%) in Rutsiro district[4]. As stated above, mothers expressed how poverty and food insecurity impacted their feeding practices and

childcare through: 1) reduced number of meals received by children; 2) inability for mothers to procure the ingredients required to prepare nutritious foods for their children; 3) breast-feeding younger children as a means to maximize foods for other household members, but limiting the complementary foods recommended in this age group's diet; 4) trade-offs involved between finding employment and childcare; and 5) inability of mothers to implement nutrition advice from health workers (e.g. having a side pot of nutritious foods (*agakono k'umwana*) for young children). Some studies suggest that maternal education or behaviour change communication strategies, with or without foods, can improve IYCF practices[53]. However, other researchers argue that such strategies must be part of more comprehensive approaches that address contextual factors such as poverty and food insecurity[54]. The government of Rwanda has been implementing various social protection programmes targeting the most vulnerable households to enable them to purchase more nutritious foods[55]. Research shows that, if implemented adequately, these programmes represent important opportunities for supporting caregivers' ability to care for their children[56]. Additional efforts to enhance economic opportunities and access to foods by caregivers in Rutsiro should be explored.

The strength of the present study lies in its qualitative approach, which allowed us to gain a deeper understanding of IYCF practices and mothers' rationale within the sociocultural context. This information is often not captured in quantitative surveys. However, there are limitations to this study. First, our findings are based on a purposive sample recruited from one sector in Rutsiro District, which may limit the transferability to populations outside this area. However, we included mothers whose children were at different age stages and that represented a wide range of maternal age and parity in order to obtain a rich data set, which is prerequisite for the nature of the study[26]. Second, the interpretation of our findings must consider that we did not collect dietary data. Third, social desirability bias may have influenced the participants' responses (e.g. breast-

feeding practices) or participants may have overemphasised the influence of poverty and food insecurity on child feeding. Mothers were encouraged to answer questions based on their own experiences. The interviewer also emphasised that there was no right or wrong answer and promised confidentiality. Finally, we acknowledge that interviewer's gender (male) is a potential limitation in interviewing mothers. However, in Rwanda, mothers are used to interact with community health workers (both males and females) who provide them with nutrition education, and we have no prior evidence or perception that mothers in this area were hesitant to speak with a male. Moreover, the interviewer took care to establish good rapport with the participants through courteous behaviour.

3.7 Conclusion

The findings from this study showed that mothers have positive attitudes towards breast-feeding and a good understanding of its health benefits. However, sub-optimal complementary feeding practices may result from the complex beliefs, perceptions and food classification systems which appear to have a strong influence on mothers' feeding decisions, this is in spite of the mothers appearing to have some nutrition knowledge received from nutrition counselling on IYCF. The views identified in this study, that certain foods are (un) suitable for young children, or that certain foods must be avoided during child diarrhoea, are likely to negatively affect the diversity and the amount of foods received by children. If these views are not recognized, the current nutrition education will not be effective in improving IYCF practices. We recommend further research to examine to which extent the beliefs, perceptions and food classification systems are shared with mothers in other districts of Rwanda. Such research could inform the design of culturally relevant interventions to improve IYCF practices. In addition, there is a need to support mothers and caregivers through improving household income and access to foods so that they can implement recommendations.

References (Paper I)

1. Development Initiatives (2018) 2018 Global Nutrition Report: Shining a light to spur action on nutrition. Bristol: Development Initiatives.
2. Black RE, Victora CG, Walker SP *et al.* (2013) Maternal and child undernutrition and overweight in low-income and middle-income countries. *The Lancet* 382, 427-451.
3. National Institute of Statistics of Rwanda (NISR) [Rwanda], Ministry of Health (MOH) [Rwanda] and ICF International (2015) *Rwanda Demographic and Health Survey 2014-15*. Rockville, Maryland, USA: NISR, MOH, ICF International.
4. National Institute of Statistics Rwanda (2018) Rwanda: Comprehensive Food Security and Vulnerability Analysis 2018. https://docs.wfp.org/api/documents/WFP-0000103863/download/ (accessed July 2019)
5. Institut National de la Statistique (NISR) & ORC Marco (2006) *Rwanda Demographic and Health Survey 2005*. Calverton, Maryland, U.S.A: INSR and ORC Macro.
6. Ministry of Health (MOH) [Rwanda] (2012) Third Health Sector Strategic Plan July 2012– June 2018. Kigali: Ministry of Health.
7. Lamichhane DK, Leem JH, Kim HC *et al.* (2016) Association of infant and young child feeding practices with under-nutrition: evidence from the Nepal Demographic and Health Survey. *Paediatrics and international child health* 36, 260-269.
8. Lutter CK, Daelmans BM, de Onis M *et al.* (2011) Undernutrition, poor feeding practices, and low coverage of key nutrition interventions. *Pediatrics* 128, e1418-e1427.

9. World Health Organization (2005) *Guiding principles for feeding non-breastfed children 6-24 months of age.* Geneva: WHO.

10. Dewey KG & Adu-Afarwuah S (2008) Systematic review of the efficacy and effectiveness of complementary feeding interventions in developing countries. *Matern Child Nutr* 4, 24-85.

11. Lung'aho M, Birachi E, Butare L *et al.* (2015) Rwanda Nutrition, Markets and Gender Analysis 2015: An integrated approach towards alleviating malnutrition among vulnerable populations in Rwanda. Nairobi: Government of Rwanda/International Center for Tropical Agriculture (CIAT).

12. White JM, Bégin F, Kumapley R *et al.* (2017) Complementary feeding practices: Current global and regional estimates. *Matern Child Nutr* 13, e12505.

13. Habyarimana F, Zewotir T, Ramroop S *et al.* (2016) Spatial Distribution of Determinants of Malnutrition of Children under Five Years in Rwanda: Simultaneous Measurement of Three Anthropometric Indices. *Journal of Human Ecology* 54, 138-149.

14. Mukabutera A, Thomson DR, Hedt-Gauthier BL *et al.* (2016) Risk factors associated with underweight status in children under five: an analysis of the 2010 Rwanda Demographic Health Survey (RDHS). *BMC Nutrition* 2, 40.

15. Nkunzimana T, Custodio E, Pérez-Hoyos A *et al.* (2016) Assessing MDG Achievements Through Under-5 Child Stunting in the East African Community: Some Insights from Urban Versus Rural Areas in Burundi and Rwanda Using DHS2010. In *Poverty and Well-Being in East Africa*, pp. 61-86 [Heshmati A., editor], Cham: Springer.

16. Nsereko E, Mukabutera A, Iyakaremye D *et al.* (2018) Early feeding practices and stunting in Rwandan children: a cross-sectional study from the 2010 Rwanda demographic and health survey. *Pan Afr Med J* 29, 157-157.

17. Aoun N, Matsuda H Sekiyama M (2015) Geographical accessibility to healthcare and malnutrition in Rwanda. *Soc Sci Med* 130, 135-145.

18. Binagwaho A, Condo J, Wagner C *et al.* (2014) Impact of implementing performance-based financing on childhood malnutrition in Rwanda. *BMC Public Health* 14, 1132.

19. Chunling L, Mejia-Guevara I, Hill K *et al.* (2016) Community-Based Health Financing and Child Stunting in Rural Rwanda. *Am J Public Health* 106, 49-55.

20. Roesler A, Smithers LG, Winichagoon P *et al.* (2018) Local perspectives and context in relation to feeding practices of children under 2 years in the mountain villages of northern Thailand. *Public Health Nutr* 21, 2989-2997.

21. Arts M, Geelhoed D, De Schacht C *et al.* (2011) Knowledge, beliefs, and practices regarding exclusive breast-feeding of infants younger than 6 months in Mozambique: a qualitative study. *J Hum Lact* 27, 25-32.

22. Lee J, Dusingizimana T Umutoni F (2016) Understanding Consumer Demand for Nutritious Food in Nyanza District, Rwanda. https://www.usaid.gov/sites/default/files/documents/1860/GAIN%20Summary%20Focused%20Ethnographic%20Survey%20Report.pdf (accessed June 2019)

23. National Institute of Statistics of Rwanda (NISR) [Rwanda], Ministry of Health (MOH) [Rwanda] and ICF International (2012) *Rwanda Demographic and Health Survey 2010*. Calverton, Maryland, USA: NISR, MOH, and ICF International.

24. National Institute of Statistics of Rwanda (2015) Integrated Household Living Conditions Survey 4 (EICV 4). http://www.statistics.gov.rw/publication/rwanda-poverty-profile-report-results-eicv-4 (accessed January 2020)

25. Pelto GH, Goodman AH Dufour DL (2000) The biocultural perspective in nutritional anthropology. In *Nutritional anthropology: Biocultural perspectives on food and nutrition*, pp. 1-10 [AH Goodman, GH Pelto and DL Dufour, editors]. Mountain View, CA: Mayfield Publishing.

26. Patton MQ (2002) Qualitative research and evaluation methods. Thousand Oaks. *Cal: Sage Publications*.

27. Saunders B, Sim J, Kingstone T *et al.* (2018) Saturation in qualitative research: exploring its conceptualization and operationalization. *Qual Quant* 52, 1893-1907.

28. Given LM (2008) The SAGE Encyclopedia of Qualitative Research Methods. Thousand Oaks, California: SAGE Publications, Inc.

29. Fook J & Gardner F (2007) *Practising critical reflection: a resource handbook*: Maidenhead: Open University Press.

30. DiCicco-Bloom B & Crabtree BF (2006) The qualitative research interview. *Med Educ* 40, 314-321.

31. Braun V & Clarke V (2006) Using thematic analysis in psychology. *Qualitative Research in Psychology* 3, 77-101.

32. Saldaña J (2013) *The coding manual for qualitative researchers*, 2 ed. London: SAGE Publications Ltd.

33. Tong A, Sainsbury P Craig J (2007) Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *Int J Qual Health Care* 19, 349-357.

34. Ministry of Health (MOH) [Rwanda] (2013) National Food and Nutrition Strategic Plan (NFNSP 2013-2018). Kigali: Ministry of Health.

35. Pelto GH, Levitt E Thairu L (2003) Improving feeding practices: current patterns, common constraints, and the design of interventions. *Food Nutr Bull* 24, 45-82.

36. Alderman H & Headey DD (2017) How Important is Parental Education for Child Nutrition? *World Development* 94, 448-464.

37. Engle PL, Menon P Haddad L (1999) Care and Nutrition: Concepts and Measurement. *World Development* 27, 1309-1337.

38. Ip S, Chung M, Raman G *et al.* (2007) Breast-feeding and maternal and infant health outcomes in developed countries. *Evid Rep Technol Assess (Full Rep)*, 153, 1-186.

39. Kramer MS & Kakuma R (2012) Optimal duration of exclusive breast-feeding. *Cochrane Database Syst Rev*, Cd003517.

40. Ministry of Health (MOH) [Rwanda] (2014) 1000 Days to a Healthy Rwanda. https://rwanda.thecompassforsbc.org/first-1000-days-healthy-rwanda (accessed December 2019)

41. Sukkary-Stolba S (1987) Food classifications and the diets of young children in rural Egypt. *Soc Sci Med* 25, 401-404.

42. Laderman C (1981) symbolic and empirical reality: a new approach to the analysis of food avoidances. *American Ethnologist* 8, 468-493.

43. Zobrist S, Kalra N, Pelto G *et al.* (2017) Results of Applying Cultural Domain Analysis Techniques and Implications for the Design of Complementary Feeding Interventions in Northern Senegal. *Food Nutr Bull* 38, 512-527.

44. Alive & Thrive (2010) IYCF practices, beliefs and influences in Tigray Region, Ethiopia. Addis Ababa: Alive & Thrive.

45. Paul KH, Muti M, Khalfan SS *et al.* (2011) Beyond Food Insecurity: How Context Can Improve Complementary Feeding Interventions. *Food Nutr Bull* 32, 244-253.

46. Zeitlyn S, Rowshan R, Mahalanabis D *et al.* (1993) The ethnophysiology of digestion and diarrhoea in a Bangladeshi hospital population. *J Diarrhoeal Dis Res* 11, 243-248.

47. Assis AM, Barreto ML, Santos LM *et al.* (2005) Growth faltering in childhood related to diarrhea: a longitudinal community based study. *Eur J Clin Nutr* 59, 1317-1323.

48. Shubh KKR, Ruchira N & Bhattarai S (1997) *Childcare practices associated with positive and negative nutritional outcomes for children in Bangladesh: a descriptive analysis*. Washington, DC: International Food Policy Research Institute.

49. Ali NS, Azam SI Noor R (2003) Women's beliefs regarding food restrictions during common childhood illnesses: a hospital based study. *J Ayub Med Coll Abbottabad* 15, 26-28.

50. Berggren WL & Wray JD (2002) Positive Deviant Behavior and Nutrition Education. *Food Nutr Bull* 23, 7-8.

51. McLean J, Northrup-Lyons M, Reid RJ *et al.* (2019) From evidence to national scale: An implementation framework for micronutrient powders in Rwanda. *Matern Child Nutr* 15, e12752.

52. Feed the Future (2018) Postharvest Loss Assessment of Orange-Fleshed Sweet Potatoes in Rwanda. https://horticulture.ucdavis.edu/sites/g/files/dgvnsk1816/files/extension_material_files/Postharvest%20Loss%20Assessment%20of%20OFSP%20in%20Rwanda.pdf (accessed December 2019)

53. Bhutta ZA, Ahmed T, Black RE *et al.* (2008) What works? Interventions for maternal and child undernutrition and survival. *The Lancet* 371, 417-440.

54. Jones AD, Cruz Agudo Y, Galway L *et al.* (2012) Heavy agricultural workloads and low crop diversity are strong barriers to improving child feeding practices in the Bolivian Andes. *Soc Sci Med* 75, 1673-1684.

55. Ministry of Local Government (2011) National Social Protection Strategy. https://www.minaloc.gov.rw/fileadmin/documents/Minaloc_Documents/National_Social_Protectiion_Strategy.pdf (accessed June 2019)

56. Roelen K, Shelmerdine H, Delap E *et al.* (2014) Researching the linkages between social protection and children's care in Rwanda: The VUP and its effects on child wellbeing, care and family reunification. London: Family for Every Child.

Chapter 4 An empirical analysis of factors associated with child height-for-age *z*-scores in northwest Rwanda: the role of care practices related to child feeding and health.

Stunting among children under 5 years in Rutsiro district has been consistently high, affecting 54% of children under 5 years of age in 2018 (up from 46% in 2015). The underlying factors remain unknown. It has been hypothesized that suboptimal care practices may be contributing to the high stunting prevalence in Rwanda; however, there has been no study to examine this relationship. The study presented in this chapter aimed to identify the factors associated with child height-for-age *z*-score (HAZ) of children aged 6–23 months, with particular emphasis on care practices related to child feeding and health. It is has been accepted for publication in the *British Journal of Nutrition.*

This chapter is not an exact replication of the published version. It has been formatted according to the Massey University guidelines, and minor changes, including references to appropriate appendices have been included in the thesis.

This chapter has been published as:

Dusingizimana, T., Weber, J., Ramilan, T., Iversen, P., & Brough, L. (2020). An empirical study of factors associated with height-for-age z-scores of children aged 6−23 months in northwest Rwanda: The role of care practices related to child feeding and health. *British Journal of Nutrition,* 1-12. doi:10.1017/S0007114520004961

4.1 Abstract

Child undernutrition, especially stunting persists in Rwanda. Care practices are hypothesized to be among the contributing factors, but little is known about how these practices influence child nutritional status. We aimed to identify the factors influencing child height-for-age *z*-scores (HAZ) as a measure of child nutritional status in Rwanda, and to examine the role of child feeding and health practices. We conducted a cross-sectional study involving 379 children (age 6–23 months) and their mothers in the northwest Rwanda. Data were collected using a pre-tested, structured questionnaire. An infant and young child feeding practices index (ICFI) and health practices index (HPI) were developed and categorised into tertiles, and linear regression analyses were performed to assess their association with child HAZ. Overall, mothers of non-stunted children exhibited better feeding and health practices than those of stunted children. ICFI was positively associated with child HAZ. We found an adjusted mean HAZ difference of 0.14 between children whose mothers were in high ICFI tertile compared to those in low tertile. Neither HPI nor any of its components were significantly associated with child HAZ. Other factors that were positively associated with child HAZ were infant birth weight ($P < 0.001$) and maternal height ($P < 0.001$). Child age, sex (male) ($P< 0.05$) and altitude ($P< 0.05$) were negatively associated with child HAZ. Diarrhoea ($P< 0.05$) and respiratory infections ($P< 0.05$) were negatively associated with HAZ in younger children aged 6–11 months. Policies to reduce stunting in this population must focus on both pre- and postnatal factors. Appropriate child feeding practices, particularly breast-feeding promotion and improvement in children's dietary diversity combined with measures to control infections should be given priority.

Keywords: care practices, child feeding practices, health practices, stunting.

4.2 Introduction

Stunting, or low height-for-age[1], also referred to as linear growth retardation, is the most common form of undernutrition among children under 5 years[2]. With an estimated 149 million (22%) of children affected[3], stunting has been identified as a global public health priority. Stunting is associated with an increased risk of morbidity and mortality, poor cognitive and physical development, with significant educational and economic consequences[4] as well as an increased risk of non-communicable diseases in adulthood[4, 5]. The World Health Assembly has set targets to reduce stunting by 40% between 2010 and 2025[6]; however, at the current rate of reduction, several countries, especially low- and middle-income countries are unlikely to achieve the targets[2].

For many years, policies to reduce child undernutrition in low- and middle-income countries, particularly in sub-Saharan Africa, have often focused on improving household income and food security[7, 8]. However, evidence shows that increasing household income and food security, though necessary, is not sufficient for improved child nutritional status[9]. Research also shows that interventions to improve child nutritional status through improved household income and/or food security depend largely on childcare practices within the household[10, 11]. Several studies showed that better care practices related to feeding and preventive health practices can significantly improve child nutritional status, even in households with limited economic and food resources[12-14].

In Rwanda, 35% of children younger than 5 years were stunted in 2018[15]. Data on prevalence of stunting in Rwanda show a national downward trend (48.3% in 2000 to 35% in 2018); however, the reduction has not been consistent across the country. For example, in fourteen out of thirty districts of Rwanda, 40–54% of children under 5 years are stunted[15]. Based on the WHO thresholds[16], these rates of stunting are of very high public health significance and require urgent actions. Thus, research is needed to

understand the factors underlying the persistence of child stunting in Rwanda. Given the significant disparity in stunting prevalence, a greater understanding of subnational level factors is needed to inform the design of more targeted programmes and policies to effectively address child stunting in Rwanda.

Studies[17, 18] have documented gaps in care practices related to child feeding practices in Rwanda. For example, the number of children aged 6–23 months who met the minimum acceptable diet remained unchanged (17%) between 2010 and 2018[15]. Increasing evidence also suggests that poor care practices, including sub-optimal child feeding practices are potentially contributing to the high rates of child undernutrition in Rwanda[15, 19, 20]. In addition, studies indicate inadequate health practices such as low utilisation of child growth monitoring for screening of child nutritional status[21]. However, research is limited on the influence of child feeding patterns on child nutrition status. A few studies examining the relationship between infant and young child feeding (IYCF) practices and child nutrition status in Rwanda have assessed single indicators of feeding practices and produced mixed results. Uwiringiyimana *et al.*[22] found that exclusive breast-feeding was significantly positively associated with height-for-age *z*-scores (HAZ) in children aged 5–30 months (*n* 138). Conversely, Matsiko[23] found that achieving minimum dietary diversity, minimum meal frequency and acceptable diet were not significantly associated with HAZ in children aged 6–12 months (*n* 192). Given that child feeding has several dimensions (e.g. the type, quality and variety of foods, the quantity of foods, responsive feeding, etc.), studies examining the association between single feeding practices and child nutrition status may not provide a comprehensive picture of the association between overall child feeding patterns and nutritional outcomes[24]. Ruel & Menon[25] proposed a novel approach of assessing the relationship between child feeding patterns and nutritional status using an index that combined various dimensions of child feeding. Drawing from Ruel and Menon's approach, Condo *et al.*[26] examined

the association between a feeding index and nutritional status in Rwanda. The authors found no association between the feeding index and child nutritional status; however, their findings may not apply to all children because the study focused on HIV-infected children whose caregivers' feeding practices may differ from those of caregivers with healthy children.

The objectives of the present study were to identify the factors influencing child nutritional status in Rwanda, including the relationship between indices of child feeding and health practices and child nutritional status. Our assumption was that better feeding and health practices are positively associated with better height-for-age, and that mothers of non-stunted children have better child feeding and health practices than those of stunted children. This study contributes to the knowledge on the determinants of child nutritional status in Rwanda and extends the literature on the usefulness of child feeding and health practices indices in relation to child nutritional status in the Rwandan context.

4.3 Methods

4.3.1 Settings

The study was conducted in Rutsiro district, northwest of Rwanda, 150 km from the capital city, Kigali. The inhabitants of the district are predominantly rural and engaged in subsistence agriculture[15]. About 50% of the population in Rutsiro are food insecure, and the prevalence of stunting increased from 46% in 2015 to 54% in 2018[15]. The public health system of the district consists of a network of seventeen health centres and one district hospital[27].

4.3.2 Design and sample size

This was a cross-sectional study involving mother–child pairs. The sample size was calculated using the Cochrane formula for estimation of a single proportion[28]. Although our focus was not to estimate the proportion of stunted children, this would allow us to

analyse the determinants of child nutritional status with a 95% confidence of having an anticipated prevalence of stunting.

$n = Z^2 pq/d^2$

where n is the sample size, Z is 1.96, p is the proportion of stunting (46% at the time of the survey[29]), q is $1-p$, and d is the relative desired precision of 5%. The calculated sample size (n 382) was increased by 5% to account for contingencies such as recording error, resulting in a final sample of 400. Because of the variability in geographical landscape, it was assumed that child feeding and/or health practices might differ across the district. Therefore, the district was divided into three zones based on the main roads connecting Rutsiro district to its neighbouring districts. Health centres were used as an entry point to facilitate access to the community, and community health workers who work under supervision of the health centres assisted in identifying potential participants. Three health centres (nine in total across the district) were purposively selected in each zone to maximise geographic distribution. Within each health centre's catchment area, two administrative entities (i.e. cells) were selected. The cell containing the health centre was automatically selected, and the next was randomly selected among distant cells. In each cell, one village was randomly selected, a list of all potentially eligible mothers with children aged 6−23 months was compiled using growth monitoring records obtained from community health workers, and children were randomly selected from the lists using random tables. Eligibility criteria were: (1) child aged 6–23 months; (2) child was apparently healthy; and (3) being in the lowest socio-economic categories. All participants gave oral informed consent prior to data collection. The survey was undertaken from September 2018 to January 2019.

Ethical approval

All study guidelines were in accordance with the guidelines laid down in the Declaration of Helsinki. The study procedures were also approved by the Massey University Human Ethics Committee (reference: SOA 17/67) and the Institutional Review Board of the University of Rwanda's College of Medicine and Health Sciences (reference: 003/CMHS IRB/2017). Permission to collect data was also obtained from the District public health office. Oral informed consent was obtained from all participants, after the purpose of the study was explained. Each participant received five soap bars (~$US 1) as a recognition for their participation.

Face-to-face interviews were conducted with mothers, and data were collected using a structured questionnaire (**Appendix 14**) digitally preprogramed on the CommCare platform[30]. The data were captured on a hand-held tablet. Information on socio-demographic characteristics, maternal and child characteristics were collected. Mothers also reported infant birth weight, child morbidities in previous 4 weeks: diarrhoea (defined as ≥ 3 watery or loose stools per day), upper respiratory infections (coughing, runny nose, or wheezing), fever, and other illnesses. In addition, household socioeconomic characteristics such as size, number of children under 5 years, ownership of agricultural land and other household assets, and source of drinking water were reported. Altitude and location of the household premises were recorded using a handheld Global Positioning System (Tremble Juno SB Handheld).

4.3.3 Measures

4.3.3.1 Anthropometry

Anthropometric measurements were taken following standard procedures [31]. Child length was measured to the nearest 1 mm in a recumbent position using a UNICEF designed length board. The height of mothers was measured using a wall-mounted

portable stadiometer to the nearest 0.1 cm. The weight of both mother and child was measured to the nearest 100 g using an electronic scale (SECA Model 874).

Feeding and health practices

Breast-feeding and complementary feeding practices, and health practices (antenatal care visits during the last pregnancy, attendance at growth monitoring, use of deworming tablets, child immunisation status, use of vitamin A supplements) were reported by the mother. Birth certificates and immunisation records were used to verify information on birth weight and immunisation status, respectively.

4.3.3.2 Infant and child feeding index

We adapted the methodology used by Ruel & Menon[25] and others[32-34] to construct an infant and child feeding index (ICFI). The ICFI consisted of five child feeding practice components: current breast-feeding (yes/no), duration of exclusive breast-feeding (i.e. whether the mother exclusively breastfed for the first 6 months), dietary diversity indicator, feeding frequency, and responsiveness during feeding. Dietary diversity and meal frequency were calculated using 24 h dietary recall data[35]. The feeding practice components and the scoring system used to create the ICFI for the different age-groups are described in the online Supplemental Table S1 (**Appendix 2**). Briefly, a score of 1 or 2 was assigned for a positive practice, and a score of 0 was assigned for a potentially negative practice. The practices were judged positive or negative based on child feeding recommendations[36] as well as evidence about their potential benefits or risks [37].

For children aged 6−8 months and 9−11 months, a score of 2 was assigned for mothers whose children were still breast-feeding. For children aged 12−23 months, a score of 1 was assigned for mothers whose children were still breast-feeding. For all children, a score of 0 was assigned for mothers whose children were not breast-feeding. A score of 1 was also assigned for mothers who reported exclusive breast-feeding for the first 6

months, and a score of 0 was given to those who introduced complementary foods to their children prior to 6 months.

A dietary diversity indicator was created using information collected on the number of food groups consumed by the child in the previous 24 hrs. Following the guidelines for young child feeding[35], seven food groups, adapted from the Rwanda's Demographic and Health Survey[29], were considered: grains/roots/tubers, legumes/nuts, milk or dairy products, flesh foods (meat/fish/poultry), eggs, vitamin A fruits and vegetables, and other fruits and vegetables. A score of 1 was given for each food group consumed, resulting in a dietary diversity score ranging from 0 to 7 which was divided into three categories: low, medium, and high. For all age groups, low category included children who had not received any foods. For both 6−8 months and 9−11 months age groups, a child was classified into medium category if a child received 1–2 food groups, or into high category if a child received three or more food groups. For children 12−23 months, a medium category composed of children who had received 2–3 food groups, whereas a high category comprised those receiving ≥ 4 food groups.

Feeding frequency scoring criteria used information collected on the number of meals received by the child in the past 24 h. This indicator reflects the WHO recommended minimum meal frequency for breast-fed and non-breast-fed children (i.e. breast-fed children aged 6−8 months and 9−23 months should receive solid- or semi-solid or soft foods at least two times/d and three times/d, respectively). Thin/watery porridges and trivial snacks were not counted[35].

Indicator of responsive feeding was based on current young child feeding recommendation[36], and it was informed by a previous study[38] conducted in the same population. It was defined as caregiver's self-report of encouraging food intake of children who refuse to eat due to loss of appetite or during diarrhoea[10]. A score of 1 was

assigned for an action to encourage food intake, and a score of 0 if the action potentially restricted/ discouraged child's food intake.

The ICFI was created by adding up the scores obtained from all the component practices. For each age group, the minimum ICFI score was 0 and maximum possible ICFI score was 9. The scores were ranked, and tertiles were created to form three categories: low (score: 1–4), medium (score: 5–6) and high (score: 7–9). Grouping the ICFI score into tertiles, although arbitrary, was done to allow comparison with other studies that have examined the relationship between ICFI and child HAZ.

4.3.3.3 Health practices index

A methodology used by Ruel *et al.*[13] was adapted to develop a health practices index (HPI). Five health practices were considered: attendance at growth monitoring in the past month, the number of antenatal care visits when pregnant with the study child, child diarrhoea treatment methods, vitamin A supplementation (whether the child received vitamin A supplements in the previous 6 months) and immunisation status (whether the child received all age-specific vaccines). The scoring system for the different health practices is described in the online Supplemental Table S2 (**Appendix 3**).

4.3.3.4 Household hunger level

Household hunger level was assessed and categorised using a validated cross-cultural household hunger scale[39]. Following the household hunger scale measurement guide, a six-point household hunger score was generated and categorised into three levels of household hunger: little or no hunger (score: 0−1 score); moderate hunger (score: 2–3), and severe hunger (score: 4–6). The moderate and severe hunger level categories were combined to form one category, that is, moderate/severe, as there were few households (4.2%, *n* 16) in the severe hunger category.

4.3.3.5 Household wealth index

A household wealth index – a proxy measure of household socioeconomic status – was constructed using a principal component analysis[40], with the following twelve variables: access to agricultural land, purchase of commercial fertilizer in the previous cropping season, the quality of housing (type of floor, wall), degree of household crowding, that is, the number of persons sleeping in a room (1 if ≤ 3 persons/room and 0 if ≥ 4 persons/room), source of lighting (none, petrol lamp or solar/electricity), ownership of durable assets (radio, thermos, mattress, umbrella), ownership of health insurance for all household members, and a measure of animal ownership expressed in tropical livestock units. The tropical livestock unit is a metric combining multiple species of livestock into a weighted measure representing total body weight and potential market value[41]. The tropical livestock unit variable was skewed and, therefore, three categories were created. All variables were thus categorical, and were ranked in ascending order, that is, from the worst to the best. The scores of the first two extracted components of the principal component analysis were used as a measure of household wealth index and included as covariates in multivariable regression analyses.

4.4 Statistical analysis

The WHO Anthro software version 3.2.2 was used to calculate HAZ[42]. A child was classified as stunted if his/her HAZ was 2 SD below the median of the WHO reference population[43]. A binary indicator of stunting (stunted/non-stunted) was used to allow comparison between care practices and other characteristics of mothers of non-stunted and those of stunted children. We also used HAZ as a dependent variable to examine its association with ICFI and HPI and other variables. Continuous variables were summarised using means and SD or medians and interquartile ranges for non-normally distributed variables. Categorical variables were summarised using frequencies and percentages. Mann–Whitney *U* test or independent *t* test (continuous variables) and χ^2

test (categorical variables) were used to test differences in care practices and other characteristics between non-stunted and stunted children. Multiple linear regression analyses were used to examine the relationship between various factors and child HAZ. To identify confounders, we first represented hypothetical assumptions about the causal relationships between various factors and child nutritional status using DAGitty software[44]. The software was used to construct directed acyclic graphs which specify the relationships among factors based on *a priori* evidence, theoretical knowledge and researcher's subject matter expertise[45], while enabling identifying all minimally sufficient adjustment sets, i.e. sets of variables that are minimally sufficient to adjust for confounding in multiple regression models[45]. In the present analysis, different sets of variables were identified for the two variables of interest, i.e. ICFI and HPI. Therefore, different regression models were fitted for each of these variables. Because of age-related variability in child feeding practices[36], we ran separate regression analyses: for all children, and for those aged 6−11 months and 12−23 months. All assumptions were assessed for all models. Multicollinearity was checked using the variance inflation factor (VIF) of ten for all explanatory variables[46]. Homoscedasticity was assessed by visual inspection of a plot of standardized residuals *v.* standardised predicted values. Variables with $P < 0.05$ were considered statistically significant. All analyses were performed using SPSS version 25 (IBM).

4.5 Results

Of the 400 child−mother pairs recruited, twenty-one children (5%) were excluded from the analysis due to preterm birth or lack of health cards to verify birthweight information. Thus, the descriptive analysis was performed on 379 children. Of these, thirty-five mothers (9%) had no height measurements, whereas 10 (2.5%) had no data on education. The final sample considered for regression analyses was thus 334 (~84%) mother-child pairs. The median age was significantly lower ($P < 0.001$) for non-stunted

children than for stunted children (**Table 4.1**). Mothers of non-stunted children were older and taller than those of stunted children. Approximately 60% of the mothers had either never attended school or did not complete primary education; 16% had some secondary education, and 65% did not achieve the recommended number of ≥ 4 antenatal care visits. Forty-three percent of households had experienced moderate to severe hunger in the past 4 weeks**.**

Nutritional status

The mean (SD) HAZ was -1.69 (SD 1.3). Thirty-eight percent of the children were stunted (**Table 4.1**), and the stunting prevalence in older children was more than twice that in younger children (47% *v.* 21%, $P < 0.001$). There was no significant difference in the prevalence of stunting between males and females or between household wealth index categories.

Table 4-1 Child-, maternal-, and household-level characteristics, by child nutritional status*
(Frequencies and percentages; means and standard deviations; medians and interquartile ranges (IQR))

	Full sample		Non-stunted		Stunted		
Characteristics	***n***	**%**	***n***	**%**	***n***	**%**	***P***
Number of children	379	100	233	61.5	146	38.5	
Child-level							
Age (months)							<0.001
Median	15.1		13.3		17.2		
IQR	10.9, 19.4		9.7, 18.5		13.5, 20.8		
Age group							<0.001
6−11	120	31.7	95	79.2	25	20.8	
12−23	259	68.3	138	53.3	121	46.7	
Sex							0.13
Males	184	48.5	106	57.6	78	42.4	
Females	195	51.5	127	65.1	68	34.9	
Birth weight (kg)							<0.001
Median	3.2		3.3		2.8		
IQR	3.0, 3.6		3.0, 3.6		3.0, 3.5		
HAZ							<0.001
Mean	−1.69		−0.97		−2.83		
SD	1.3		0.9		0.8		
Maternal-level							
Age (years)							0.02
Median	28		30		27		
IQR	24, 34		25, 35		23, 33		
Height (cm)							<0.001
Mean	156		157.3		153.8		
SD	5.9		5.5		5.7		
Marital status							0.06
Married	304	80.0	194	64.0	110	36.0	
Unmarried/widowed	75	20.0	39	52.0	36	48.0	
Number of ANC visits							0.58
< 4	248	65.0	150	60.0	98	40.0	
≥ 4	131	35.0	83	63.0	48	37.0	

Characteristics	Full sample		Non-stunted		Stunted		*P*
	n	%	*n*	%	*n*	%	
Education level							0.54
None/incomplete primary	219	59.3	132	60.3	87	39.7	
Completed primary	88	23.8	53	60.2	35	39.8	
Some secondary	62	16.8	20	67.7	42	32.3	
Household-level							
Household size							0.22
Median	4		5		4		
IQR	3, 6		3, 6		3, 5		
Number of children < 5 years							0.42
Median	1		1		1		
IQR	1, 2		1, 2		1, 2		
Altitude (masl)							0.003
Median	1977.2		1913		2023.5		
IQR	1729.0, 2198.0		1726.5, 2137.5		1760.3, 2229.8		
Wealth index							0.11
Lowest tertile	126	33.2	78	61.9	48	38.1	
Middle tertile	126	33.2	69	54.8	57	45.2	
Upper tertile	127	33.5	86	67.7	41	32.3	
Hunger level							0.10
Little/no hunger	215	56.7	140	65.1	75	34.9	
Moderate/severe	164	43.3	93	56.7	71	43.3	
Source of drinking water[§]							0.92
Improved	222	58.6	136	61.3	86	38.7	
Unimproved	157	41.4	97	61.8	60	38.2	
Zone							0.19
Zone 1	100	26.4	55	23.6	45	30.8	
Zone 2	100	26.4	60	25.8	40	27.4	
Zone 3	179	47.2	118	50.6	61	41.8	

HAZ, height-for-age z-score; ANC, antenatal care; masl, metres above sea level.

[*] Data are missing for maternal education (n 10) and maternal height (n 36).

[§] Source of drinking water defined according to UNICEF/WHO[(47)]: improved = public taps, standpipes, tube wells, boreholes, protected well and springs, rainwater; unimproved = unprotected well and spring, surface water.

Child feeding practices

Almost all children (96%) were still breastfed at the time of the survey. However, over one third of the mothers (39%) introduced complementary foods to their children before the recommended age (i.e. 6 months) (**Table 4.2**). Approximately half (54%) of the children were fed at the recommended minimum frequency; however, the diversity of foods consumed was low. On average, children consumed three food groups, and only 36% met the WHO recommended minimum dietary diversity (≥4 food groups) (online Supplemental Table S3 – **Appendix 4**). As compared to children aged 12−23 months, children in the age group of 6−11 months were less likely to achieve the recommended minimum dietary diversity (23% *v.* 42%, *P* = 0.001) (data not presented). Nearly all children (93%) consumed staples (grains, roots or tubers), whereas the consumption of animal source foods was low (27%) (online Supplemental Table S3 – **Appendix 4**). The mean ICFI score for all children was 5.8 (SD 1.6.) Non-stunted children had significantly higher ICFI score than stunted children (6.0 *v*. 5.4, *P* = 0.001) (**Table 4.2**).

Table 4-2 Distribution of the infant and child feeding index (ICFI) and its components by child nutritional status of children aged 6–23 months, Rutsiro district, Rwanda, September 2018–January 2019
(Frequencies and percentages; ranges; means and standard deviations)

	Full sample		Non-stunted		Stunted		*P*
	n	**%**	***n***	**%**	***n***	**%**	
Current breast-feeding							<0.001
Yes	362	95.5	230	63.5	132	36.5	
No	17	4.5	3	17.6	14	82.4	
Child was exclusively breastfed to 6 months							0.20
Yes	231	60.9	148	64.1	56	35.9	
No	148	39.1	85	57.4	63	42.6	
Dietary diversity score*							0.043
Low	28	7.4	18	64.3	10	35.7	
Medium	172	45.4	94	54.7	78	45.3	
High	179	47.2	121	67.3	58	32.4	
Meal frequency score†							0.58
Low	43	11.3	28	65.1	15	34.9	
Medium	195	61.5	115	59.0	80	41.0	
High	141	37.2	90	63.8	51	36.2	
Responsive feeding when child refuses foods							0.50
Yes	262	69.1	164	62.6	98	37.4	
No	117	30.9	69	59.0	48	41.0	
Food restriction during diarrhoea							0.11
Yes	175	46.2	100	57.1	75	42.9	
No	204	53.8	133	65.2	71	34.8	
ICFI score							
Range	1−9		1−9		1−9		
Mean	5.7		6.0		5.4		<0.001
SD	1.6		1.6		1.6		
ICFI tertiles							0.001
Low (1−4)	82	21.6	41	50.0	41	50.0	
Medium (5−6)	165	43.5	95	57.6	70	42.2	
High (7−9)	132	34.8	97	73.5	35	26.5	

* For age 12−23 months, medium = 2−3 food groups/d and high = 4 or more food groups/d.
† For age 12−23 months, medium = 1−2 meals/d and high = 4+ meals/d.

Child morbidity and health practices

Morbidity among children during the previous 4 weeks was high: 47% had experienced diarrhoea, 78% had symptoms of respiratory infections, 43% had fever and 11% had

other illness (online Supplemental Table S3 – **Appendix 4**). No significant difference was observed in the prevalence of morbidity between non-stunted and stunted children. However, results from sub-analyses (data not shown) showed that, in younger children (6–11 months), stunted children were more likely to have diarrhoea than non-stunted (64% *v.* 42%, *P* = 0.05). About half (46%) of the mothers whose children had suffered from diarrhoea reported either never seeking treatment or using home remedies to treat their child diarrhoea. The proportion of mothers seeking appropriate treatment for diarrhoea was higher among mothers of non-stunted children than among those of stunted children and the difference approached statistical significance (58% *v.* 48%, *P* = 0.057). The mean HPI was 4.5 (SD 1.0), with no significant difference between non-stunted and stunted children (*P* = 0.58) (**Table 4.3**).

Table 4-3 Distribution of the health practices index (HPI) and its components by nutritional status of children aged 6–23 months, Rutsiro district, Rwanda.
(Frequencies and percentages; ranges; means and standard deviations)

	Full sample		Non-stunted		Stunted		
	n	**%**	***n***	**%**	***n***	**%**	***P***
Attendance at growth monitoring (past month)							0.67
Yes	318	83.9	197	61.9	121	38.1	
No	61	16.1	36	59.0	25	41.0	
Antenatal care							0.66
Poor (0−1)	46	12.1	30	65.2	16	34.8	
Average (2−3 visits)	202	53.3	120	59.4	82	40.6	
Good (≥ 4 visits)	131	34.6	83	63.4	48	36.6	
Diarrhoea treatment method							0.06
No treatment/home remedy	174	45.9	98	56.3	76	43.7	
Health centre/health worker	205	54.1	135	65.9	70	34.1	
Child received vitamin A supplements (past 6 months)							0.07
Yes	362	95.5	219	60.5	143	39.5	
No	17	4.5	14	82.4	3	17.6	
Child fully immunized							0.26
Yes	357	94.2	217	60.8	140	39.2	
No	22	5.8	16	72.7	6	27.3	
HPI score							
Range	1−6		2−6		1−6		
Mean	4.5		4.5		4.5		0.58
SD	1.0		1.0		1.0		
HPI tertiles							0.043
Low (score: 1−3)	58	15.3	37	63.8	21	36.2	
Medium (score: 4)	127	33.5	67	52.8	60	47.2	
High (score: 5−6)	194	51.2	129	66.5	65	33.5	

Association between ICFI, HPI and child nutritional status

Results from bivariate analyses showed that ICFI was associated with child nutritional status. We found a significant difference of 0.34 in mean HAZ between children in the highest compared to the lowest ICFI tertiles ($P < 0.001$) (data not shown). Additionally, the prevalence of stunting was significantly lower among children whose mothers were in the high ICFI tertile compared with those in the lowest tertile (27% *v.* 50%, $P = 0.001$)

(**Table 4.2**). In bivariate analysis, the association between HPI and HAZ was not statistically significant (*P* = 0.10) (data not shown). The prevalence of stunting was also not as expected; it was significantly higher among children whose mothers were in the medium HPI tertile as compared with low and high tertiles (**Table 4.3**). However, when the two lowest tertiles (low and medium) were combined and compared with the high tertile, the prevalence of stunting was significantly lower among children in the highest tertile compared with the lowest tertile (33.5% *v*. 43.8 %, *P* = 0.04) (data not shown).

Results from multiple linear regression analyses are shown in **Table 4.4**. There was a significant and positive association between ICFI and HAZ, after controlling for potential confounders at child-, maternal-, and household-level. We found a mean difference of 0.14 HAZ between children of mothers in the high ICFI tertile compared with those in the low ICFI tertile (*P* = 0.039) (**Table 4.4, model 1**). When analysis was stratified by age, the association between ICFI and HAZ remain significant (β = 0.16, *P* = 0.025) only in older children (12−23 months) (online Supplemental Table S4 – **Appendix 5**). The association between HPI and HAZ was not statistically significant, neither when all age groups were combined (**Table 4.4, model 2**) nor in stratified analysis (online Supplemental S5 – **Appendix 6**). We also analysed individual components of ICFI and HPI, while controlling for variables as in ICFI or HPI models (**Appendix 7**). Among the components of ICFI, a significant and positive association was observed between breast-feeding and child HAZ (β = 0.13, *P* = 0.011). The association between dietary diversity indicator and child HAZ also approached statistical significance (β = 0.17, *P* = 0.087). None of the components of HPI was significantly associated with HAZ.

Table 4-4 Factors associated with HAZ of children aged 6−23 months in Rutsiro district, Rwanda, September 2018–January 2019*

(Standardized coefficients and 95% confidence intervals)

	Model 1			Model 2		
	β	95% CI	P	β	95% CI	*P*
ICFI terciles (Ref.= Low)						
Medium	0.07	−0.13, 0.47	0.27	0.06	−0.16, 0.45	0.35
High	0.14	0.02, 0.72	0.039	0.13	−0.01, 0.72	0.06
HPI (Ref.= Low)						
Medium	−	−	−	0.03	−0.29, 0.42	0.71
High	−	−	−	0.09	−0.13, 0.57	0.22
Age (months)	−0.29	−0.10, −0.05	<0.001	−0.30	−0.10, −0.05	<0.001
Birth weight (kg)	0.22	0.29, 0.72	<0.001	0.22	0.29, 0.72	<0.001
Sex (Ref.= female)						
Male	−0.12	−0.53, −0.08	0.008	−0.13	−0.54, −0.9	0.007
Diarrhoea – yes	−0.04	0.32, 0.14	0.45	−0.03	−0.30, 0.17	0.58
Respiratory infection – yes	−0.09	−0.51, 0.04	0.09	−0.09	−0.53, 0.02	0.07
Maternal height (cm)	0.28	0.04, 0.08	< 0.001	0.28	0.04, 0.08	< 0.001
Maternal education (Ref. = none/incomplete primary)						
Complete primary	0.07	−0.08, 0.49	0.16	0.08	−0.07, 0.50	0.13
Some secondary	0.08	−0.03, 0.63	0.08	0.09	−0.05, 0.61	0.10
Altitude (1000 m above sea level)	−0.15	−1.06, 0.25	0.002	−0.14	−1.00, −0.18	0.005
Household hunger (Ref. = little/no hunger)						
Mild/severe	−0.05	−0.37, 0.13	0.34	−0.05	−0.37, 0.14	0.37
Wealth index						
1st Factor	−0.01	−0.14, 0.11	0.82	−0.02	−0.16, 0.10	0.65
2nd Factor	−0.03	−0.16, 0.09	0.58	−0.04	−0.17, 0.08	0.49
Adjusted R^2	0.31			0.31		

β, standardized coefficients; ICFI, infant and child feeding index; Ref., reference category; HPI, health practices index.

* Model 1 included ICFI as main independent variable. Model 2 included HPI as main independent variable. Both models included the same covariates, except that model 2 also included ICFI. (−) means that HPI was not controlled in model 1.

In both model 1 and model 2, child's birth weight and maternal height were positively associated with HAZ. By contrast, child's age, sex (male), and altitude were negatively associated with HAZ. In models including both ICFI and HPI and for all children (6–23 months), respiratory infections tended to be significant and negatively associated with HAZ, but no association was observed between diarrhoea and HAZ. When analysed by age group, we found a statistically significant and negative association between both diarrhoea and respiratory infections and HAZ only in younger children (6–11 months) (online Supplemental Tables S4 and S5 – **Appendices 5 and 6**).

4.6 Discussion

Findings from the present study indicate that the burden of stunting among children aged 6–23 months in Rutsiro district is high (39%). National estimates show that the prevalence of stunting increases from 18% among children 6−8 months to 21% among those aged 9−11 months to 49% among those aged 18−23 months[29]. Our results showed a similar trend and are comparable to those observed in other studies showing that the odds of stunting increases with age[48].

In the present study, we found a feeding pattern that is similar to what has been observed in other studies conducted in Rwanda. For example, 39% of the mothers reported introducing complementary foods to their children before 6 months. In a cross-sectional study[22] and a longitudinal study[23] conducted in northern and southern provinces of Rwanda, respectively, researchers found that only 50% of children were exclusively breastfed for the first 6 months. These results suggest that national estimates of exclusive breast-feeding prevalence (87%)[29] may be an overestimation in rural Rwanda. In addition, the diet of children was less diverse, with majority of children (64%) consuming less than the recommended four food groups, and the consumption of animal sources foods was extremely low. Other studies conducted in rural Rwanda have reported that 65–70% of children younger than 24 months do not meet the WHO

recommended dietary diversity[22, 29]. Although monotonous diets are correlated with household poverty in low- and middle-income countries[49], several studies conducted in Rwanda revealed other important factors underlying poor child feeding practices, including maternal beliefs and food restrictions, especially during child illness[18, 38].

Our finding of a positive association between ICFI and child HAZ is consistent with other studies that have investigated the relationship between a summary of child feeding practices and child HAZ in rural[32, 34, 50] and urban populations[13, 51]. However, our result contrasts those of Ntab *et al.*[52] who found no association between ICFI and child HAZ in rural Senegalese children (*n*= 500, age 12–42 months). These inconsistent results are probably due to differences in feeding practices. For example, contrary to our observation, breastfed children in the Senegalese study had lower mean HAZ than non-breastfed children because mothers prolonged breast-feeding for stunted children. Our findings of an association between ICFI and child HAZ only in older children are consistent with those of Ruel & Menon[25] who found a positive association between ICFI and HAZ in older children (12–36 months). These authors suggested that the cumulative effect of improved care practices on child health may increase over time, and therefore, the effect of better child feeding practices may become more apparent in older children than in younger children[25].

In the present study, two components of ICFI, that is, breast-feeding and dietary diversity indicators, were associated with child HAZ. Other studies in Rwanda[22] and Kenya[53] have reported positive associations between breast-feeding and linear growth among children < 24 months. However, our results regarding breast-feeding should be interpreted with caution because only a small number (5%) of children were not breast-feeding. Our finding of a positive association between dietary diversity and child HAZ is also supported by findings from several countries in Africa (including Rwanda), Asia and Latin America[54, 55]. This result underscores the use of the dietary diversity as a better proxy of feeding practices and suggests that interventions to diversify children's diet have

potential to improve child nutritional status of young children in Rwanda. However, studies found that complementary foods in Rwanda may be source of mycotoxins[56, 57]. Consumption of mycotoxins, particularly aflatoxins, through complementary foods was found to be associated with child stunting in children (9–60 months)[58]. This could be one of the reasons why the relationship of ICFI with child HAZ was not as strong as might be expected, but further investigation is needed in this area. Thus, to maximise the benefits of dietary diversification on children's nutritional status, interventions should focus not only on improving the diversity of complementary foods, but also the safety of these foods.

The lack of association between HPI and child HAZ in the present study contrasts findings of Liu *et al.*[59] who reported a significant and positive association between a health practices index (measured by access to prenatal care, timing and frequency of prenatal care visits) and child HAZ in a multi-country/pooled analysis of longitudinal data from four low-and middle-income countries. The discrepancy between our results and those of Liu *et al.* may be due to methodological differences. Our health index included five aspects of health practices, whereas that of Liu *et al*. included only indicators related to antenatal care. Additionally, some components (e.g. growth monitoring and antenatal care) used to construct the HPI serve as an entry point to nutrition services (e.g. counselling on IYCF practices and micronutrient supplementation); therefore, the effect of HPI in the present study on child nutritional status may be much more dependent on the quality of services provided to mothers. It was found in India and Bangladesh that growth monitoring programmes had little or no effect on child nutritional status because of failure to identify growth faltering among children or ineffective nutritional counselling to mothers[60].

Research shows that health promoting practices tend to cluster. That is, a mother who, for example, exclusively breastfeeds is more likely to engage in other positive practices[24]. So, it has been suggested that summary indices may be useful to

comprehensively assess the cumulative effect of various dimensions of child feeding and/or health practices on child nutritional status, while accounting for the interrelationships between these practices[51]. Thus, conceptually, one would expect the effect size (i.e. adjusted mean HAZ difference between high and low categories) of the index on child HAZ to be higher than that of single practices. However, in the present analysis, only a few components (i.e. breast-feeding and dietary diversity) were associated with child HAZ, and the effect size of each of these components on child HAZ was comparable to that of the ICFI. Moreover, the addition or removal of the ICFI from the model did not significantly change the adjusted R^2 (data not shown). These results suggest that, at least in this sample, these indices did not perform better than individual practices. Although indices have some advantages, such as summarising information on child feeding or health practices, they can also mask the individual practices they include[34]. In addition, while composite indices have previously been used to examine associations between feeding/health practices and child nutritional status in various settings, there still no consensus on methodology to construct these indices. Therefore, further research is required to validate these indices and to address their limitations. Such research could, for example, examine the performance of ICFI constructed by including other aspects of child feeding such as hygiene practices during food preparations, the types or amounts of foods as opposed to food groups.

Among covariates, child age, sex (male) and altitude were negatively associated with HAZ. These factors have been found to be associated with child stunting in Rwanda[61, 62] and other sub-Saharan African countries[63]. In addition, maternal height and infant birth weight were positively associated with child HAZ. This relationship has been described in previous studies showing that both maternal height and child birthweight reflect the prenatal environment and strong determinants of subsequent child nutritional status[64, 65]. The association between maternal height and child HAZ may be explained by two mechanisms: shorter mothers have small uterine volume which constrains fetal

growth[66], and/or placental transport mechanisms that limit provision of nutrients to the fetus and growth[67]. It is also suggested that this association could reflect shared genetic factors and/or common environmental factors that affect a mother during her early childhood and subsequently the growth of her offspring[68]. However, studies indicated that, in early childhood, the effect of environmental factors on child linear growth is stronger than that of genetic factors, especially in poorer regions where adverse environmental conditions, such as poor quality of diet and diseases, may not permit full expression of height potential[68-70]. A significant negative association was observed between child morbidities (diarrhoea and respiratory infection) and child HAZ, but only in younger children. This finding corroborates the previous aforementioned longitudinal study[23] that also found a significant negative association between days with diarrhoea or respiratory infection with decreased child linear growth among children aged < 12 months.

Strengths and limitations

One of the strengths of the present study is the use of summary indices to comprehensively examine the relationship between a variety of feeding and health practices and child HAZ. There are some limitations to the present study. First, the cross-sectional nature of the present study means that our analysis cannot establish causal relationships. A longitudinal study design is recommended to somewhat address this limitation. Second, the study was conducted in one district only and was limited to the lowest socio-economic groups, which limits the generalisability of our findings. Third, most of the information on feeding and health practices was obtained from mothers' recall which is prone to recall bias and social desirability. Fourth, although we used the standard 24 h recall method to assess child feeding practices, dietary information may not represent the usual diet of children because certain foods may be infrequently consumed. For example, the consumption of animal source foods may be rare whereas

some fruits may be available only in certain seasons. Lastly, even though we controlled for several covariates, we cannot rule out the influence of unmeasured variables, such as hygiene and sanitation which are known to influence child nutritional status, particularly in resource-limited settings[53].

4.7 Conclusion

Findings from the present study indicated that stunting among children 6–23 months in Rutsiro district remains of high public health concern, and that child HAZ is associated with both pre- and postnatal factors. The results on the relationship between ICFI, HPI and child HAZ provided a mixed picture, making the overall conclusion regarding the role of care practices less clear cut. On one hand, the finding of a positive association between ICFI and child HAZ supports our assumption that better feeding practices are positively associated with better child HAZ in this setting. On the other hand, however, the fact that only a few components of the ICFI were significantly associated with child HAZ (findings also observed in other studies), and given the lack of a significant association between HPI and child HAZ, the findings of the present study raise questions on the usefulness of the composite indices and call for further research to validate such indices. Such research could help elucidate the strengths and weakness of using indices *v.* individual components. In the context of the present study, breast-feeding and child's dietary diversity appear to have potential to improve child HAZ.

References (Paper II)

1. de Onis M (2006) WHO Child Growth Standards based on length/height, weight and age. *Acta Paediatr* 95, 76-85.
2. Development Initiatives (2018) 2018 Global Nutrition Report: Shining a Light to Spur Action on Nutrition. Bristol: Development Initiatives.
3. United Nations Children's Fund (UNICEF), World Health Organization International Bank for Reconstruction and Development/The World Bank (2020) Levels and trends in child malnutrition: Key Findings of the 2020 Edition of the Joint Child Malnutrition Estimates. Geneva: World Health Organization.
4. Victora CG, Adair L, Fall C *et al.* (2008) Maternal and child undernutrition: consequences for adult health and human capital. *Lancet* 371, 340-357.
5. Gluckman PD, Hanson MA Beedle AS (2007) Early life events and their consequences for later disease: a life history and evolutionary perspective. *Am J Hum Biol* 19, 1-19.
6. World Health Organization (2014) Global Nutrition Targets 2025: Stunting Policy Brief (WHO/NMH/NHD/14.3). Geneva: World Health Organization.
7. Amugsi DA, Mittelmark MB, Lartey A *et al.* (2014) Influence of childcare practices on nutritional status of Ghanaian children: a regression analysis of the Ghana Demographic and Health Surveys. *BMJ Open* 4, e005340.
8. Kennedy E & Haddad L (1992) Food security and nutrition, 1971–91: lessons learned and future priorities. *Food Policy* 17, 2-6.
9. Engle PL, Bentley M Pelto G (2007) The role of care in nutrition programmes: current research and a research agenda. *Proc Nutr Soc* 59, 25-35.
10. Engle PL, Lhostika L Armstrong H (1997) The Care Initiative: Assessment, Analysis and Action to Improve Care for Nutrition. New York: United Nations Children's Fund.

11. Kennedy E & Peters P (1992) Household food security and child nutrition: the interaction of income and gender of household head. *World Dev* 20, 1077–1085.
12. Brown LV, Zeitlin MF, Peterson KE *et al.* (1992) Evaluation of the impact of weaning food messages on infant feeding practices and child growth in rural Bangladesh. *Am J Clin Nutr* 56, 994–1003.
13. Ruel MT, Levin CE, Armar-Klemesu M *et al.* (1999) Good care practices can mitigate the negative effects of poverty and low maternal schooling on children's nutritional status: evidence from Accra. *World Dev* 27, 1993–2009.
14. Zeitlin M (1991) Nutritional resilience in a hostile environment: positive deviance in child nutrition. *Nutr Rev* 49, 259–268.
15. National Institute of Statistics of Rwanda (2018) Comprehensive Food Security and Vulnerability Analysis 2018. https://www.wfp.org/publications/rwanda-comprehensive-food-security-vulnerability-analysis-december-2018 (accessed July 2020)
16. de Onis M, Borghi E, Arimond M *et al.* (2019) Prevalence thresholds for wasting, overweight and stunting in children under 5 years. *Public Health Nutr* 22, 175–179.
17. Ministry of Health [Rwanda] & United Nations Children's Fund (UNICEF) (2014) Knowledge, Attitudes and Practices Assessment on Early Nurturing of Children Report. Kigali: Ministry of Health & UNICEF Rwanda.
18. Lee J, Dusingizimana T Umutoni F (2016) Understanding consumer demand for nutritious food in Nyanza district, Rwanda. https://www.usaid.gov/sites/default/files/documents/1860/GAIN%20Summary%20Focused%20Ethnographic%20Survey%20Report.pdf (accessed June 2020)
19. Lung'aho M, Birachi E, Butare L *et al.* (2015) Rwanda Nutrition, Markets and Gender Analysis 2015: An Integrated Approach Towards Alleviating Malnutrition

Among Vulnerable Populations in Rwanda. Nairobi: Government of Rwanda/International Center for Tropical Agriculture (CIAT).

20. Ministry of Health (2014) Rwanda National Food and Nutrition Policy. http://www.moh.gov.rw/fileadmin/templates/policies/National_Food_and_Nutrition_Policy_.pdf (accessed July 2020)
21. Ngirabega JD, Leonard W, Munyanshongore C *et al.* (2010) Utilization of community based growth monitoring services by eligible children in rural Rwanda. *Rwanda Med J* 68, 40-47.
22. Uwiringiyimana V, Ocké MC, Amer S *et al.* (2019) Predictors of stunting with particular focus on complementary feeding practices: a cross-sectional study in the northern province of Rwanda. *Nutrition* 60, 11–18.
23. Matsiko E (2019) Exploring linear growth retardation in Rwandan children : Ecological and biological factors. PhD Thesis, Wageningen University.
24. Arimond M & Ruel MT (2001) *Assessing Care: Progress Towards the Measurement of Selected Childcare and Feeding Practices, and Implications for Programs. Discussion Paper 119*. Washington, DC: International Food Policy Research Institute.
25. Ruel MT & Menon P (2002) Child feeding practices are associated with child nutritional status in Latin America: innovative uses of the demographic and health surveys. *J Nutr* 132, 1180–1187.
26. Condo JU, Gage A, Mock N *et al.* (2015) Sex differences in nutritional status of HIV-exposed children in Rwanda: a longitudinal study. *Trop Med Int Health* 20, 17–23.
27. National Institute of Statistics of Rwanda (2012) 2012 Rwanda Fourth Population and Housing Census. District Profile: Rutsiro. Kigali: National Institute of Statistics of Rwanda.

28. Cochran WG (1977) *Sampling Techniques*, 3rd ed, *Wiley Series in Probability and Mathematical Statistics.* New York: John Wiley & Sons Inc.

29. National Institute of Statistics of Rwanda, Ministry of Health (MOH) ICF International (2015) *Rwanda Demographic and Health Survey 2014-15*. Rockville, Maryland: National Institute of Statistics of Rwanda (NISR) [Rwanda], Ministry of Health (MOH) [Rwanda] and ICF International.

30. Dimagi CommCare. https://www.dimagi.com/commcare/ (accessed January 2019)

31. Cogill B (2003) Anthropometric Indicators Measurement Guide. Washington, DC: Food and Nutrition Technical Assistance (FANTA) Project, FHI 360.

32. Jones AD (2015) The production diversity of subsistence farms in the Bolivian Andes is associated with the quality of child feeding practices as measured by a validated summary feeding index. *Public Health Nutr* 18, 329–342.

33. Arimond M & Ruel M (2002) Progress in Developing an Infant and Child Feeding Index: An Example Using the Ethiopia Demographic Health Survey 2000. Washington DC: International Food Policy Research Institute.

34. Sawadogo PS, Martin-Prevel Y, Savy M *et al.* (2006) An infant and child feeding index is associated with the nutritional status of 6-to 23-month-old children in rural Burkina Faso. *J Nutr* 136, 656–663.

35. World Health Organization (2010) Indicators for Assessing Infant and Young Child Feeding Practices: Part 2: Measurement. Geneva: World Health Organization.

36. Dewey KG (2003) Guiding Principles for Complementary Feeding of the Breastfed Child. Washington, DC: Pan American Health Organization/World Heath Organization.

37. Brown K, Dewey K Allen L (1998) Complementary Feeding of Young Children in Developing Countries: A review of Current Scientific Knowledge. Geneva: WHO.

38. Dusingizimana T, Weber JL, Ramilan T *et al.* A qualitative analysis of infant and young child feeding practices in rural Rwanda. *Public Health Nutr*. doi: 10.1017/S1368980020001081.

39. Ballard T, Coates J, Swindale A *et al.* (2011) *Household Hunger Scale: Indicator Definition and Measurement Guide*. Washington DC: Food and Nutrition Technical Assistance II Project, FHI 360.

40. Vyas S & Kumaranayake L (2006) Constructing socio-economic status indices: how to use principal components analysis. *Health Policy Plan* 21, 459–468.

41. Mosites EM, Rabinowitz PM, Thumbi SM *et al.* (2015) The relationship between livestock ownership and child stunting in three countries in Eastern Africa using national survey data. *PLoS One* 10, e0136686.

42. World Health Organization (2011) WHO Anthro for Personal Computers, Version 3.2.2: Software for Assessing Growth and Development of the World's Children. Geneva: World Health Organization.

43. World Health Organization (2006) *Multicentre Growth Reference Study Group. WHO Child Growth Standards: Length/Height-for-Age, Weight-for-Age, Weight-for-Length, Weight-for-Height and Body Mass Index-for-Age: Methods and Development*. Geneva: World Health Organization.

44. Textor J, Hardt J Knüppel S (2011) DAGitty: a graphical tool for analyzing causal diagrams. *Epidemiology* 22, 745.

45. Greenland S, Pearl J Robins JM (1999) Causal diagrams for epidemiologic research. *Epidemiology* 10, 37–48.

46. James G, Witten D, Hastie T *et al.* (2013) *An introduction to statistical learning*. vol. 112. New York: Springer.

47. World Health Organization & United Nations Children's Fund (2015) Joint Monitoring Programme (JMP) for water supply and sanitation. 2015.

48. Binagwaho A, Rukundo A, Powers S *et al.* (2020) Trends in burden and risk factors associated with childhood stunting in Rwanda from 2000 to 2015: policy and program implications. *BMC Public Health* 20, 83.

49. Onyango AW (2003) Dietary diversity, child nutrition and health in contemporary African communities. *Comp Biochem Physiol A Mol Integr Physiol* 136, 61–69.

50. Qu P, Mi B, Wang D *et al.* (2017) Association between the infant and child feeding index (ICFI) and nutritional status of 6- to 35-month-old children in rural western China. *PLoS One* 12, e0171984.

51. Moursi MM, Trèche S, Martin-Prével Y *et al.* (2008) Association of a summary index of child feeding with diet quality and growth of 6–23 months children in urban Madagascar. *Eur J Clin Nutr* 63, 718–724.

52. Ntab B, Simondon KB, Milet J *et al.* (2005) A young child feeding index is not associated with either height-for-age or height velocity in rural Senegalese children. *J Nutr* 135, 457–464.

53. Onyango AW, Esrey SA Kramer MS (1999) Continued breast-feeding and child growth in the second year of life: a prospective cohort study in western Kenya. *The Lancet* 354, 2041–2045.

54. Arimond M & Ruel MT (2004) Dietary Diversity Is Associated with Child Nutritional Status: evidence from 11 Demographic and Health Surveys. *J Nutr* 134, 2579–2585.

55. Menon P, Bamezai A, Subandoro A *et al.* (2015) Age-appropriate infant and young child feeding practices are associated with child nutrition in India: insights from nationally representative data. *Matern Child Nutr* 11, 73–87.

56. Grosshagauer S, Milani P, Kraemer K *et al.* (2020) Inadequacy of nutrients and contaminants found in porridge-type complementary foods in Rwanda. *Matern Child Nutr* 16, e12856.

57. Matsiko F, Kanyange C, Ingabire G *et al.* (2017) Detection and quantification of aflatoxin in cassava and maize flour sold in Kigali open markets, Rwanda. *Int Food Res J* 24, 459–464.

58. Gong Y, Hounsa A, Egal S *et al.* (2004) Postweaning exposure to aflatoxin results in impaired child growth: a longitudinal study in Benin, West Africa. *Environ Health Perspect* 112, 1334–1338.

59. Liu X, Behrman JR, Stein AD *et al.* (2017) Prenatal care and child growth and schooling in four low- and medium-income countries. *PLoS One* 12, e0171299.

60. Ashworth A, Shrimpton R Jamil K (2008) Growth monitoring and promotion: review of evidence of impact. *Matern Child Nutr* 4 86–117.

61. Habyarimana F, Zewotir T, Ramroop S *et al.* (2016) Spatial distribution of determinants of malnutrition of children under five years in Rwanda: Simultaneous measurement of three anthropometric indices. *J Hum Ecol* 54, 138–149.

62. Uwiringiyimana V, Veldkamp A Amer S (2019) Stunting spatial pattern in Rwanda: an examination of the demographic, socio-economic and environmental determinants. *Geospat Health* 14.

63. Wamani H, Åstrøm AN, Peterson S *et al.* (2007) Boys are more stunted than girls in Sub-Saharan Africa: a meta-analysis of 16 demographic and health surveys. *BMC Pediatr* 7, 17.

64. Young MF, Nguyen PH, Gonzalez Casanova I *et al.* (2018) Role of maternal preconception nutrition on offspring growth and risk of stunting across the first 1000 days in Vietnam: A prospective cohort study. *PLoS One* 13, e0203201.

65. Schmidt MK, Muslimatun S, West CE *et al.* (2002) Nutritional status and linear growth of Indonesian infants in west Java are determined more by prenatal environment than by postnatal factors. *J Nutr* 132, 2202–2207.

66. Zhang X, Cnattingius S, Platt RW *et al.* (2007) Are Babies Born to Short, Primiparous, or Thin Mothers “Normally” or “Abnormally” Small? *J Pediatr* 150, 603–607.e603.

67. Price KC & Coe C (2000) Maternal constraint on fetal growth patterns in the rhesus monkey (Macaca mulatta): the intergenerational link between mothers and daughters. *Hum Reprod* 15, 452–457.

68. Hernandez-Diaz S, Peterson K, Dixit S *et al.* (1999) Association of maternal short stature with stunting in Mexican children: common genes vs common environment. *Eur J Clin Nutr* 53, 938–945.

69. Jelenkovic ASund RHur YM *et al.* (2016) Genetic and environmental influences on height from infancy to early adulthood: an individual-based pooled analysis of 45 twin cohorts. *Sci Rep* 6, 28496.

70. Liu Q, Yu C, Gao W *et al.* (2015) Genetic and Environmental Effects on Weight, Height, and BMI Under 18 Years in a Chinese Population-Based Twin Sample. *Twin Res Hum Genet* 18, 571–580.

Chapter 5 A mixed-methods study of factors influencing access to and use of micronutrient powder in Rwanda

As highlighted in Chapter 2 (literature review), anaemia in Rwanda is another form of undernutrition, affecting 37% of all children under 5 years and 60–70% of those aged 6–11 months. Given that in many low- and middle-income countries, including Rwanda, stunting coexists with anaemia[97], and having identified gaps in infant and young child feeding (IYCF) practices and their potential negative impact on the use of multiple micronutrients powder (MNP) that are distributed as part of complementary feeding programmes to improve child nutritional status (Chapter 3), it was deemed important to determine to what extent these practices as well as other factors affect the use of MNP by children in a large sample. The study presented in this chapter is based on Paper III entitled "A mixed-methods study of factors influencing access to and use of MNP programme in rural Rwanda." Data from this chapter were also orally presented at the Micronutrient Forum 5th Global Conference: Connected 2020 (November 2–20, 2020).

This chapter is not an exact replication of the submitted version. It has been formatted according to the Massey University guidelines, and minor changes, including references to appropriate appendices have been included in the thesis.

This chapter is under review in the *Global Health: Science and Practice* (Manuscript No: GHSP-D-20-00422R1).

5.1 Abstract

The World Health Organization (WHO) recommends provision of multiple micronutrients powder (MNP) to children aged 6–23 months where anaemia among children under 2 years or under 5 years is 20% or higher. In Rwanda, anaemia affects 37% of children under 5 years, and multiple micronutrient powder (MNP) supplementation programme is implemented to address anaemia. However, research on factors affecting the MNP programme implementation is limited. We conducted a mixed-methods study to examine the factors influencing access to and use of micronutrient powders (MNP) in Rwanda. Qualitative data indicated that lack of MNP supplies and limited information about the MNP programme were the main barriers to access MNP. We also found that the use of MNP is influenced by perceived side effects, mothers' perceptions, as well as inadequate complementary feeding practices. Results from logistic regression analysis showed that mothers of older children (12–23 months) were more likely to use MNP than those of younger children (6–11 months) (adjusted odds ratio [aOR]= 3.63, P< 0.001). Mothers whose children participated in the supplementary food programme were nearly three times more likely to use MNP than those whose children had never participated in the programme (aOR= 2.84, P= 0.001). Increasing household hunger score was significantly associated with lower odds of using MNP (aOR= 0.80, P= 0.038). Gaps in infant and young child feeding practices and lack of adequate foods must be addressed. Mechanisms to monitor MNP supply and programme implementation need to be strengthened to ensure mothers have access to the product.

Keywords: micronutrient powders, micronutrient supplementation, child feeding practices, anaemia, Rwanda

5.2 Introduction

Inadequate intake of micronutrients is recognized as one of the most important contributors to the global burden of diseases.[1] It has been estimated that about two million children worldwide die (19% of total child deaths) each year due to insufficient micronutrient intake, mainly of iron, vitamin A and zinc.[1] Iron deficiency is the most common micronutrient deficiency worldwide[2], and it has numerous functional consequences on child health, including low birth weight, impaired physical growth, and poor neurocognitive development[3,4]

In Rwanda, the prevalence of anaemia among children under 5 years of age declined significantly from 52% in 2005 to 38% in 2010;[5] but the most recent Demographic and Health Survey (DHS) found that 37% of children under 5 years of age had anaemia in 2019-20.[6] The same survey showed that children aged 6–23 months were the most affected. For example, anaemia affects 70% of children aged 6–8 months and 64% of those aged 9–11 months.[6] Although other factors, such as parasite infections, may contribute to the high rates of anaemia, evidence suggests that iron deficiency, resulting from inadequate dietary iron intake and/or low bioavailability, and increased needs for iron during child growth is a major cause.[7] Like in many other low- and middle-income countries, the diets of Rwandan children are predominantly plant-based, thus contain low bioavailable iron.[8] A recent study conducted in Rwanda found that > 60% of children aged 6–23 months do not meet their requirements for iron and other minerals such as calcium and zinc due to low nutrient density for these micronutrients in complementary foods.[9] The consumption of iron-rich foods, such as animal source foods, and commercial fortified infant foods is low among children aged 6–23 months (20% and 2%, respectively).[5] This type of diet makes it difficult for young children to meet their requirements for iron and other micronutrients during the critical development stages.[10]

The Rwandan food and nutrition policy[11] recognises the severity of anaemia among Rwandan children, and has proposed several solutions, including dietary diversity promotion, food fortification, point-of-use fortification with micronutrient powders, use of biofortified crops (e.g. high iron beans), and deworming[11]. The Rwandan government also implements a supplementary food programme which aims to address undernutrition in the child's first 1000 days of life. The programme provides fortified complementary blended porridge flour (locally known as *Shisha Kibondo*) to pregnant and lactating mothers as well as young children aged 6−23 months from the most vulnerable households[12]. Moreover, in 2011, the government of Rwanda, with support from the United Nations Children's Fund (UNICEF), introduced a point-of-use fortification programme using multiple micronutrients powder (MNP) as a measure to improve the nutritional quality of complementary foods consumed by children aged 6–23 months and to prevent micronutrient deficiencies among these children.[13]

The point-of-use fortification of complementary foods with iron-containing MNP is recommended in populations where anaemia prevalence among children under 2 or under 5 years of age is 20% or more.[14] Studies conducted in many countries, including Rwanda, with high burden of anaemia demonstrated efficacy of MNP in reducing the prevalence of anaemia and iron deficiency among children aged 6–24 months.[15,16] While MNP interventions have been shown to be efficacious in many studies, they are often conducted in controlled trials using resources that are not usually available during a national implementation or scale-up.[17] In some settings, MNP programmes have thus been ineffective[18,19] due, in part, to contextual factors. For example, a study in Uganda [19] found that mothers cooked foods with soda ash to reduce cooking time. The authors argued that the ash might have negatively influenced the bioavailability and absorption of micronutrients, making MNP programme ineffective. It is also acknowledged that contextual factors such as beliefs, resource constraints, etc. have an influence on the

coverage and utilization of nutrition programmes targeting infants and young children.[20] A review[21] of 11 studies on coverage of nutrition programmes, including MNP programmes, in 5 countries reported a significant variability in message coverage (i.e. whether respondents have ever heard of the product), contact coverage (whether the product has ever been fed to the child) or effective coverage (i.e. whether the product has been utilized as per the recommended frequency and quantity or whether the product has been consumed in the previous 7 days[22]) due to different context-specific factors in which the programmes were implemented. The review concluded that achieving impact at scale of such programmes requires a better understanding of the factors affecting coverage and utilization.[21] The need for research to understand the factors influencing MNP programme implementation in a variety of contexts has been recognized.[23,24]

The purpose of the present study was to examine the factors influencing access to and use of MNP among mothers in Rwanda. In the context of the current study, the MNP programme is of interest for several reasons. First, the MNP programme was introduced in Rwanda in 2011. Second, the programme was adopted by the Rwanda's 2013 national food and nutrition strategic action plan to address anaemia in a group of children aged 6–23 months with the highest anaemia prevalence.[11] Third it was scaled up in all 30 districts of Rwanda in 2017.[13] However, despite these efforts, the prevalence of anaemia among children aged 6–23 months has barely changed between 2010 and 2020.[6,11]

5.3 Methods

This study was conducted in Rutsiro district, northwest of Rwanda, approximately 140 km from the capital city, Kigali. The district has the highest prevalence of child stunting (54%) among children under 5 years.[25] The majority (~98%) of the district's population is rural, and agriculture on small plots of land is the main livelihood.[26] The main subsistence crops are maize, beans, banana plantain, cassava and, sweet and Irish

potatoes. The health system in the district consists of one hospital and 17 health centres[27]. Each health centre oversees community health workers (CHWs) who provide community-based nutrition and other health services to approximately 23,000 inhabitants living within the health centre's catchment area.[28]

Among the services provided by CHWs include distribution of MNP, locally known as *Ongera*, to caregivers with children aged 6–23 months. In Rwanda, MNP are normally delivered to district hospitals by the Ministry of Health or UNICEF; and district hospitals distribute MNP supplies to health centres. The health centres distribute MNP to CHWs, who, in turn distribute MNP to caregivers during monthly child growth monitoring and promotion activities. Every caregiver with a child aged 6−23 months is entitled to 30 sachets of MNP, which they are receive free of charge. Using cooking demonstrations, CHWs also counsel caregivers on optimal complementary feeding practices, such as age-specific dietary diversity, consistency and quantity of complementary foods, and on MNP usage (i.e. adding MNP to thick, solid or semi-solid complementary foods before consumption, 1 sachet of MNP/day, 3 times/week).[8,13]

5.3.1 Study design and participants

This study was a cross-sectional convergent mixed-methods design[29], combining both quantitative and qualitative data. The data used in this study were collected as part of a survey conducted between September 2018 and January 2019 to investigate the factors associated with nutritional status of children aged 6–23 months. Details on the survey sample size estimation and participants recruitment are described elsewhere[30]. Briefly, the district was first divided into 3 zones based on main roads connecting the district to its neighbouring districts. In each zone, 3 health centres were purposely selected, for a total of 9 health centres. Within each of the selected health centre's catchment area, two villages were randomly selected. In these villages, monthly growth monitoring lists were obtained from community health workers and used to compile a sampling frame from

which participants were randomly selected using random tables. Mothers who refused to participate, and those who were not found in their homes were replaced (11 mothers in total) by selecting the next name on the list. Eligibility criteria were: (1) having a child aged 6–23 months; (2) child was apparently healthy, i.e. no overt signs of illness; and (3) being in the two lowest socioeconomic categories. Of the 400 survey participants, twenty-one (5%) of the children were excluded from the analysis due to premature birth (i.e., before 37 weeks of gestation) or low birthweight (i.e., less than 2.5 kg). The remaining 379 participants form the basis of the present study.

5.3.2 Data collection

Quantitative and qualitative data were collected in parallel using a survey questionnaire **(Appendix 14** – the same questionnaire as used in Chapter 4). The questionnaire was developed in English, translated in Kinyarwanda and programmed into a hand-held tablet (Samsung Galaxy Tab 8.0 T295, Korea). It was pre-tested, and data were collected through face-to-face interviews. Interviews were conducted by the first author.

5.3.2.1 Quantitative data

Outcome variable

"Ever using MNP" was the primary outcome variable. Mothers were asked if they added (yes/no) MNP to the target child's foods in the last 7 days prior to the survey. Mothers who had not used MNP were asked whether they ever used MNPs before (yes/no). A mother was categorised as "ever used MNP" if she had used MNP in the previous 7 days or before, and those who had not used MNP neither within 7 days prior to the survey nor before were categorised as "never used MNP."

Other variables

Information related to participants' demographics, socioeconomic, household food security, and indicators of health system engagement were obtained through mothers'

recall. Health cards were used for verification (e.g. child's age, and heath information). Demographic information reported by mothers included child's age and sex, and maternal age at first birth. Mothers also reported presence of symptoms of child diarrhoea (defined as ≥ 3 watery or loose stools per day) and upper respiratory infections (runny nose, coughing, or wheezing) in the previous 4 weeks. Socioeconomic variables included maternal education level (coded as none/incomplete primary education, complete primary education, secondary education) and household asset ownership (e.g. radio, land, domestic animals, housing characteristics). Fourteen household assets were used to create a household wealth index using principal component analysis.[31] The first component was taken to represent the household wealth index and divided into terciles (lower, middle, and upper). A household hunger score – a proxy of a household's ability to access food – was measured using a validated cross-cultural household hunger scale (HHS).[32] Following the HHS measurement guide, mothers were asked three questions intended to capture three situations (i.e. lack of food of any kind in the house; going to sleep hungry because there was not enough food; and going a whole day and night without eating) reflecting a household's experience of insufficiency of food supply and intake and physical consequences. Each question was followed by the frequency-of-occurrence question, i.e. how often the reported situation was experienced. The responses were coded and used to generate a household hunger score which ranged from 0 (indicating no hunger) to 6 (indicating severe hunger). Indicators of health system engagement are (i) attendance at growth monitoring site in the previous month (coded as yes/no); (ii) the number of antenatal care visits when pregnant with the study child (coded as < 4 visits or ≥ 4 visits; a minimum of 4 visits is recommended in Rwanda[5]); and (iii) whether the child ever participated in the supplementary food programme (coded as yes/no).

5.3.2.2 Qualitative data

The questionnaire included an open-ended question, which was used to collect in-depth information on the reasons for not using MNP. Mothers who had not used MNP in the previous 7 days (i.e. those who used MNP but not in the previous 7 days and those who never used MNP; see Table 2, n= 234) were asked to provide reasons for not using MNP. Probes (either open-ended or specific to the mothers' comments) were used to obtain additional information.[33]

5.4 Data analysis

Quantitative data: Median (interquartile range [IQR]) were determined for continuous data and percentage for categorical data. Bivariate and multiple logistic regression analyses were performed to examine factors associated with using MNP. The full model adjusted for the presence of diarrhoea and respiratory infection in the past 4 weeks.[34] We adjusted for these variables because our previous research in the same population showed that child illness has negative effects on how mothers feed their children, including withholding or restricting some foods from children's diets. Unadjusted and adjusted odds ratios (OR) and 95% confidence intervals (CI) were computed. Variables with P value < 0.05 were considered significant predictors. All statistical analyses were performed using SPSS version 25.0 (IBM Corp, Armonk, NY, 2018).

Qualitative data: Mothers' responses to the questions on reasons for not using MNP were audio-recorded, transcribed verbatim and translated into English. Content analysis[35] was used to analyse the data. Inductive content analysis approach, which is recommended when there is no prior research, or little is known about the studied phenomenon, was used. The data analysis had three phases: preparation, organization and reporting.[36] The first phase consisted of careful reading of the data several times to become immersed and familiar with the data. In the organization phase, each transcript was read carefully by the first author, highlighting the text (words or phrases) that

appeared to describe the phenomenon under study (i.e. access to and/or use of MNP). The highlighted texts were openly and manually coded by giving each text a descriptive code. The second author read the data to confirm the descriptive codes. The descriptive codes were revised, and the codes that emerged from the revision were jointly reviewed before integrating them into the analysis. Final codes were examined, compared and grouped into categories that represented similar meaning.[37] The first, second and last authors reviewed, discussed and agreed on the final code categories. In the final phase of analysis, SPSS (version 25) was used to quantify the frequency of major categories and sub-categories of the codes.[38] To interpret and report the findings, examples of original textual responses representing specific code or category are presented.

The Human Ethics Committee of the Massey University and by the Institutional Review Board of the University of Rwanda approved the study. A permission to collect data was also obtained from the District Public Health Office. Oral informed consent was obtained from all participants.

5.5 Results

5.5.1 Quantitative results

Characteristics of the participants (n= 379) are presented in **Table 5.1**. The median (IQR) age of children was 15 (11-19) months whereas the median (IQR) age of mothers at first birth was 22 (20–24) years. More than a half (59%) of the mothers had either no education or did not complete primary education, and only 35% of the mothers had ≥ 4 antenatal care visits during their last pregnancy. The median (IQR) household size was 4 (3–6) members.

Table 5-1 Sociodemographic and nutritional characteristics of the study participants (n= 379)

Characteristic	n (%) or median (IQR)
Child age, months, median (IQR)	15 (11–19)
Child age group	
6–11 months	120 (32)
12–23 months	259 (68)
Sex	
Male	184 (49)
Female	195 (51)
Child had diarrhoea (past 4 weeks) – yes	179 (47)
Child had respiratory infection (past 4 weeks) – yes	297 (78)
Child ever participated in the supplementary food programme – yes	283 (75)
Mother's age at first birth, years, median (IQR)	22 (20–24)
Mother's education level [1]	
Illiterate/Incomplete primary	219 (59)
Completed primary	88 (24)
Some secondary	62 (17)
No. of antenatal care visits attended	
1–3	248 (65)
4 +	131 (35)
Mother attended child growth monitoring site (past month) – yes	318 (84)
Household hunger score, median, (IQR)	1 (1–2)
Household size, median (IQR)	4 (3–6)
Wealth index tertiles	
Lower	126 (33)
Middle	126 (33)
Upper	127 (34)

Abbreviations: MNP, multiple micronutrients powder; IQR, interquartile range
[1] Owing to missing data, n= 369

The majority of the mothers (64%) reported ever adding MNP to their children's food (**Table 5.2**). However, only 38% added MNP to their children's food in the previous 7 days. The proportion of mothers using MNP to feed their children was significantly lower among mothers with children aged 6–11 months than among those with children aged 12–23 months (39% vs. 76%, P< 0.001) (results not shown).

Table 5-2 Proportion of Mothers who Used/Did not Use MNP to Feed their Children (n= 379) by Age Group, in Rutsiro District, Rwanda, September 2018 – January 2019[1]

Age group (months)	N	Used MNP in the past 7 days	Used MNP but not in the past 7 days	Ever used MNP[2]	Never used MNP
6–8	57	10 (17)	2 (4)	12 (21)	45 (79)
9–11	63	22 (35)	13 (21)	35 (56)	28 (44)
12–23	259	113 (44)	83 (32)	196 (76)	63 (24)
Total	379	145 (38)	98 (26)	243 (64)	136 (36)

MNP indicates micronutrient powders
[1] Values are n (%).
[2] Sum of "used in the past 7 days" and "used MNP but not in the past 7 days."

Table 5.3 shows that mothers of older children (12–23 months) were about four times more likely to use MNP than those of younger children (6–11 months) (aOR= 3.63, P< 0.001). Similarly, mothers whose children ever participated in the supplementary food programme were three times more likely to use MNP than the mothers whose children have never participated in the programme (aOR= 2.84, P< 0.001). Conversely, as the household hunger score increases by one unit, the odds of using MNP decreased significantly by about 20% (aOR= 0.80, P= 0.038). Even though attendance to growth monitoring was a significant predictor of the use of MNP, this variable was not significant in the adjusted model.

Table 5-3 Multiple logistic regression model for factors Associated with the Use of MNP in Rutsiro District, Rwanda, September 2018–January 2019[1]

Variables	COR (95% CI)	P-value	aOR (95% CI)	P
Child age group		< 0.001		< 0.001
6–11 months	1		1	
12–23 months	4.83 (3.04, 7.68)		3.63 (2.14, 6.16)	
Child sex		0.52		0.53
Female	1		1	
Male	0.87 (0.57, 1.33)		0.86 (0.53, 1.39)	
Maternal age at first birth	1.03 (0.96, 1.09)	0.41	1.01 (0.94, 1.09)	0.82
Maternal education level		0.32		0.44
None/incomplete primary education	1		1	
Complete primary education	1.12 (0.67, 1.88)		1.01 (0.56, 1.83)	
Some secondary education	1.62 (.87–3.01)		1.57 (0.77, 3.19)	
ANC visits		0.82		0.60
< 4 visits	1		1	
≥ 4 visits	0.95 (0.61, 1.47)		0.87 (0.53, 1.45)	
Mother attended GM (past month)		0.01		0.43
No	1		1	
Yes	2.10 (1.21, 3.45)		1.31 (0.68, 2.53)	
Child ever participated in the supplementary food programme		< 0.001		0.001
No	1		1	
Yes	4.54 (2.78, 7.41)		2.84 (1.57, 5.13)	
Household hunger score	0.89 (0.76, 1.05)	0.18	0.80 (0.65, 0.99)	0.038
Household wealth index		0.77		0.26
Lowest tertile	1		1	
Middle tertile	1.20 (0.71, 2.00)		0.83 (0.45, 1.56)	
Upper tertile	1.01 (0.61, 1.69)		0.59 (0.31, 1.13)	

Abbreviations: COR, crude odds ratio; aOR, adjusted odds ratio; CI, confidence interval; ANC, antenatal care; GM, growth monitoring. [1]The model was adjusted for the presence of child diarrhoea and respiratory infection in the previous 4 weeks.

5.5.2 Qualitative results

Factors influencing access to and use of MNP are summarized into 9 categories. Below we present results for 6 major categories. A summary of these 6 categories, as well as other three minor categories are presented in the Supplemental Table **(Appendix 9).**

Limited availability of MNP supplies*:* A frequently reported barrier to accessing to MNP was the lack of supplies. One-third (n= 72) of the mothers reported getting information from CHWs that there was no MNP stock at their health centres. For example, one mother said:

> "I don't have Ongera (MNP) now. We get it from health workers but this month they said they don't have Ongera in the stock at the health centre. They told us to come on 13th of November when we take children for growth monitoring." Mother # 199.

CHWs–mother interactions*:* Most mothers reported receiving MNP from CHWs through monthly growth monitoring activities while others reported occasionally receiving MNP from health centres (e.g. when mothers took children there for immunization). However, information received from CHWs in the study area indicated that, if mothers ran out of MNP prior to the next distribution date, the mothers were encouraged to contact CHWs and, if available, acquire more MNP sachets. However, some mothers (n= 33) said that they preferred to wait for routine distribution of MNP, which they felt was the responsibility of CHWs:

> "I don't have Ongera [MNP]. We used all the sachets that we had received at village kitchen. I am waiting for our CHW to distribute Ongera. I don't go to her house to ask for Ongera because they [CHWs] are supposed to distribute. Many times, we were told: wait, wait. So, I prefer to wait, and if I don't have Ongera, it's their fault." Mother # 39.

The narratives also suggested that interactions between mothers and CHWs may be limited, by non-attendance to growth monitoring sites due to other competing interests (n= 6), such as the need to work for income to meet family needs. One mother said:

> "I received Ongera once; we used them up all. It's been a while without attending growth monitoring session. Most of the days for growth monitoring are days that I am working. Working is most important. It's how we get money to survive" Mother # 23.

***Limited information**:* Some mothers (n= 16) explicitly said that they did not know about MNP. A few mothers reported having heard about but not seen MNP (n= 4); others mentioned that they were unaware of the distribution schedules or eligibility criteria (n=6). One mother said:

> "I have never received Ongera. I think there are some children who are eligible… may be those that can feed themselves…, and others who are not eligible." Mother # 187

***Perceived side effects**:* Some mothers (n= 19) reported that they stopped using MNP to feed their children because of side effects experienced by their children after consumption of MNP. Diarrhoea was the most frequently reported side effect experienced, while other side effects included vomiting and fever. While most mothers who reported side effects spoke from their own children's experiences, a few mothers decided not to use MNP because of the comments by other mothers in their community about the negative side effects of MNP:

> "I received Ongera this month when he just turned 9 months. I fed him Ongera, like three times, and then he started having diarrhoea. So, I stopped adding it to his foods." Mother # 225.

> “I received 30 sachets of Ongera last month. I just kept them. I heard from other mothers that Ongera causes diarrhoea, so I never fed it to my child.” Mother # 316.

Several mothers (n= 20) also linked MNP with changes in taste of food, stating that their children disliked foods which were prepared with MNP. One mother said:

> “We have used all the sachets [of Ongera] that we received this month. But even when it was still available, he did not really like the foods when it was mixed with Ongera. I used to give him and skipped some days” Mother # 170.

Incompatibility between MNP programme recommendations and current child feeding practices*:* Several mothers (n= 33), especially those with younger children (6–8 months), reported never using MNP due to reasons related to feeding practices. For example, many of these mothers (n= 27) said that their “child had just started eating” complementary foods or that the “child was still adapting to complementary foods. Others (n= 6) mentioned that they had not yet introduced complementary foods to the child:

> “I obtained Ongera a week ago, but I have not yet started giving it to my child. She is not yet ready for all foods. She is only 7 months. We give her things like a spoon of porridge or soft Irish potatoes. I mash them with my fingers. We don't add Ongera in the porridge. We add sugar, not Ongera.” Mother # 228.

MNP were perceived as intended for malnourished children*:* There were perceptions among some mothers (n= 11) that MNP are intended for malnourished children. Those mothers perceived their children as healthy and not requiring MNP. When asked to justify their judgement regarding the healthiness of their children, the mothers explained that their child was visually not sick or did not show any signs of malnutrition. Physical appearance, weight loss and hair discoloration were the most common signs used to describe healthiness of the children:

"I know I can get Ongera from our village health worker. I don't have them now because I never asked. These [Ongera] are intended for malnourished children. My child has no health issues. He is healthy." Mother # 103.

"I don't have Ongera [MNP]. I have never fed him Ongera. Ongera are given to children who have *bwaki* (local term used to denote acute malnutrition). You don't know *bwaki*? It is when your child has golden hair and swollen tummy" Mother # 118.

5.6 Discussion

Limited information is available on the factors influencing access to and use of MNP in Rwanda. In the present study, we found that the proportion of mothers who added MNP to their children's foods in the previous 7 days was low (38%), especially with younger children aged 6–11 months. This proportion increases to 64% when considering all mothers who reported ever having added MNP to their children's foods. In a small-scale survey of 186 caregivers recruited from 19 of Rwanda's 30 districts that implemented MNP programme (n= 10 caregivers in each district), McLean *et al.* reported 87% coverage (defined as the proportion of caregivers receiving a box of MNP in the previous 3 months).[13] It is worth mentioning that our study found that some mothers who receive MNP still don't feed it to their children, so while receiving MNP is sometimes used as an indicator of programme coverage, the child consuming MNP may be a better indicator of actual programme success.[21] There is no consensus on a cut-off value for a satisfactory MNP programme coverage; however, it has been suggested that effective MNP programme performance should be appraised as satisfactory when > 70% of target children are currently receiving or consuming MNP.[39] Although estimating actual coverage was beyond the scope of this study, our results suggest that the MNP programme coverage in Rutsiro district is generally low.

In this study, a majority of mothers mentioned lack of MNP supplies as the major issue limiting mothers' access to MNP. Limited availability of MNP supplies has been identified as major constraint to access to MNP in many countries.[40,41] In Rwanda, lack of supplies and inadequate distribution of MNP were also reported as key obstacles limiting MNP programme coverage.[13] These findings highlight the need to ensure uninterrupted MNP supply in order to increase coverage of the MNP programme. However, even when MNP are available, there are factors related to MNP distribution arrangements that need to be considered. For example, while mothers were encouraged to pick up MNP sachets from their village CHWs, our data indicated that the mothers' expectation was to obtain MNP through routine distribution; although some narratives suggested there may be opportunity costs associated with attending the distribution sites. This suggests that the health system must ensure that mothers obtain MNP at no extra time cost. If mothers are to actively seek out for MNP, it is essential that they understand the health benefits of MNP.

Consistent with other studies,[17,40,42,43] qualitative results from the present study showed that perceived side effects (e.g. diarrhoea, vomiting) and change in taste of foods mixed with MNP were major barriers to using MNP. It has been suggested that possible changes to foods due to addition of MNPs and the potential negative side effects of MNP should be acknowledged and clearly communicated to caregivers before children start getting MNP.[24] Moreover, our results revealed the beliefs held by some mothers that MNP are mainly for undernourished children. According to these mothers, it was unnecessary to give MNP to their (perceived) healthy children. It is important to highlight that micronutrient deficiencies (also known as hidden hunger) such as anaemia often have no visible or immediate signs, and can coexist with other forms of undernutrition such as stunting, which is also not easily recognized.[44,45] Therefore, the beliefs among mothers that children do not need MNP because they lacked overt symptoms of ill-health

or undernutrition require further attention as they present important challenges for mothers, health professionals, as well as for MNP programme implementers. On one hand, these beliefs may undermine the demand for and use of MNP among mothers. On the other hand, the beliefs may make it difficult for the health professionals and MNP programme implementers to raise awareness among mothers about MNP. Research shows that belief is a key determinant of maternal healthcare seeking behaviour.[46] For example, a study conducted in Kenya found that parents who considered MNP as drugs were reluctant to use MNP in the absence of explicit child illness.[47] These findings point to the need for appropriate health messages to ensure mothers understand the health benefits and need for MNP intervention. More specifically, clear and straightforward messages such as “a child can still suffer from micronutrient deficiencies even when she/he is visually healthy” must be used. It has been suggested that, unless there is some perceived need, individuals may not use an intervention, even if free.[48]

MNP programmes are designed such that children should start receiving MNP as soon as they are 6 months. In the current study, we found that mothers of younger children were less likely to use MNP than mothers of older children. Similar findings have been reported in Nepal[49] where MNP programme coverage was lower among younger children (6–11 months) than among older children (≥ 12 months). In Mongolia, it was also reported that parents delayed feeding MNP to their children until an average of 13 months.[50] The authors of these two studies did not elucidate the factors responsible for the delay in feeding MNP to young children. Qualitative results from the present study suggested that the delay in receiving MNP by younger children was due, in part, to the current complementary feeding practices. For example, our data indicated that half of the mothers with children aged 6–8 months reported that they had never used MNP either because their child “was still adapting to complementary foods” or that the child “had not been introduced to complementary foods.” Previous studies conducted in

Rwanda showed that children were introduced to complementary foods later than recommended, i.e. 8 months,[13] and that dilute cereal porridges were the main food given to young children 2−8 months.[51] A recent study[52] conducted in the same population also found that thin porridges and stews/soups were the most common foods given to young children, and that the consistency of these foods hindered the use of MNP. It is recommended that MNP must be mixed with thick solid or semi-solid complementary foods because MNP dissolve in liquids which may change taste or colour of the foods, leading to less acceptance by children.[53] However, the recommendation to mix MNP with thick/solid or semi-solid foods which are introduced to children at a later stage is likely to delay the introduction of MNP to younger children. Therefore, rather than discouraging mothers not to use MNP with porridges or other soft foods, an alternative approach is to teach mothers how to improve the consistency of these foods using local ingredients such as ground nut or beans flours. Once an improved porridge/stew is accepted and feasibility to use it as a vehicle for MNP explored, it could facilitate the mothers to feed MNP to children using a culturally accepted and age-appropriate food vehicle. Similar approach has been found to be successful in Mali.[54]

Our findings also showed that access to food is a predictor of using MNP. We found that the odds of using MNP reduced significantly with increasing household hunger score. Another study in Niger found that lack of foods was a barrier to using MNP.[55] Results from the present study also showed that being a beneficiary of the supplementary food programme (*Shisha Kibondo*) was associated with higher odds of using MNP. However, it is worth noting that the supplementary food programme distributes a fortified cereal-based flour used to prepare porridge, which is not recommended to mix with MNP. Thus, although the influence of supplementary food programme on the use of MNP needs further exploration, it can be speculated that the provision of supplementary porridge flour allows mothers to use their limited resources – that would otherwise be used to buy

porridge flour – to buy other foods which were used to mix with MNP. Nevertheless, data show that Rutsiro remains the most food insecure district in Rwanda, with 62% of households consuming an inadequate diet in 2018.[25] In the context of such a widespread food insecurity, mothers' ability to appropriately use MNP may be limited. Therefore, addressing anaemia through MNP programme will require, in addition to better programme coverage, improvements in the household access to adequate foods.

Strengths and limitations

The strength of the current study is the integration of both quantitative and qualitative approaches. Limitations of this study include a cross-sectional design which only demonstrates association and not causal relationships. In addition, the study focused on one district. Thus, the findings may not be generalised to other districts. Moreover, our qualitative findings are based on mothers' perspectives, but it would be important to understand the perspectives of other key informants such as community health workers and health centre managers on how to improve uptake and/use of MNP. This could potentially provide additional insights into other context-specific factors that may also inform the MNP programme implementation.

5.7 Conclusion

Findings from the current study point to several issues that need to be addressed to improve the MNP programme implementation in Rwanda. The findings suggest the need for regular monitoring to gauge the continuity of MNP supply and availability at community level. However, even if MNP supply issues are addressed, it remains crucial to address gaps in complementary feeding practices, including inappropriate consistency of complementary foods and maternal perceptions about young children's developmental ability to consume a variety of foods, while enhancing mothers' access to foods. In order to increase the demand and use of MNP, the programme implementers must also ensure that mothers have a clear understanding of the health benefits of MNP.

Lastly, future research should examine the effect of other factors, including the quality of information and the frequency of interactions between CHWs and mothers on MNP programme implementation.

References (Paper II)

1. Black R. Micronutrient deficiency-An underlying cause of morbidity and mortality. *Bull World Health Organ.* 2003;81:79.
2. World Health Organization. Nutrition health topics: Micronutrient deficiencies. World Health Organization. https://www.who.int/nutrition/topics/en/. Published 2020. Accessed March, 2020.
3. Lozoff B. Iron deficiency and child development. *Food Nutr Bull.* 2007;28:S560-S571.
4. Soliman AT, Al Dabbagh MM, Habboub AH, Adel A, Humaidy NA, Abushahin A. Linear growth in children with iron deficiency anemia before and after treatment. *J Trop Pediatr.* 2009;55:324–327.
5. National Institute of Statistics of Rwanda (NISR) [Rwanda], Ministry of Health (MOH) [Rwanda], ICF International. *Rwanda Demographic and Health Survey 2014-15.* Rockville, Maryland: NISR, MOH and ICF International;2015.
6. National Institute of Statistics of Rwanda (NISR) [Rwanda], Ministry of Health (MOH) [Rwanda], ICF International. *Rwanda Demographic and Health Survey 2019-20 Key Indicators Report.* Kigali, Rwanda, and Rockville, Maryland, USA: NISR and ICF;2020.
7. Ahmed F. Anaemia in Bangladesh: a review of prevalence and aetiology. *Public Health Nutr.* 2000;3:385–393.
8. United Nations Children's Fund. *Nourishing a new generation in Rwanda: Scaling-up the point-of-use fortification programme nationwide.* New York: UNICEF;2019.
9. Umugwaneza M. *The development of food based dietary guidelines (FBDGs) for 6 to 23 month old Rwandan children*. South Africa, North-West University; 2017.

10. Dewey KG. The challenge of meeting nutrient needs of infants and young children during the period of complementary feeding: an evolutionary perspective. *J Nutr.* 2013;143:2050–2054.
11. Ministry of Health [Rwanda]. National food and nutrition strategic plan 2013-2018. In. Kigali: Ministry of Health; 2013.
12. Iruhiriye E, Olney DK, Ramani GV, Heckert J, Niyongira E, Frongillo EA. *Stories of change-Rwanda: Final report.* International Food Policy Research Institute;2019.
13. McLean J, Northrup-Lyons M, Reid RJ, et al. From evidence to national scale: An implementation framework for micronutrient powders in Rwanda. *Matern Child Nutr.* 2019;15:e12752.
14. World Health Organization. *WHO guideline: use of multiple micronutrient powders for point-of-use fortification of foods consumed by infants and young children aged 6–23 months and children aged 2–12 years.* World Health Organization,; 2016.
15. De-Regil LM, Suchdev PS, Vist GE, Walleser S, Peña-Rosas JP. Home fortification of foods with multiple micronutrient powders for health and nutrition in children under two years of age. *Evidence-Based Child Health: A Cochrane Review Journal.* 2013;8:112–201.
16. Michaux K. *Assessing the impacts of home fortification with micronutrient powders on anemia, growth, and diarrhoea in children aged 6 - 24 months living in rural Rwanda*. Vancouver, University of British Columbia; 2015.
17. Locks LM, Dahal P, Pokharel R, et al. Predictors of micronutrient powder (MNP) knowledge, coverage, and consumption during the scale-up of an integrated infant and young child feeding (IYCF-MNP) programme in Nepal. *Matern Child Nutr.* 2019;15:e12712.

18. Andrew A, Attanasio O, Fitzsimons E, Rubio-Codina M. Why is multiple micronutrient powder ineffective at reducing anaemia among 12–24 month olds in Colombia? Evidence from a randomised controlled trial. *SSM - Population Health.* 2016;2:95–104.

19. Ford ND, Ruth LJ, Ngalombi S, et al. An integrated infant and young child feeding and micronutrient powder intervention does not affect anemia, iron status, or vitamin a status among children aged 12–23 months in eastern Uganda. *J Nutr.* 2020;150:938–944.

20. Menon P, Covic NM, Harrigan PB, et al. Strengthening implementation and utilization of nutrition interventions through research: a framework and research agenda. *Ann NY Acad Sci.* 2014;1332:39–59.

21. Leyvraz M, Aaron GJ, Poonawala A, et al. Coverage of nutrition interventions intended for infants and young children varies greatly across programs: results from coverage surveys in 5 countries. *J Nutr.* 2017;147:995s–1003s.

22. Nguyen M, Poonawala A, Leyvraz M, et al. A Delivery Model for Home Fortification of Complementary Foods with Micronutrient Powders: Innovation in the Context of Vietnamese Health System Strengthening. *Nutrients.* 2016;8:259.

23. de Pee S, Kraemer K, van den Briel T, et al. Quality criteria for micronutrient powder products: report of a meeting organized by the World Food Programme and Sprinkles Global Health Initiative. *Food Nutr Bull.* 2008;29:232–241.

24. Pelletier D, DePee S. Micronutrient powder programs: New findings and future directions for implementation science. *Matern Child Nutr.* 2019;15:e12802.

25. National Institute of Statistics Rwanda. Comprehensive Food Security and Vulnerability Analysis 2018. In. Vol 2019. Kigali: National Institute of Statistics Rwanda; 2018.

26. National Institute of Statistics of Rwanda (NISR) [Rwanda], Ministry of Health (MOH) [Rwanda], ICF International. *Rwanda Demographic and Health Survey 2010.* Calverton, Maryland: NISR, MOH and ICF International;2012.

27. Rutsiro District [Government of Rwanda]. District Development Plan. Rutsiro District. http://www.rutsiro.gov.rw/fileadmin/templates/document/Rutsiro_DDP_2013-2018.pdf. Published 2018. Accessed March 2020, 2020.

28. World Health Organization. Primary health care systems (PRIMASYS): case study from Rwanda. World Health Organization. https://www.who.int/alliance-hpsr/projects/primasys/en/. Published 2017. Accessed March 2020.

29. Fetters MD, Curry LA, Creswell JW. Achieving integration in mixed methods designs-principles and practices. *Health Serv Res.* 2013;48:2134–2156.

30. Dusingizimana T, Weber JL, Ramilan T, Iversen PO, Brough L. An empirical study of factors associated with height-for-age z-scores of children aged 6−23 months in northwest Rwanda: the role of care practices related to child feeding and health. Br J Nutr. 2020:1-12. doi:10.1017/S0007114520004961.

31. Vyas S, Kumaranayake L. Constructing socio-economic status indices: how to use principal components analysis. *Health Policy Plan.* 2006;21:459-468.

32. Ballard T, Coates J, Swindale A, Deitchler M. *Household hunger scale: indicator definition and measurement guide.* Washington DC: Food and Nutrition Technical Assistance II Project, FHI 360;2011.

33. Hsieh HF, Shannon SE. Three approaches to qualitative content analysis. *Qual Health Res.* 2005;15:1277–1288.

34. Steyerberg EW, Eijkemans MJC, Harrell FE, Habbema JDF. Prognostic modeling with logistic regression analysis:in search of a sensible strategy in small data sets. *Med Decis Making.* 2001;21:45–56.

35. Krippendorff K. *Content analysis: An introduction to its methodology* 3ed. London: Thousand Oaks, Sage Publications, Inc; 2004.

36. Elo S, Kyngas H. The qualitative content analysis process. *J Adv Nurs.* 2008;62:107–115.

37. Patton MQ. *Qualitative research and evaluation methods.* 3 ed. Thousand Oaks. California: Sage Publications, Inc; 2002.

38. Leech NL, Onwuegbuzie AJ. An array of qualitative data analysis tools: A call for data analysis triangulation. *Sch Psychol Q.* 2007;22:557–584.

39. Reerink I, Namaste SM, Poonawala A, et al. Experiences and lessons learned for delivery of micronutrient powders interventions. *Matern Child Nutr.* 2017;13 Suppl 1:e12495.

40. Tumilowicz A, Habicht J-P, Mbuya MNN, et al. Bottlenecks and predictors of coverage and adherence outcomes for a micronutrient powder program in Ethiopia. *Matern Child Nutr.* 2019;15:e12807.

41. Mehta R, Martorell R, Chaudhuri I, et al. Use of monitoring data to improve implementation of a home fortification program in Bihar, India. *Matern Child Nutr.* 2019;15:e12753–e12753.

42. Jefferds MED, Ogange L, Owuor M, et al. Formative research exploring acceptability, utilization, and promotion in order to develop a micronutrient powder (sprinkles) intervention among Luo families in western Kenya. *Food Nutr Bull.* 2010;31:S179–S185.

43. de Barros SF, Cardoso MA. Adherence to and acceptability of home fortification with vitamins and minerals in children aged 6 to 23 months: a systematic review. *BMC Public Health.* 2016;16:299.

44. Mohammed SH, Larijani B, Esmaillzadeh A. Concurrent anemia and stunting in young children: prevalence, dietary and non-dietary associated factors. *Nutr J.* 2019;18:10.

45. de Onis M, Branca F. Childhood stunting: a global perspective. *Matern Child Nutr.* 2016;12:12–26.

46. Hill Z, Kendall C, Arthur P, Kirkwood B, Adjei E. Recognizing childhood illnesses and their traditional explanations: exploring options for care-seeking interventions in the context of the IMCI strategy in rural Ghana. *Trop Med Int Health.* 2003;8:668–676.

47. Kodish S, Rah JH, Kraemer K, de Pee S, Gittelsohn J. Understanding low usage of micronutrient powder in the Kakuma refugee camp, Kenya: findings from a qualitative study. *Food Nutr Bull.* 2011;32:292–303.

48. Shengelia B, Tandon A, Adams OB, Murray CJ. Access, utilization, quality, and effective coverage: an integrated conceptual framework and measurement strategy. *Soc Sci Med.* 2005;61:97–109.

49. Jefferds MED, Mirkovic KR, Subedi GR, Mebrahtu S, Dahal P, Perrine CG. Predictors of micronutrient powder sachet coverage in Nepal. *Matern Child Nutr.* 2015;11:77–89.

50. World Vision. *Effectiveness of home-based fortification of complementary foods with Sprinkles in an integrated nutrition program to address rickets and anemia.* Ulaanbaatar: World Vision;2005.

51. Michaux K, Anema A, Green T, et al. Home fortification with micronutrient powders: lessons learned from formative research across six countries. *Sight and Life.* 2014;28:26–32.

52. Dusingizimana T, Weber JL, Ramilan T, Iversen PO, Brough L. A qualitative analysis of infant and young child feeding practices in rural Rwanda. *Public Health Nutr.* 2020:1-10. doi:10.1017/S1368980020001081.

53. Siekmans K, Bégin F, Situma R, Kupka R. The potential role of micronutrient powders to improve complementary feeding practices. *Matern Child Nutr.* 2017;13:e12464.

54. Roschnik N, Diarra H, Dicko Y, et al. Adherence and acceptability of community-based distribution of micronutrient powders in Southern Mali. *Matern Child Nutr.* 2019;15:e12831–e12831.

55. Tripp K, Perrine CG, de Campos P, et al. Formative research for the development of a market-based home fortification programme for young children in Niger. *Matern Child Nutr.* 2011;7:82–95.

Chapter 6 Summary of findings, their implications and conclusion

6.1 Summary of findings

The first objective of this thesis focused on understanding how children in Rutsiro district are fed, and the factors influencing IYCF practices. Chapter 3 addressed this objective and contributed to our understanding of these factors and how they relate to child's dietary patterns. Such an understanding is crucial as it reveals context-specific barriers and/or facilitators to be targeted by interventions to improve IYCF practices[12].

In our qualitative study (Chapter 3), mothers appeared to be knowledgeable about the benefits of breast-feeding and to have a positive attitude towards breast-feeding. But in addition to being regarded as beneficial for children, breast-feeding was considered by mothers as an important component of household food supply system. The view among mothers that during food scarcity young breastfed children can rely on breast milk while available foods is given to non-breastfed children means that, over an extended period, breastfed children may receive insufficient energy and other nutrients from non-breastmilk sources, which increases their risk for undernutrition. It is accepted that breastmilk alone cannot provide children above the age of 6 months with enough nutrients needed for their growth[21].

Findings of Chapter 3 also demonstrated that mothers use two different food classification systems to make decisions related to food choices and child feeding. These classification systems reflect two different frameworks of reference for IYCF practices. In the first food classification system in which mothers classify foods into 3 groups (body building foods, energy foods, disease protective foods), the mothers refer to health/nutrition information received from health professionals. The second food classification system, which appeared to have a greater influence on mothers' feeding practices, draws from a system of cultural beliefs and perceptions related to physical properties and/or suitability of foods for young children. These findings concur with previous research showing that, in different settings and cultures, mothers' food choices

and child feeding decisions are not always conceptualised from the biomedical perspective (i.e. organizing foods based on their nutrients or biological attributes) which is used to formulate child feeding recommendations[134, 135]. For example, Sukkary-Stolba [136] described the "light" and "heavy" food classifications among urban poor mothers in Egypt, where "light" foods were perceived by mothers as suitable for toddlers while "heavy" foods were withheld because of the fear of negative impact on the toddlers' digestive system. Similarly, in many other parts of the world (see Kuhnlein & Pelto [137]), foods are labelled, for example, as "cold" or "hot" based on perceived (nutrition and health) properties of the foods. Interestingly, in our study, it appeared that the second food classification may not be absolute. Some mothers indicated that they could change how some foods were traditionally prepared to meet children's needs or adapt to their health status (e.g. preparing thick porridges when a child suffers from diarrhoea). Building on this positive practice, nutrition education messages could be formulated to increase awareness among mothers that thick foods provide children with more energy than thin foods.

Another finding of Chapter 3 was that current IYCF practices influence not only the diversity, quality and quantity of complementary foods fed to children, but also the success of intervention programmes that aim to fill gaps in children's nutrient intake. For example, we found that sweet potato is withheld from children's diet due to being classified as an adult food and/or the beliefs among mothers that the consumption of sweet potatoes results in child diarrhoea and/or acute malnutrition. This finding suggested that the nutritional benefits of the orange-fleshed sweet potato (OFSP) variety, which is currently being promoted in many sub-Sahara African countries to address vitamin A deficiencies (OFSP is a source of beta-carotene, a precursor of vitamin A)[138], could remain unrealized if mothers' beliefs about sweet potatoes remain unchanged. Also, the mothers' strong preference to feed their children complementary

foods of a watery/thin consistency was found to have a negative implication on the consumption of multiple micronutrients powder, which are distributed to mothers as part of IYCF programmes to prevent nutritional deficiencies, including iron deficiency anaemia. This finding was confirmed by results from Chapter 5 and it suggested that, in this setting, giving mothers information from the biomedical perspective (first food classification system) is not sufficient to override existing culturally-based feeding practices (which is reflected in the second food classification system – Chapter 3). Another important barrier to appropriate feeding practices identified in Chapter 5 was the mothers' inability to recognise undernutrition in the children which results in limited use of MNP. This again highlighted the need to identify a new approach to clearly communicate with and educate mothers on appropriate feeding practices.

Poverty and food insecurity were also mentioned as constraints to appropriate child feeding and childcare. The influence of poverty and food insecurity on child feeding practices and their potential implications are discussed later under this section.

The second objective of this thesis was to assess and compare care practices related to child feeding and health between caregivers with non-stunted and those with stunted children. An infant and child feeding practices index (ICFI) and health practices index (HPI) were first constructed (**Appendices 2 and 3)** and tertiles created. It was observed that the prevalence of stunting among children was significantly lower among mothers in the highest ICFI and HPI tertiles compared to children among mothers in the lowest tertiles. Mothers with non-stunted and those with stunted children were also compared based on individual practices from the indices. We found that only a few practices distinguished mothers with non-stunted from those with stunted children. These practices were current breast-feeding and dietary diversity indicator (**Table 4.2**). However, it is important to highlight that only 5% of the children were not breast-feeding at the time of the study; though nearly all non-breastfed children (14 out of 17) were

stunted. Two additional practices which tended to distinguish the mothers' care practices (in favour of those with non-stunted children; although the difference was not statistically significant), included food restriction during diarrhoea (P= 0.11) (**Table 4.3**) and diarrhoea treatment methods (P= 0.06) (**Table 4.4**). The fact that food restrictions during diarrhoeal episodes was reported by about a half of the mothers (46.2%), and that about half of the mothers (45.9%) did not seek appropriate treatment for child diarrhoea, confirmed our findings from the qualitative study (Chapter 3), which indicated that children in this setting may be getting inadequate care during diarrhoea. As highlighted in Chapter 3, diarrhoea was seen by some mothers as part of normal development of children. This view may partly explain when many mothers do not seek appropriate diarrhoea treatment. Bivariate analysis of the relationship between ICFI and HPI and selected caregivers' resources showed that lack of key resources, such as education and community health insurance may be a barrier to better feeding/health practices (**Appendix 8**). However, further investigation to fully understand the barriers and enablers to adequate care practices during child diarrhoea in this setting.

Multiple linear regression models were used to examine associations between various factors, including care practices and child HAZ (objective 3). Findings (Chapter 4) indicated that HAZ was positively and significantly associated with maternal height, infant birth weight and ICFI. Negative and significant association was found between HAZ and child's age, sex (being a male child), diarrhoea and upper respiratory infections, and altitude. Diarrhoea and respiratory infections were associated with HAZ only in younger children (**Appendices 4 and 5**). These findings are consistent with existing literature indicating the multidimensional nature of factors associated with child stunting[12, 139-141], which suggests the need for a multi-sectoral approach for addressing child stunting in this setting.

While findings from the qualitative study (Chapter 3) indicated that mothers have a good knowledge about breast-feeding such as the age of introduction of complementary foods, our results from Chapter 4 showed that more than one-third of mothers (39%) did not exclusively breastfed up to 6 months, which is not consistent with the WHO guidelines. These results contrast a general view that exclusive breast-feeding is nearly universal in Rwanda[13] and highlight the need to reinforce strategies to promote exclusive breast-feeding in this setting. Our findings suggest the need to ensure mothers attend antenatal care during pregnancy, as it provides an opportunity to counsel mothers on appropriate breast-feeding practices[142]. Another important aspect to highlight is the discrepancy between our estimates (also supported by data from other studies discussed in Chapter 4) and the national estimates of exclusive breast-feeding (e.g. 87%, according to the 2014/15 DHS). This discrepancy is possibly due to methodological differences. In the DHS survey methodology, mothers are asked whether their infants 0–5 months received any foods/liquids other than breastmilk in the past 24 hours before the survey. Thus, the data on exclusive breast-feeding reflects what has occurred in the 24 hours prior to the survey. In other words, infants who had been given foods/liquids other than breastmilk, but not in the 24-hour period, are counted as exclusively breastfed, leading to overestimation of the proportion of exclusively breastfed infants. In our methodology, mothers were asked to report the age at which they first introduced food/liquid to their children. It should be acknowledged that this approach is prone to recall bias, as mothers might not remember precisely when they introduced foods to their children. However, our results are supported by other studies. For example, researchers in Uganda[143] and Tanzania[144] contrasted the 24 hours recall method and the recall since birth method (i.e. asking mothers the time when she introduced the first foods since the child was born) and found that the rate of exclusive breast-feeding was consistently lower when using recall since birth method than when using the 24-hour recall method. Thus, these

methodological issues must be kept in mind while interpreting the estimates of exclusive breast-feeding reported in cross-sectional surveys.

Another finding from Chapter 4 which needs consideration while designing interventions to prevent stunting in Rutsiro district is the negative association between child HAZ and altitude. The literature on the association between child stunting and altitude is not consistent. For example, surveys from Rwanda tend to suggest that high stunting prevalence among Rwandan children living in high-altitudes areas results from food insecurity in these areas[14]. A review of studies from other countries also suggested that children born to mothers living in high altitudes may be stunted as a result of lower birth weight due to hypoxia-induced growth retardation (i.e. prolonged exposure to low oxygen in breath air by mothers during pregnancy)[145]. Other researchers have argued that child's low HAZ relates more to socioeconomic conditions and diet than to altitude[146, 147]. However, a recent study including 964299 infants and children aged 0−59 months from 59 countries found that an increase in altitude of 1000 metres above sea level was significantly associated with a 0.16 decrease in HAZ, after controlling for other potential risk factors for stunting[148]. When these researchers restricted their analysis to children living in ideal home environments known to support child growth (i.e. being born to educated mothers, with access to health care, water and sanitation and fully vaccinated), they found HAZ distribution of these children followed the HAZ distribution of the WHO reference population, but only up to 500 metres above sea level. In Rutsiro district, the altitude ranges from 1500 to 3000 metres above sea level (see **Figure 2-2**). Thus, whether altitude affects child growth directly, or whether it could be acting as a proxy for other factors related to stunting, our findings and those of others suggest that children living in high altitude environment face unique risk factors which deserve consideration. Further studies are needed to elucidate these factors in order to inform the development

of effective health interventions to improve nutritional status of children living in high altitude areas.

Caregivers living in resource-poor settings may be unable to implement recommended childcare practices, including child feeding and health-seeking behaviours[149]. In the present study, the associations between household wealth index or household hunger level and child HAZ were not statistically significant (Chapter 4). This may partly be due to the fact that our sample was drawn from low-income households, and there was no significant difference between households with and those without stunted children in terms of resources (**Appendix 10**). Thus, within this sample, a small socio-economic difference may not be detected in the multiple regression analysis. However, in bivariate analysis, wealth index and household hunger level (and other resources) were found to be related to child feeding and health practices (**Appendix 8**). In Chapter 3, we also described how poverty and food insecurity influence child feeding practices. For example, we found that some mothers consider breast-feeding to meet the needs for younger children and give available foods to older children in order to cushion the effect of lack of foods. This finding tends to suggest that younger children are somewhat buffered against the effect of food insufficiency in the household. However, it can be argued that during food-scarce months there may be change in intrahousehold food allocation at the expense of younger breastfed children. These children may get no food other than breastmilk or get inequitably lower share of foods, which may increase their risk for undernutrition. Moreover, in addition to an adverse effect on children's diet diversity and amount of food, poverty also negatively affected mothers' ability to provide quality care for their children as mothers delegated childcare responsibilities to inexperienced older siblings so the mothers could be free and get employment outside of their homes (Chapter 3).

Furthermore, we found a statistically significant association between increasing household hunger score (a proxy for access to foods) and reduced odds of using MNP during complementary feeding. Interestingly, participation in the supplemental food programme targeting children aged 6–23 months was significantly associated with increased odds of using MNP (Chapter 5). These findings indicate that poverty and food insecurity are barriers to appropriate child feeding practices and childcare, in general, and that education alone cannot fix the problem of inadequate care practices without adequate resources. In food-secure populations, nutrition education interventions to improve complementary feeding practices are recommended, whereas food supplementation and/or cash transfer interventions are recommended in food-insecure populations[150]. Our findings indicate that, in this setting, both food insecurity and poverty alleviation strategies are required and must be part of interventions to address childcare practices and stunting.

6.2 Implications of findings and conclusions

Despite a remarkable decrease in stunting among children under 5 years of age in Rwanda in the past 2 decades, stunting remains a public health challenge, especially in Rutsiro district. The findings from this thesis underscore the complexity of factors associated with child stunting and point to the need for a multi-sectoral approach to prevent stunting in this setting.

The findings highlight several aspects that have implications for future programmes and interventions to reduce child stunting in this setting.

Our finding of strong associations between child HAZ and maternal height and birth weight indicate that interventions focusing on maternal health improvement before and during pregnancy could prevent intrauterine fetal growth retardation and/or adverse pregnancy outcomes such as low birth weight, and thus reduce risk of stunting. Our finding that the majority of mothers do not achieve the recommended antenatal care

visits during pregnancy indicates the need for more efforts to strengthen antenatal care interventions and to encourage and support mothers to seek timely antenatal care services during pregnancy, which is a critical entry point to promote maternal and child well-being.

The association between child HAZ and ICFI also suggests that interventions to improve IYCF practices still have potential to reduce child stunting in this setting. We identified three important gaps that could be addressed by nutrition education interventions in order to improve IYCF practices as well as the quality of children's diet. First, given that a significant proportion of mothers introduce complementary foods to their children before 6 months, the promotion and support of exclusive breast-feeding practice must remain a priority for public health interventions that aim to improve children's nutritional status in Rutsiro district. Second, education intervention messages should address maternal beliefs and misconceptions about foods, as well as the food classification systems that influence mothers' food choices and feeding decisions. For instance, the messages must address the widespread beliefs that consumption of sweet potatoes causes child diarrhoea, and that withholding sweet potatoes or other foods (e.g. soft foods) from children's diet would stop diarrhoea. Further, such messages could emphasize, for example, that sweet potato contributes to the diversity of children's diet; that it is not sweet potatoes per se that cause child diarrhoea, but inadequate hygiene practices such as poor hand hygiene, unhygienic preparation and storage of the foods; and that non-responsive child feeding, such as withholding foods when a child suffers from diarrhoea, negatively affects food intake and nutritional status of the child. Third, interventions should provide mothers with practical skills to enhance the consistency of complementary foods using locally available ingredients. For example, germination of cereals and legumes has been found to improve the consistency of complementary

foods, especially cereal-based porridges, while enhancing the nutritional quality of the foods[151, 152].

Given the high rates of poverty and food insecurity in this setting, an education intervention can lead to improvement in caregivers' knowledge about appropriate IYCF practices, but not necessarily the diets of children due to limited availability of and accessibility to foods. Therefore, education interventions must be combined with strategies to improve food security and caregivers' purchasing power so they can acquire sufficient and nutritious foods.

Nevertheless, even if food insecurity and poverty issues are addressed, locally available complementary foods may still not provide children with adequate micronutrients required to support their rapid growth and development. We observed that majority of children in this setting consume a diet that is dominated with plant foods, which are known to have low density for micronutrients, such as iron and zinc. The consumption of animal sources foods (a better source of high quality protein and other micronutrients) was also low. Therefore, interventions to improve household food security should not only focus on increasing the quantity but also quality and diversity of foods. Meanwhile, the current home-fortification programme using multiple micronutrients powder (MNP) remains an important alternative to fill gaps in nutrient of locally available complementary foods. In order to maximise the benefits of the MNP programme, our findings highlight the need to address gaps in IYCF practices. Moreover, there is a need to increase MNP programme coverage, particularly at 6 months, and to address issues related to distribution so as to reach, for example, mothers not attending growth monitoring.

Although the exact mechanism by which altitude affects child growth remains unclear, the negative association observed in this study between child HAZ and altitude calls for more attention. While further research is awaited to provide intervention guidelines to

address this phenomenon, it is important to make sure health services and programmes reach the population in Rutsiro district.

Finally, the discrepancy observed between our estimates, which mirror findings reported in other studies conducted in Rwanda, and the national estimates of exclusive breast-feeding also indicates the need to rethink the best way to estimate the prevalence of exclusive breast-feeding. Accurate data on the rate of exclusive breast-feeding are crucial to inform appropriate actions and to track the progress for breast-feeding policies and programmes.

Chapter 7 Strengths, limitations, and recommendations for future research

7.1 Strengths and limitations of the thesis

To the best of my knowledge, this is the first study to explore qualitatively IYCF practices, as well as the range of factors influencing these practices, and how they relate to child stunting in a district with the highest prevalence of child stunting in Rwanda. Strengths of this thesis also include the integration of qualitative and quantitative approaches and the focus on the most prevalent form of undernutrition (stunting) in Rwanda.

Each study presented in Chapter 3, 4 and 5 highlights its limitations, but there are general methodological limitations that must be taken into consideration when interpreting the findings of this thesis. First, the study was conducted in a single district and the sample was drawn from the two lowest socioeconomic groups. This selection bias means that the findings may not be generalised to other socioeconomic groups or populations in other regions in Rwanda. Second, as a cross-sectional study, the reliance on respondents' memory introduce recall and reporting bias. Third, in Chapter 4, we included in our analysis care practices related to feeding and health practices. However, care is a multidimensional concept, and some dimensions may be better studied by systematically observing participants in their home environment[24]. For example, hygiene practices are an important care dimension which can influence occurrence of diarrhoea, and therefore child stunting. Although we intended to collect indicators of hygiene practices using spot-check observations, all aspects could not be observed in many households, therefore this data was not used in the analysis due to the small sample. Lastly, our analysis did not take into account the fact that growth faltering in some of the children might have occurred much earlier. This limitation could be addressed by a longitudinal study design.

7.2 Recommendations for future research

While this thesis has generated insights into the relationship between child stunting and a range of factors in this setting, including how IYCF and health practices may be

influencing these relationships, there are still knowledge gaps that require further investigations.

Future qualitative work in this setting should examine how to address and counter the current belief systems underlying food classifications. Research is also needed to explore whether mothers across regions and socioeconomic strata share similar beliefs, perceptions or food classification systems. Such research could inform the development of effective, contextually-relevant nutrition education and behaviour change messages to address gaps in IYCF practices in Rwanda.

Future research examining the relationship between child feeding and health practices and child stunting using indices must consider validation of such indices. Validation studies should examine the performance of indices that incorporate other key dimensions such as hygiene practices during food preparations, the types or amounts of foods as opposed to food groups or the quality of care service that mothers receive during antenatal care besides the number of visits.

Given that both multiple micronutrients powder (MNP) and the fortified cereal-based porridge flour that children obtain through supplemental food programme contain similar micronutrients and target the same group of children, further research should examine the potential risk for toxicity or excessive intake of some micronutrients.

Research is also needed to better understand the barriers to/understanding of exclusive breast-feeding practices. A related priority is the need for research to evaluate the barriers to seeking antenatal care during pregnancy in order to inform appropriate actions.

Lastly, the assessment of child stunting using anthropometry has several advantages, such as non-invasiveness, availability of inexpensive and accepted standards for clinal and population use, especially in resource-limited countries such as Rwanda. However,

future studies should identify biomarkers (e.g. some researchers have investigated the role of growth factors such as insulin-like growth factor-1 or markers of enteric infections) that could be used to examine objectively the relationship between stunting and its underlying factors. Using biomarkers could perhaps provide a better understanding of, for example, the exact mechanisms by which living in a high-altitude environment contributes to child stunting in Rwanda.

References (Chapter 1, 2, 6 & 7)

1. Black RE, Victora CG, Walker SP *et al.* (2013) Maternal and child undernutrition and overweight in low-income and middle-income countries. *The Lancet* 382, 427-451.
2. de Onis M, Onyango AW, Borghi E *et al.* (2006) Comparison of the World Health Organization (WHO) Child Growth Standards and the National Center for Health Statistics/WHO international growth reference: implications for child health programmes. *Public Health Nutr* 9, 942-947.
3. Development Initiatives (2020) *2020* Global Nutrition Report: Action on equity to end malnutrition. Bristol: Development Initiatives.
4. United Nations Children's Fund, World Health Organization World Bank (2019) Levels and trends in child malnutrition: Key findings of the 2019 edition. Washington, DC: World Health Organization.
5. United Nations Children's Fund (UNICEF), World Health Organization International Bank for Reconstruction and Development/The World Bank (2020) Levels and trends in child malnutrition: Key Findings of the 2020 Edition of the Joint Child Malnutrition Estimates. Geneva: World Health Organization.
6. Development Initiatives (2018) 2018 Global Nutrition Report: Shining a light to spur action on nutrition. Bristol: Development Initiatives.
7. Gillespie S & van den Bold M (2017) Stories of Change in nutrition: An overview. *Glob Food Sec* 13, 1-11.
8. de Onis M & Branca F (2016) Childhood stunting: a global perspective. *Matern Child Nutr* 12, 12-26.
9. Victora CG, Adair L, Fall C *et al.* (2008) Maternal and child undernutrition: consequences for adult health and human capital. *Lancet* 371, 340-357.

10. Fenske N, Burns J, Hothorn T *et al.* (2013) Understanding child stunting in India: a comprehensive analysis of socio-economic, nutritional and environmental determinants using additive quantile regression. *PLoS One* 8, e78692.
11. Maluccio JA, Hoddinott J, Behrman JR *et al.* (2009) The Impact of Improving Nutrition During Early Childhood on Education among Guatemalan Adults. *The Economic Journal* 119, 734-763.
12. Stewart CP, Iannotti L, Dewey KG *et al.* (2013) Contextualising complementary feeding in a broader framework for stunting prevention. *Matern Child Nutr* 9 Suppl 2, 27-45.
13. Development Initiatives (2017) *Global Nutrition Report 2017: Nourishing the SDGs.* Bristol: Development Initiatives.
14. National Institute of Statistics of Rwanda (2018) Comprehensive Food Security and Vulnerability Analysis 2018. https://docs.wfp.org/api/documents/WFP-0000103863/download/ (accessed July 2020)
15. World Health Organization (2014) Global targets tracking tool. https://www.who.int/nutrition/trackingtool/en/ (accessed August 2020)
16. Kinyoki DK, Osgood-Zimmerman AE, Pickering BV *et al.* (2020) Mapping child growth failure across low- and middle-income countries. *Nature* 577, 231-234.
17. World Bank Group (2018) Rwanda Economic Update.Tackling Stunting: An Unfinished Agenda, 2 ed., vol. 2020. Washington DC: World Bank.
18. United Nations Children's Fund (2013) *Improving child nutrition: The achievable imperative for global progress*. New York: United Nations Children's Fund.
19. Victora CG, de Onis M, Hallal PC *et al.* (2014) Worldwide timing of growth faltering: revisiting implications for interventions. *Pediatrics* 125, e473-480.

20. Dewey KG & Huffman SL (2009) Maternal, infant, and young child nutrition: combining efforts to maximize impacts on child growth and micronutrient status. *Food Nutr Bull* 30, S187-189.
21. Dewey KG (2003) Guiding principles for complementary feeding of the breastfed child. Washington, DC: Pan American Health Organization/World Heath Organization.
22. Martorell R, Khan LK & Schroeder DG (1994) Reversibility of stunting: epidemiological findings in children from developing countries. *Eur J Clin Nutr* 48 Suppl 1, S45-57.
23. Engle PL (1999) The role of caring practices and resources for care in child survival, growth, and development: South and Southeast Asia. *Asian Dev Rev* 17, 132-167.
24. Engle PL, Menon P & Haddad L (1999) Care and Nutrition: Concepts and Measurement. *World Dev* 27, 1309-1337.
25. The Cebu Study Team (1991) Underlying and Proximate Determinants of Child Health: The Cebu Longitudinal Health and Nutrition Study. *Am J Epidemiol* 133, 185-201.
26. National Institute of Statistics of Rwanda (NISR) [Rwanda], Ministry of Health (MOH) [Rwanda] ICF International (2015) *Rwanda Demographic and Health Survey 2014-15*. Rockville, Maryland: NISR, MOH and ICF International.
27. Lung'aho M, Birachi E, Butare L *et al.* (2015) Rwanda nutrition, markets and gender analysis 2015: An integrated approach towards alleviating malnutrition among vulnerable populations in Rwanda. Nairobi: Government of Rwanda/International Center for Tropical Agriculture (CIAT).
28. Agho KE, Mukabutera C, Mukazi M *et al.* (2019) Moderate and severe household food insecurity predicts stunting and severe stunting among Rwanda

children aged 6–59 months residing in Gicumbi district. *Matern Child Nutr* 15, e12767.

29. de Onis M (2006) WHO Child Growth Standards based on length/height, weight and age. *Acta Paediatr* 95, 76-85.
30. World Health Organization (2017) Global Health Observatory data repository: Global and regional trends by UN Regions, Underweight: 1990-2016. http://apps.who.int/gho/data/view.main.NUTUNUNDERWEIGHTv?lang=enhttp://apps.who.int/gho/data/view.main.NUTUNUNDERWEIGHTv?lang=en (accessed October 2020)
31. Olofin I, McDonald CM, Ezzati M *et al.* (2013) Associations of Suboptimal Growth with All-Cause and Cause-Specific Mortality in Children under Five Years: A Pooled Analysis of Ten Prospective Studies. *PLoS One* 8, e64636.
32. Prendergast AJ & Humphrey JH (2014) The stunting syndrome in developing countries. *Paediatr Int Child Health* 34, 250-265.
33. Georgiadis A & Penny ME (2017) Child undernutrition: opportunities beyond the first 1000 days. *Lancet Public Health* 2, e399.
34. Prentice AM, Ward KA, Goldberg GR *et al.* (2013) Critical windows for nutritional interventions against stunting. *Am J Clin Nutr* 97, 911-918.
35. Shrimpton R, Victora CG, de Onis M *et al.* (2001) Worldwide timing of growth faltering: implications for nutritional interventions. *Pediatrics* 107, e75-e75.
36. Fishman SM, Caulfield LE, De Onis M *et al.* (2004) Childhood and maternal underweight. In *Comparative quantification of health risks: global and regional burden of disease attributable to selected major risk factors*, vol. 1, pp. 39-161 [LA Ezzati M, Rodgers A, Murray CJL,, editor]. Geneva: World Health Organization.

37. Rice AL, Sacco L, Hyder A *et al.* (2000) Malnutrition as an underlying cause of childhood deaths associated with infectious diseases in developing countries. *Bull World Health Organ* 78, 1207-1221.

38. Kossmann J, Nestel P, Herrera MG *et al.* (2000) Undernutrition in relation to childhood infections: a prospective study in the Sudan. *Eur J Clin Nutr* 54, 463-472.

39. Sazawal S, Black RE, Ramsan M *et al.* (2006) Effects of routine prophylactic supplementation with iron and folic acid on admission to hospital and mortality in preschool children in a high malaria transmission setting: community-based, randomised, placebo-controlled trial. *Lancet* 367, 133-143.

40. Hoddinott J, Alderman H, Behrman JR *et al.* (2013) The economic rationale for investing in stunting reduction. *Matern Child Nutr* 9, 69-82.

41. Popkin B, Richards M & Montiero C (1997) Stunting is associated with overweight in children of four nations that are undergoing the nutrition transition. *J Nutr* 126, 3009-3016.

42. Popkin B (1994) The nutrition transition in low-income countries: An emerging crisis. *Nutr Rev* 52, 285-298.

43. Martorell R & Zongrone A (2012) Intergenerational influences on child growth and undernutrition. *Paediatr Perinat Epidemiol* 26, 302-314.

44. von Grebmer K, Saltzman A, Birol E *et al.* (2014) 2014 Global Hunger Index: The Challenge of Hidden Hunger. Bonn, Washington, D.C., and Dublin: Welthungerhilfe, International Food Policy Research Institute, and Concern Worldwide.

45. United Nations Children's Fund (1990) *Strategy for improved nutrition of children and women in developing countries*. New York: United Nations Children's Fund.

46. Black RE, Allen LH, Bhutta ZA *et al.* (2008) Maternal and child undernutrition: global and regional exposures and health consequences. *The Lancet* 371, 243-260.

47. Teshome B, Kogi-Makau W, Getahun Z *et al.* (2010) Magnitude and determinants of stunting in children under-five years of age in food surplus region of Ethiopia: the case of West Gojam Zone. *Ethiop J Health Dev* 23, 98-106.

48. Kumar D, Goel NK, Mittal PC *et al.* (2006) Influence of infant-feeding practices on nutritional status of under-five children. *Indian J Pediatr* 73, 417-421.

49. Fikadu T, Assegid S & Dube L (2014) Factors associated with stunting among children of age 24 to 59 months in Meskan district, Gurage Zone, South Ethiopia: a case-control study. *BMC Public Health* 14, 800.

50. Kuchenbecker J, Jordan I, Reinbott A *et al.* (2015) Exclusive breastfeeding and its effect on growth of Malawian infants: results from a cross-sectional study. *Paediatr Int Child Health* 35, 14-23.

51. Woodruff BA, Wirth JP, Bailes A *et al.* (2017) Determinants of stunting reduction in Ethiopia 2000 – 2011. *Matern Child Nutr* 13, e12307.

52. Khan MN & Islam MM (2017) Effect of exclusive breastfeeding on selected adverse health and nutritional outcomes: a nationally representative study. *BMC Public Health* 17, 889.

53. Jones AD, Ickes SB, Smith LE *et al.* (2014) World Health Organization infant and young child feeding indicators and their associations with child anthropometry: a synthesis of recent findings. *Matern Child Nutr* 10, 1-17.

54. Dhami MV, Ogbo FA, Osuagwu UL *et al.* (2019) Stunting and severe stunting among infants in India: the role of delayed introduction of complementary foods and community and household factors. *Global Health Action* 12, 1638020.

55. Steyn NP, Nel JH, Nantel G *et al.* (2006) Food variety and dietary diversity scores in children: are they good indicators of dietary adequacy? *Public Health Nutr* 9, 644-650.

56. Onyango AW, Borghi E, de Onis M *et al.* (2014) Complementary feeding and attained linear growth among 6-23-month-old children. *Public Health Nutr* 17, 1975-1983.

57. Marriott BP, White A, Hadden L *et al.* (2012) World Health Organization (WHO) infant and young child feeding indicators: associations with growth measures in 14 low-income countries. *Matern Child Nutr* 8, 354-370.

58. Ruel MT & Menon P (2002) Child feeding practices are associated with child nutritional status in Latin America: innovative uses of the demographic and health surveys. *J Nutr* 132, 1180-1187.

59. Ruel MT, Levin CE, Armar-Klemesu M *et al.* (1999) Good care practices can mitigate the negative effects of poverty and low maternal schooling on children's nutritional status: Evidence from Accra. *World Dev* 27, 1993-2009.

60. Ehiri JE, Azubuike MC, Ubbaonu CN *et al.* (2001) Critical control points of complementary food preparation and handling in eastern Nigeria. *Bull World Health Organ* 79, 423-433.

61. Motarjemi Y, Kaferstein F, Moy G *et al.* (1993) Contaminated weaning food: a major risk factor for diarrhoea and associated malnutrition. *Bull World Health Organ* 71, 79-92.

62. Goto R, Mascie-Taylor CGN & Lunn PG (2009) Impact of intestinal permeability, inflammation status and parasitic infections on infant growth faltering in rural Bangladesh. *Br J Nutr* 101, 1509-1516.

63. Campbell DI, Elia M & Lunn PG (2003) Growth faltering in rural Gambian infants is associated with impaired small intestinal barrier function, leading to endotoxemia and systemic inflammation. *J Nutr* 133, 1332-1338.

64. Checkley W, Buckley G, Gilman RH *et al.* (2008) Multi-country analysis of the effects of diarrhoea on childhood stunting. *Int J Epidemiol* 37, 816-830.

65. Assis AM, Barreto ML, Santos LM *et al.* (2005) Growth faltering in childhood related to diarrhea: a longitudinal community based study. *Eur J Clin Nutr* 59, 1317-1323.

66. Gong Y, Cardwell K, Hounsa A *et al.* (2002) Dietary aflatoxin exposure and impaired growth in young children from Benin and Togo: cross sectional study. *BMJ* 325, 20-21.

67. Gong Y, Hounsa A, Egal S *et al.* (2004) Postweaning exposure to aflatoxin results in impaired child growth: a longitudinal study in Benin, West Africa. *Environ Health Perspect* 112, 1334-1338.

68. Checkley W, Gilman RH, Black RE *et al.* (2004) Effect of water and sanitation on childhood health in a poor Peruvian peri-urban community. *Lancet* 363, 112-118.

69. Young MF, Nguyen PH, Addo OY *et al.* (2015) The relative influence of maternal nutritional status before and during pregnancy on birth outcomes in Vietnam. *Eur J Obstet Gynecol Reprod Biol* 194, 223-227.

70. Varela-Silva MI, Azcorra H, Dickinson F *et al.* (2009) Influence of maternal stature, pregnancy age, and infant birth weight on growth during childhood in Yucatan, Mexico: A test of the intergenerational effects hypothesis. *Am J Hum Biol* 21, 657-663.

71. Luxemburger C, McGready R, Kham A *et al.* (2001) Effects of Malaria during Pregnancy on Infant Mortality in an Area of Low Malaria Transmission. *Am J Epidemiol* 154, 459-465.

72. Aryastami NK, Shankar A, Kusumawardani N *et al.* (2017) Low birth weight was the most dominant predictor associated with stunting among children aged 12–23 months in Indonesia. *BMC Nutrition* 3, 16.

73. Engle PL, Bentley M & Pelto G (2007) The role of care in nutrition programmes: current research and a research agenda. *Proc Nutr Soc* 59, 25-35.

74. Raza A, Fox EL, Morris SS *et al.* (2020) Conceptual framework of food systems for children and adolescents. *Glob Food Sec* 27, 100436.

75. Robertson RC, Manges AR, Finlay BB *et al.* (2019) The Human Microbiome and Child Growth – First 1000 Days and Beyond. *Trends Microbiol* 27, 131-147.

76. Wells JC & Stock JT (2011) Re-examining heritability: genetics, life history and plasticity. *Trends Endocrinol Metab* 22, 421-428.

77. Martorell R, Yarbrough C, Lechtig A *et al.* (1977) Genetic-environmental interactions in physical growth. *Acta Paediatr* 66, 579-584.

78. Deaton A & Drèze J (2009) Food and nutrition in India: facts and interpretations. *Economic and Political Weekly* 44, 42-65.

79. Droomers M, Gross R, Schultink W *et al.* (1995) High socioeconomic class preschool children from Jakarta, Indonesia are taller and heavier than NCHS reference population. *Eur J Clin Nutr* 49, 740-744.

80. WHO Working Group on the Growth Reference Protocol & WHO Task Force on Methods for the Natural Regulation of Fertility (2000) Growth patterns of breastfed infants in seven countries. *Acta Paediatr* 89, 215-222.

81. National Institute of Statistics of Rwanda (2018) Rwanda Statistical Year Book 2018. Kigali: National Institute of Statistics of Rwanda.

82. Worldometer (2021) African Countries by population (2021). https://www.worldometers.info/population/countries-in-africa-by-population/ (accessed January 2021)

83. Ansoms A & McKay A (2010) A quantitative analysis of poverty and livelihood profiles: The case of rural Rwanda. *Food Policy* 35, 584-598.

84. Minsitry of Finance and Economic Planning (2013) Economic Development and Poverty Reduction Strategy II 2013-2018. Kigali: Minsitry of Finance and Economic Planning, Government of Rwanda.

85. Kathiresan A (2011) *Strategies for sustainable crop intensification in Rwanda*. Strategies for Sustainable Crop Intensification in Rwanda Shifting focus from producing enough to producing surplus. Kigali: Ministry of Agriculture and Animal Resources, Government of Rwanda.

86. Ministry of Agriculture and Animal Resources (2009) *Strategic Plan for the Transformation o f Agriculture in Rwanda Phase II. Final Report.* Kigali: Ministry of Agriculture and Animal Resources. Government of Rwanda.

87. National Institute of Statistics of Rwanda (2015) Integrated Household Living Conditions Survey 4 (EICV 4). http://www.statistics.gov.rw/publication/rwanda-poverty-profile-report-results-eicv-4 (accessed October 2020)

88. National Institute of Statistics of Rwanda (2015) Fifth Integrated Household Living Conditions Survey 2016/17. http://www.statistics.gov.rw/publication/eicv5-power-point-presentation (accessed October 2020)

89. Binagwaho A, Farmer PE, Nsanzimana S *et al.* (2014) Rwanda 20 years on: investing in life. *The Lancet* 384, 371-375.

90. Sayinzoga F & Bijlmakers L (2016) Drivers of improved health sector performance in Rwanda: a qualitative view from within. *BMC Health Serv Res* 16, 123.

91. Binagwaho A, Condo J, Wagner C *et al.* (2014) Impact of implementing performance-based financing on childhood malnutrition in Rwanda. *BMC Public Health* 14, 1132.

92. Development Initiatives (2019) Rwanda: Country Overview. Malnutrition burden. https://globalnutritionreport.org/resources/nutrition-profiles/africa/eastern-africa/rwanda/ (accessed September 2020)
93. Compact2025 Team (2016) *Rwanda: Ending hunger & undernutrition: Challenges & opportunities*. Kigali: Compact 2025.
94. Renewed Efforts Against Child Hunger (REACH) (2015) Stakeholder and Action Mapping for Rwanda 2014/15. https://www.unnetworkforsun.org/sites/default/files/2018-11/REACH%20Planning%20Booklet.pdf (accessed November 2020)
95. Mohammed SH, Larijani B & Esmaillzadeh A (2019) Concurrent anemia and stunting in young children: prevalence, dietary and non-dietary associated factors. *Nutr J* 18, 10.
96. Gosdin L, Martorell R, Bartolini RM *et al.* (2018) The co-occurrence of anaemia and stunting in young children. *Matern Child Nutr* 14, e12597.
97. Tran TD, Biggs B-A, Holton S *et al.* (2019) Co-morbid anaemia and stunting among children of pre-school age in low- and middle-income countries: a syndemic. *Public Health Nutr* 22, 35-43.
98. Ministry of Health [Rwanda] (2014) Rwanda National Food and Nutrition Policy. Kigali: Ministry of Health, Government of Rwanda.
99. AUC & NEPAD (2013) *The Cost of Hunger in Rwanda: Social and Economic Impacts of Child Undernutrition in Rwanda - Implications on National Development and Vision 2020*. Kigali: African Union Commission (AUC), New Patnership for Africa's Development (NEPAD), UN Economic Commission for Africa (ECA) and World Food Program (WFP).
100. Ministry of Health [Rwanda] (2018) Maternal Newborn and Child Health Strategic Plan (2018–2024). Kigali: Ministry of Health

101. Institut National de la Statistique (NISR) & ORC Marco (2006) *Rwanda Demographic and Health Survey 2005*. Calverton, Maryland, U.S.A: INSR and ORC Macro.

102. National Institute of Statistics of Rwanda (NISR) [Rwanda], Ministry of Health (MOH) [Rwanda] & ICF International (2012) *Rwanda Demographic and Health Survey 2010*. Calverton, Maryland: NISR, MOH and ICF International.

103. Ministry of Health [Rwanda] (2013) National food and nutrition strategic plan 2013-2018. Kigali: Ministry of Health.

104. Habyarimana F, Zewotir T, Ramroop S *et al.* (2016) Spatial distribution of determinants of malnutrition of children under five years in Rwanda: Simultaneous measurement of three anthropometric indices. *J Hum Ecol* 54, 138-149.

105. Binagwaho A, Rukundo A, Powers S *et al.* (2020) Trends in burden and risk factors associated with childhood stunting in Rwanda from 2000 to 2015: policy and program implications. *BMC Public Health* 20, 83.

106. Nkunzimana T, Custodios E, Perez-Hoyos A *et al.* (2016) Assessing MDG Achievements Through Under-5 Child Stunting in the East African Community: Some Insights from Urban Versus Rural Areas in Burundi and Rwanda Using DHS2010. In *Poverty and Well-Being in East Africa*, pp. 61-86 [Almas Heshmati, editor]: Springer International Publishing.

107. Nshimyiryo A, Hedt-Gauthier B, Mutaganzwa C *et al.* (2019) Risk factors for stunting among children under five years: a cross-sectional population-based study in Rwanda using the 2015 Demographic and Health Survey. *BMC Public Health* 19, 175.

108. Mukabutera A, Thomson DR, Hedt-Gauthier BL *et al.* (2016) Risk factors associated with underweight status in children under five: an analysis of the 2010 Rwanda Demographic Health Survey (RDHS). *BMC Nutrition* 2, 40.

109. Chunling L, Mejia-Guevara I, Hill K *et al.* (2016) Community-Based Health Financing and Child Stunting in Rural Rwanda. *Am J Public Health* 106, 49-55.

110. Antunes A, Saksena P, Elovainio R *et al.* (2009) *Health Financing Systems Review of Rwanda: options for universal coverage*. Geneva: World Health Organization and Ministry of Health, Rwanda.

111. Aoun N, Matsuda H & Sekiyama M (2015) Geographical accessibility to healthcare and malnutrition in Rwanda. *Soc Sci Med* 130, 135-145.

112. Uwiringiyimana V, Veldkamp A Amer S (2019) Stunting spatial pattern in Rwanda: An examination of the demographic, socio-economic and environmental determinants. *Geospat Health* 14.

113. Sinharoy SS, Schmidt WP, Cox K *et al.* (2016) Child diarrhoea and nutritional status in rural Rwanda: a cross-sectional study to explore contributing environmental and demographic factors. *Trop Med Int Health* 21, 956-964.

114. Lin A, Arnold BF, Afreen S *et al.* (2013) Household environmental conditions are associated with enteropathy and impaired growth in rural Bangladesh. *Am J Trop Med Hyg* 89, 130-137.

115. Uwiringiyimana V, Ocké MC, Amer S *et al.* (2019) Predictors of stunting with particular focus on complementary feeding practices: A cross-sectional study in the northern province of Rwanda. *Nutrition* 60, 11-18.

116. Matsiko E (2019) Exploring linear growth retardation in Rwandan children : Ecological and biological factors. PhD Thesis, Wageningen University.

117. Condo JU, Gage A, Mock N *et al.* (2015) Sex differences in nutritional status of HIV-exposed children in Rwanda: a longitudinal study. *Trop Med Int Health* 20, 17-23.

118. National Institute of Statistics of Rwanda (2012) Comprehensive Food Security and Vulnerability Analysis and Nutrition Survey 2012. Kigali, Rwanda: NISR, Ministry of Agriculture and World Food Programme.

119. den Hartog AP, van Staveren WA & Brouwer ID (2006) *Food habits and consumption in developing countries: Manual for field studies*: Wageningen Academic Publishers.

120. Pierce H, Gibby AL & Forste R (2016) Caregiver Decision-Making: Household Response to Child Illness in sub-Saharan Africa. *Population Research and Policy Review* 35, 581-597.

121. Brown LV, Zeitlin MF, Peterson KE *et al.* (1992) Evaluation of the impact of weaning food messages on infant feeding practices and child growth in rural Bangladesh. *Am J Clin Nutr* 56, 994-1003.

122. World Health Organization (2008) *Indicators for assessing infant and young child feeding practices: part 1, definitions*: World Health Organization

123. Lee J, Dusingizimana T & Umutoni F (2016) Understanding consumer demand for nutritious food in Nyanza district, Rwanda. https://www.usaid.gov/sites/default/files/documents/1860/GAIN%20Summary%20Focused%20Ethnographic%20Survey%20Report.pdf (accessed October 2020)

124. Ministry of Health [Rwanda] & United Nations Children's Fund (UNICEF) (2014) *Knowledge, Attitudes and Practices Assessment on Early Nurturing of Children Report*. Kigali: Ministry of Health & UNICEF Rwanda.

125. Bentley ME, Dickin KL, Mebrahtu S *et al.* (1991) Development of a nutritionally adequate and culturally appropriate weaning food in Kwara State, Nigeria: An interdisciplinary approach. *Soc Sci Med* 33, 1103-1111.

126. Izurieta LM & Larson-Brown LB (1995) Child feeding practices in Guatemala. *Ecol Food Nutr* 33, 249-262.

127. Pelto GH, Levitt E & Thairu L (2003) Improving feeding practices: current patterns, common constraints, and the design of interventions. *Food Nutr Bull* 24, 45-82.

128. Rutsiro District [Government of Rwanda] (2017) Local Economic Development (LED): Seven Year Strategy for Rutsiro District 2017-2024. https://www.rutsiro.gov.rw/fileadmin/user_upload/LED_strategy_Rutsiro.pdf

129. National Institute of Statistics of Rwanda (2012) 2012 Rwanda fourth population and housing census. District profile: Rutsiro. Kigali: National Institute of Statistics of Rwanda.

130. Morgan DL (1998) Practical Strategies for Combining Qualitative and Quantitative Methods: Applications to Health Research. *Qual Health Res* 8, 362-376.

131. Johnson RB, Onwuegbuzie AJ & Turner LA (2007) Toward a definition of mixed methods research. *J Mix Methods Res* 1, 112-133.

132. Braun V & Clarke V (2006) Using thematic analysis in psychology. *Qualitative Research in Psychology* 3, 77-101.

133. Pelto GH, Goodman AH & Dufour DL (2000). The biocultural perspectives in nutritional anthropology. In *Nutritional anthropology: Biocultural perspectives on food and nutrition*, p.1-10 [AH Goodman, DL Dufour, GH Pelto, editors]. Mountain View, CA: Mayfield Publishing.

134. Zobrist S, Kalra N, Pelto G *et al.* (2017) Results of Applying Cultural Domain Analysis Techniques and Implications for the Design of Complementary Feeding Interventions in Northern Senegal. *Food Nutr Bull* 38, 512-527.

135. Rodriguez-Oliveros MG, Bisogni CA & Frongillo EA (2014) Knowledge about food classification systems and value attributes provides insight for understanding complementary food choices in Mexican working mothers. *Appetite* 83, 144-152.

136. Sukkary-Stolba S (1987) Food classifications and the diets of young children in rural Egypt. *Soc Sci Med* 25, 401-404.

137. Kuhnlein HV & Pelto GH (1997) *Culture, environment and food to prevent vitamin A deficiency.* Ottawa: International Nutrition Foundation for Developing Countries and International Development Research Centre.

138. Low JW & Thiele G (2020) Understanding innovation: The development and scaling of orange-fleshed sweetpotato in major African food systems. *Agric Syst* 179, 102770.

139. Wamani H, Åstrøm AN, Peterson S *et al.* (2007) Boys are more stunted than girls in Sub-Saharan Africa: a meta-analysis of 16 demographic and health surveys. *BMC Pediatr* 7, 17.

140. Danaei G, Andrews KG, Sudfeld CR *et al.* (2016) Risk Factors for Childhood Stunting in 137 Developing Countries: A Comparative Risk Assessment Analysis at Global, Regional, and Country Levels. *PLoS Med* 13, e1002164.

141. Reinhardt K & Fanzo J (2014) Addressing chronic malnutrition through multi-sectoral, sustainable approaches: A review of the causes and consequences. *Front Nutr* 1, 13.

142. World Health Organisation (2009) Integrated Management of Pregnancy and Childbirth. WHO Recommended Interventions for Improving Maternal and Newborn Health. Geneva: World Health Organisation.

143. Hussein TH, Mgongo M, Uriyo JG *et al.* (2019) Exclusive Breastfeeding Rates and Factors Associated with Exclusive Breastfeeding Practices in Northern Tanzania: Measurement using Two Different Methodologies-24 Hours Recall and Recall Since Birth. *Int J MCH AIDS* 8, 32-43.

144. Engebretsen IM, Wamani H, Karamagi C *et al.* (2007) Low adherence to exclusive breastfeeding in Eastern Uganda: a community-based cross-sectional study comparing dietary recall since birth with 24-hour recall. *BMC Pediatr* 7, 10.

145. Niermeyer S, Andrade Mollinedo P Huicho L (2009) Child health and living at high altitude. *Arch Dis Child* 94, 806-811.

146. Artiningrum NT, Suryobroto B & Widiyani T (2014) Physical Growth of Sasak Children at Different Altitudes in Lombok Island. *HAYATI Journal of Biosciences* 21, 101-110.

147. Harris NS, Crawford PB, Yangzom Y *et al.* (2001) Nutritional and health status of Tibetan children living at high altitudes. *N Engl J Med* 344, 341-347.

148. Baye K & Hirvonen K (2020) Evaluation of Linear Growth at Higher Altitudes. *JAMA Pediatr* 140, 977-984.

149. Miller AL, Miller SE & Clark KM (2018) Child, Caregiver, Family, and Social-Contextual Factors to Consider when Implementing Parent-Focused Child Feeding Interventions. *Curr Nutr Rep* 7, 303-309.

150. Bhutta ZA, Ahmed T, Black RE *et al.* (2008) What works? Interventions for maternal and child undernutrition and survival. *Lancet* 371, 417-440.

151. Nkhata SG, Ayua E, Kamau EH *et al.* (2018) Fermentation and germination improve nutritional value of cereals and legumes through activation of endogenous enzymes. *Food Sci Nutr* 6, 2446-2458.

152. Mamiro PS, Kolsteren PW, van Camp JH *et al.* (2004) Processed complementary food does not improve growth or hemoglobin status of rural tanzanian infants from 6-12 months of age in Kilosa district, Tanzania. *J Nutr* 134, 1084-1090.

Appendices

Appendix 1: Consolidated criteria for reporting qualitative studies (COREQ): 32-item checklist (Supplemental Table; Chapter 3)

Developed from: Tong A, Sainsbury P, Craig J (2007) Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *Int J Qual Health Care* 19, 349–357

No. Item	**Guide questions/description**
1. Interviewer/facilitator	TD conducted all interviews.
2. Credentials	BSc Food Science and Technology, MSc Human Nutrition, PhD Candidate
3. Occupation	At the time of the interviews, TD was a PhD student
4. Gender	Male
5. Experience and training	Prior to the study TD had a background in Human Nutrition. TD had previously conducted qualitative interviews with a range of different participant groups including caregivers on child feeding practices in Rwanda.
6. Relationship established	No
7. Participant knowledge of the interviewer	Participants were informed on the purpose of the study. They were also informed that the study was part of a research study for TD's PhD.
8. Interviewer characteristics	TD was a PhD student during the time of the interviews
9. Methodological orientation and Theory	Biocultural model according to Pelto GH, Goodman AH and Dufour DL (2000) & Thematic Analysis according to Braun and Clarke (2006).
10. Sampling	Purposive sampling was used to recruit participants.
11. Method of approach	The researcher (TD) approached participants, explained the purpose of the study and invited them to participate in the study. Face-to-face interviews were used using interview guide.
12. Sample size	24
13. Non-participation	All participants agreed to participate in the study, and none withdrew consent.
14. Setting of data collection	Interviews were conducted in the participants' homes
15. Presence of non-participants	No.
16. Description of sample	Age range (mothers): 24−42 years. Age mean (mothers): 30.5 years Age range (children): 6−22 months Age mean (children): 16.1 months (see also Table 1)

No. Item	Guide questions/description
17. Interview guide	Interviews were semi-structured using an interview guide. Interview guide was pilot-tested with mothers from a different community prior to the study
18. Repeat interviews	No
19. Audio/visual recording	Audio Recorder was used during face-to-face interviews.
20. Field notes	TD wrote reflective diary entries after the completion of each interview.
21. Duration	Interview durations ranged from 30–60 minutes
22. Data saturation	The point of saturation occurred by the twenty-fourth interview. At this point, no new information was generated
23. Transcripts returned	No
24. Number of data coders	TD coded all interviews. Three authors (TD, WJ and LB) discussed the data, reviewed codes and themes during and after data collection and throughout data analysis.
25. Description of the coding tree	Coding process was described
26. Derivation of themes	Analysis was inductive, whereby themes derived from the data.
27. Software	Word documents were used to transcribe verbatim audio-recorded interviews. Data were manually coded. Microsoft Excel was used to analyse quantitative data
28. Participant checking	No
29. Quotations presented	Yes, specific quotations were presented to help illustrate themes and provide examples. Quotations were identified by a participant number, age, and age of the child.
30. Data and findings consistent	Yes
31. Clarity of major themes	Major themes were presented in the findings
32. Clarity of minor themes	-

Note: Reference included in this appendix appears under the list of references of Chapter 3 (Paper I)

Appendix 2: Supplemental Table 1 (Chapter 4) Feeding practices and scoring system used to construct the infant and young child feeding index (ICFI)

Practices	**Scores allocated to different practices, by age group**		
	6−8 months	9−11 months	12−23 months
Still breast-feeding	No= 0 Yes= 2	No= 0 Yes= 2	No= 0 Yes= 1
Foods/liquids given before 6 months	No= 1 Yes= 0	No= 1 Yes= 0	No= 1 Yes= 0
Dietary diversity score (24 h)	0 food groups= 0 1−2 food groups= 1 ≥ 3 food groups = 2	0 food groups = 0 1−2 food groups = 1 ≥ 3 food groups = 2	0−1 food group= 0 2−3 food groups = 1 ≥ 4 food groups = 2
Meal frequency (24 h)	0 times = 0 1time = 1 ≥ 2 times= 2	0 times= 0 1−2 times= 1 ≥ 3 times = 2	0−1 time= 0 2times= 1 3 times= 2 ≥ 4 times= 3
Responsive feeding			
How does the mother response to child food refusal due to loss of appetite?	(a) Nothing (leave child alone)/forces child = 0 (b) Other (change types of foods, coax, role model, child has just started eating foods/never refuses foods) = 1		
Does mother restrict foods when child gets diarrhoea? †	No= 1 Yes= 0	No= 1 Yes= 0	No= 1 Yes= 0
Minimum−Maximum score	0–9	0–9	0–9

† a score of 1 was assigned if a child has never had diarrhoea.

Appendix 3: Supplemental Table 2 (Chapter 4) Health practices and scoring system used to construct health practices index (HPI)

Practices	**Score allocated to different practices**
Mother attended growth monitoring last month	Yes= 1 No= 0
Number of achieved antenatal care visits during pregnancy	0−1 visit= 0 2−3 visits= 1 ≥ 4 visits= 2
How was child diarrhoea treated? a) No treatment/home remedy b) Child was taken to health centre/health worker/ORS	 a) = 0 b) = 1
Did the child receive vitamin A supplements in the previous 6 months?	Yes= 1 No= 0
Did the child receive all age-appropriate vaccines?	Yes= 1 No= 0
Minimum−Maximum score	0–6

ORS, oral rehydration solution

Appendix 4: IYCF practices and child morbidity of 379 children aged 6–23 months in Rutsiro district, Rwanda, September 2018–January 2019

(Frequencies and percentages; means and standard deviations)

	Full sample		**Non-stunted**		**Stunted**	
	n	**%**	***n***	**%**	***n***	**%**
Number of children	379	100	233	61.5	146	38.5
Child was exclusively breastfed – yes	231	60.9	148	63.5	83	56.8
Child is currently breast-feeding – yes	362	95.5	230	98.7	132	90.4
Food groups consumed (24 h)						
Grains/roots/tubers	353	93.1	212	91.0	141	96.6
Legumes & nuts	275	72.6	168	72.1	107	73.3
Milk/dairy products	35	9.2	18	7.7	17	11.6
Flesh foods (meat, fish, poultry, liver/organ meat	70	18.5	49	21.0	21	14.4
Eggs	8	2.1	6	2.6	2	1.4
Vitamin A rich fruits & vegetables	225	59.4	143	61.4	82	56.2
Other fruits & vegetables	199	52.5	120	51.5	79	54.1
Any animal source foods	101	26.6	67	28.8	34	23.3
Minimum dietary diversity [a]	136	35.9	88	37.8	48	32.9
Number of food groups consumed						
Mean	3.1		3.1		3.1	
SD	1.2		1.3		1.1	
Minimum meal frequency [b]	206	54.4	121	51.9	85	58.2
Number of meals						
Mean	2.6		2.5		2.9	
SD	1.3		1.3		1.3	
Minimum acceptable diet [c]	90	23.7	55	23.6	35	24.0
Morbidity (past 4 weeks)						
Diarrhoea	179	47	105	45	74	51
URI	297	78	179	77	118	61
Fever	163	43	100	43	63	43
Other illnesses	40	11	24	10	16	11

IYCF, infant and young child feeding; SD, standard deviation; URI, upper respiratory infection.
[a] Minimum is defined as the consumption of foods from at least 4 food groups/d; [b] Minimum is defined as 2 and 3 meals/d for the children of 6−8 months and 9−23 months of age, respectively, in addition to breastmilk feeds, and 3 meals/d for the non-breastfeed children of 6−23 months of age. [c] Minimum is defined as achieving both minimum meal frequency and minimum dietary diversity[35].

Note: Reference included in this Appendix appears under the list of references of Chapter 4 (Paper II)

Appendix 5: Supplemental Table 3 (Chapter 4) Factors associated with height-for-age z-scores (HAZ) of children aged 6−23 months in Rutsiro district, Rwanda, by age group, September 2018–January 2019*

	HAZ, 6–11 months			**HAZ, 12–23 months**			**HAZ, 6–23 months**		
	β	95% CI	*P*	*β*	95% CI	*P*	*β*	95% CI	*P*
ICFI tertiles (ref.= low)									
Mid	0.10	−0.78, 1.34	0.60	0.08	−0.14, 0.51	0.26	0.07	−0.13, 0.47	0.27
High	0.03	−0.97, 1.12	0.89	0.16	0.06, 0.89	0.025	0.14	−0.02, 0.72	0.039
Age (months)	0.03	−0.11, 0.15	0.71	−0.23	−0.12, −0.04	< 0.001	−0.29	−0.10, −0.05	< 0.001
Birthweight (kg)	0.31	0.32, 1.18	0.001	0.21	0.21, 0.71	< 0 .001	0.22	0.29, 0.72	< 0.001
Child sex - male	−0.19	−0.93, −0.04	0.034	−0.11	−0.52, −0.02	0.07	−0.12	−0.53, −0.08	0.008
Diarrhoea - yes	−0.24	−1.06, −0.12	0.014	0.03	−0.20, 0.36	0.56	−0.04	−0.32, 0.14	0.45
Respiratory infection - yes	−0.18	−1.05, 0.00	0.048	−0.03	−0.43, 0.26	0.68	−0.08	−0.51, 0.04	0.09
Maternal height (cm)	0.16	−0.01, 0.08	0.11	0.32	0.04, 0.09	< 0.001	0.28	0.04, 0.08	< 0.001
Maternal education (ref.= none/incomplete primary)									
Primary	0.10	−0.30, 0.91	0.31	0.03	−0.27, 0.41	0.68	0.07	−0.08, 0.49	0.16
Secondary	0.19	−0.02, 1.19	0.06	0.05	−0.25, 0.53	0.46	0.09	−0.05, 0.61	0.08
Altitude (1000 m above sea level)	−0.20	−1.73, −0.04	0.04	−0.13	−1.00, −0.04	0.033	−0.15	−1.06, −0.25	0.002
Household hunger level (ref.= little/no hunger)									
Mild/severe	−0.15	−0.97, 0.22	0.21	−0.03	−0.35, 0.23	0.67	−0.05	−0.37, 0.13	0.34
Wealth factor scores									
1st factor	−0.07	−0.35, 0.18	0.51	0.02	−0.13, 0.18	0.75	−0.01	−0.14, 0.11	0.82
2nd factor	−0.02	−0.29, 0.24	0.86	−0.02	−0.17, 0.12	0.73	−0.03	−0.16, 0.98	0.58
N	102			232			334		
Adjusted R^2	0.28			0.25			0.31		

Ref., reference category; ICFI, infant and child feeding index; PHI, health practices index; *β*, standardized coefficients.

∗ Regression model included ICFI as the main independent variable.

Appendix 6: Supplemental Table 1 (Chapter 4) Factors associated with height-for-age z-scores (HAZ) of children aged 6−23 months in Rutsiro district, Rwanda, by age group, September 2018–January 2019*

	HAZ, 6–11 months			HAZ, 12–23 months			HAZ, 6 – 23 months		
	β	95% CI	P	*β*	95% CI	*P*	*β*	95% CI	*P*
HPI tertiles (ref.= Low)									
Mid	−0.03	−0.76, 0.58	0.80	0.08	−0.25, 0.2	0.40	0.03	−0.29, 0.42	0.71
High	−0.03	−0.68, 0.54	0.82	0.17	−0.06, 0.84	0.09	0.09	−0.13, 0.57	0.22
ICFI tertiles (ref.= Low)									
Mid	0.12	−0.78, 1.44	0.57	0.06	−0.19, 0.47	0.40	0.06	−0.16, 0.45	0.35
High	0.04	−0.98, 1.22	0.83	0.14	0.01, 0.84	0.047	0.13	−0.01, 0.72	0.06
Age (months)	0.04	−0.11, 0.16	0.69	−0.23	−0.12, −0.04	< 0.001	−0.30	−0.10, −0.05	< 0.001
Birthweight (kg)	0.31	0.31, 1.19	0.001	0.21	0.20, 0.70	0.001	0.22	0.29, 0.72	< 0.001
Child sex - male	−0.20	−0.94, −0.03	0.036	−0.12	−0.56, −0.02	0.037	−0.13	−0.54, −0.09	0.007
Diarrhoea - yes	−0.23	−1.06, −0.12	0.015	0.05	−0.17, 0.39	0.44	−0.03	−0.30, 0.17	0.58
Respiratory infection - yes	−0.18	−1.06, 0.01	0.05	−0.04	0.43, 0.23	0.55	−0.09	−0.53, 0.02	0.07
Maternal height (cm)	0.15	−0.01, 0.08	0.12	0.33	0.04, 0.09	< 0.001	0.28	0.04, 0.08	< 0.001
Maternal education (ref.= None/incomplete primary)									
Primary	0.10	−0.31, 0.82	0.33	0.04	−0.24, 0.43	0.58	0.08	−0.07, 0.50	0.13
Secondary	0.19	−0.04, 1.20	0.07	0.04	−0.27, 0.53	0.52	0.09	−0.05, 0.61	0.10
Altitude (1000 m above sea level)	−0.20	−1.74, −0.03	0.04	−0.10	−0.87, 0.13	0.14	−0.14	−1.00, −0.18	0.005
Household hunger level (ref.= little/no hunger)									
Mild/severe	−0.15	−0.97, 0.22	0.21	−0.02	−0.34, 0.23	0.71	−0.05	−0.37, 0.14	0.37
Wealth factor scores									
1st Factor	−0.07	−0.35, 0.19	0.51	0.00	−0.15, 0.15	0.99	−0.02	−0.16, 0.10	0.65
2nd Factor	−0.02	−0.29, 0.24	0.86	−0.04	−0.19, 0.10	0.55	−0.04	−0.17, 0.08	0.49
N	102			232			334		
Adjusted R^2	0.26			0.26			0.31		

Ref., reference category; *β*, standardized coefficients.

∗ Regression model included HPI (health practices index) as the main independent variable.

Appendix 7: Regression coefficients and adjusted R^2 from the multiple regression models including components of infant and child feeding index (ICFI) and health practices index (HPI)

	Practices	β	**95% CI**	***P***	**Adjusted R^2**
Components of ICFI	Child exclusively breastfed – yes	0.03	−0.17, 0.32	0.61	0.30
	Child currently breast-feeding – yes	0.13	0.20, 1.51	0.011	0.32
	Dietary diversity indicator (ref.= low)				0.31
	Medium	0.10	−0.22, 0.75	0.28	
	High	0.17	−0.06, 0.92	0.087	
	Meal frequency indicator				0.29
	Medium	0.01	−0.43, 0.37	0.87	
	High	0.02	−0.36, 0.48	0.77	
	Mother feeds child responsively when child refuses foods or loses appetite – yes	0.02	−0.21, 0.34	0.64	0.30
	Mother restricts foods during diarrhoea – yes	0.00	−0.26, 0.25	0.95	0.30
Components of HPI	Did the child receive all age-appropriate vaccines – yes	−0.07	−0.87, 0.10	0.12	0.31
	Child received vitamin A (last 6 months) – yes	−0.01	0.58, 0.56	0.98	0.31
	Antenatal care (ref.= low)				0.31
	Medium	0.01	−0.35, 0.39	0.99	
	High	0.05	−0.26, 0.51	0.52	
	Diarrhoea treatment method – child was taken to health centre/health worker/ORS	0.02	−0.20, 0.32	0.46	0.31
	Child was taken to growth monitoring – yes	0.02	−0.24, 0.40	0.62	0.31

Ref., reference category; β, standardized coefficients; ORS, oral rehydration solution.

Appendix 8: Bivariate association between selected care resources and infant and child feeding index (ICFI) and health practices index (HPI)*

Care resources	ICFI			P†	HPI			P†
	Low	Medium	High		Low	Average	High	
Maternal age group (years)				0.42				0.06
18−24	23.4	38.3	38.3		15.0	30.8	54.2	
25−29	16.2	49.5	34.3		9.1	30.3	60.6	
≥ 30	23.7	43.4	32.9		19.1	37.0	43.9	
Maternal education level				0.09				0.017
None/incomplete primary	26.0	42.9	31.1		17.4	36.1	46.6	
Complete primary	15.9	46.6	37.5		14.8	36.4	48.9	
Some secondary	12.9	43.5	43.5		9.7	19.4	71.0	
Civil status								
Unmarried	33.3	45.3	21.3	0.004	17.3	36.0	46.7	0.67
Married	18.8	43.1	38.2		14.8	32.9	52.3	
Household wealth index‡				<0.001				0.001
Low	32.3	43.3	24.4		24.4	35.4	40.2	
Mid	23.0	38.9	38.1		13.5	36.5	50.0	
High	9.5	48.4	42.1		7.9	28.6	63.5	
Possession of health insurance				0.22				0.001
Yes	20.9	41.0	38.1		10.0	34.3	55.6	
No	22.9	47.9	28.3		24.3	32.1	43.6	
Household hunger level				0.004				0.008
Little/no hunger	16.7	42.3	40.9		11.6	30.7	57.7	
Moderate/severe	28.0	45.1	26.8		20.1	37.2	42.7	

* Values are %.

† P values obtained using a χ^2 test;

‡ The scores of the first factor component of the were used to classify households.

Appendix 9: Supplementary Table (Chapter 5). Frequency Counts and Percentages of Major and Sub-categories of Factors Influencing Access to and Use of MNP in Rutsiro District, Rwanda, September 2018–January 2019 (n= 234)[1]

	Major categories	Sub-categories	Codes
Factors related to access to MNP	Limited availability of MNP supplies 74 (32%)	CHWs have no MNP 72 (30.7%)	Informed by CHWs about lack of supplies
		CHWs have limited quantity of MNP for all mothers attending GM 2 (0.8%)	Mothers arriving late at the GM site have no chance to get MNP
	CHWs–mother interactions 41 (17.5%)	MNP routine distribution is more convenient 33 (14.1%)	Choice to wait for routine distribution over travelling to CHW's house to get MNP supplies
		Opportunity cost 6 (2.5%)	Choice to work for income over attending taking child to GM
		Other 2 (1.3%)	Neglect; unfair treatment by CHW
	Limited information about MNP 27 (11.5%)	Mothers do not know MNP 17 (7.2%)	Mother never heard about MNP Mother heard about but never seen MNP
		Limited information MNP programme 10 (4.3%)	Unawareness of eligibility criteria Unawareness of distribution mechanisms
Factors related to the use of MNP	Perceived side effects 38 (16.2%)	MNP causes child illness 19 (8.1%)	MNP causes diarrhoea/vomiting/fever
		Child dislikes foods prepared with MNP 20 (8.5%)	MNP changes taste of foods
	Incompatibility between current complementary feeding practices and MNP programme recommendations 33 (14.1%)	Child still adapting to CF 27 (10.6)	Child is fed thin/watery foods with consistency not recommended by MNP programme
		Late introduction to CF 6 (2.6%)	Child hasn't started CF
	MNP perceived as intended for malnourished children 11 (4.7%)	MNP is meant for malnourished children 11 (4.7%)	Healthy children don't need MNP (a child who hasn't lost weight/whose hair looks healthy; has never had health issues)
	MNP is not as important as "real" food 5 (2.1%)	Demotivation due to non-participation in the supplementary programme which distribute foods 4 (1.7%)	Children need "real" foods
		No need for MNP if a child eats all foods	MNP have no additional health benefits

	Major categories	Sub-categories	Codes
		1 (0.4)	
	Lack of recommended foods 4 (1.7%)	Economic constraints to access foods 2 (0.8%)	Lack of means to buy foods
		Perceived poor quality of available foods 2 (0.8%)	Available foods (e.g. sweet potatoes) are not appropriate
	Miscellaneous 6 (2.6%)	–	Received expired product MNP left in previous rental house Perceived inability to follow MNP feeding instructions Undisclosed (personal) reasons Child's lack of appetite Child's ill-health

Abbreviations: CF, complementary foods; CHWs, community health workers; MNP, multiple micronutrients powder; GM, growth monitoring.

Note: The frequency was determined by counting the number of times a major/sub-category occurred divided by the number of participants. The frequencies do not add up to 100% as some mothers were coded more than once.

Appendix 10: Caregivers' interview guide (STUDY 1)

Interview guide

Background information

- Household identification number [__] [__] Date _____/_____/_____
- Province _____ District _____ Sector _____ Cell_____ Village _____
- Caregiver's name_____ Tel: _____
- Gender F / M Age _____ years.
- Marital status: married ___ divorced ___ widowed ___ never married ___
- Caregiver's occupation _____ Work hours per week _____
- Occupation of partner _____ Work hours per week _____
- Caregiver's education: primary ___ secondary ____ university ___other (specify)_____ none __
- Partner's education: primary __ secondary ___ university ___ other (specify)_____ none __

Information related to index child

- Caregivers' relationship with index child: Mother __ Other (specify) _____
- Index child age_____ (months) Gender F / M Birth order ___
- Length ___. ___ (cm)
- Weight _____ (in kg)
- Child has been taken to child growth monitoring in the last month: Yes / No
- Child has been immunized: complete ___incomplete ___ none __
- Child had diarrhoea in past 2 weeks: Yes / No
- Child had fever in the past 2 weeks: Yes / No
- Child had other illness in the past 2 weeks: Yes (specify) / No

Socio-economic information

- Socioeconomic group (as per the Rwandan government classification): 1 __ 2 __ 3 __ 4 __
- Main source of income _____
- Community-based health insurance ownership: all household members___ some household members _____ only children ____
- Household size ____ # of children < 5 years _____5 – 10 years ____ > 10 years ____
- # rooms used for sleeping _____ # rooms with bed net _____
- Walls: bricks _____stones _____wood and mud/dung ____ cement _____
- Floor: earth/sand ____ cement _____ bricks _____ ceramic tiles _____
- Roof: grass/thatch ___ ceramic tiles ___ iron sheet ___ other (specify)_____
- Kitchen: inside main house _____ separate building_____ outside shed _____
- Home toilet: traditional/pit latrine _____ flush toilet _____ none _____

- Main source of water: swamp _____ protected spring/well _____ unprotected spring/well _____ public tap _____ lake _____ river _____ rain water _____ borehole ____
- Main cooking fuel: wood ___ charcoal____ biogas _____ other (specify) _____
- Source of light: electricity ____ kerosene lamp ___solar system ___ candles _____other (specify) _____
- Land ownership: own land _____ hired land _____ other (specify)_____
- Crops grown: _____

INTERVIEW QUESTIONS

* = a follow-up question to be asked in order to get in-depth information.

Section 1: Child feeding practices and behaviours

1) Could you briefly describe to me how your family usually eats?

* Is there any defined eating order for the family members?
* Are there any special foods that (name) receives?
* Are (name)'s foods and family food prepared separately?

2) Is there a period of the year when your family changes how you usually eat? Yes/No

* If Yes, could you tell me about this period?
* Could you tell me how (name) is fed during this period?

3) Could you briefly describe me how you fed (name) from birth until now?

* Is there someone whom you consult on how/what to feed (name)?
* For how long did (name) receive breastmilk only?
* When were semisolid and liquid foods introduced?
* Did you continue breast-feeding after introducing semisolids and liquids? Until when?
* How did you determine that (name) was ready for complementary foods? adults' foods?
* Once (name) started eating solid/semi-solid foods, which foods did you consider appropriate for him/her? why?
* Once (name) starts eating solid/semi-solid foods, which foods does your family eat that are not given to (name)? why?

4) What do you find challenging in feeding (name)?

* Why is (name perceived challenge) a challenge?

* By addressing (name perceived challenge) how would feeding (name) be improved?

Section 2: Childcare arrangements

1) Think of a time when you have to spend many hours outside your home (for example working in the field or travelling). How is (name) taken care of?
* Could you tell me how (name) is fed at that time?

2) How do/did you decide when to entrust (name)'s care to another caregiver, e.g. father, siblings, neighbour or another family or non-family member (e.g. nanny, crèche)?
* Do you entrust them with all responsibilities including preparing food and feeding the child?

Section 3: Health-seeking practices and behaviours

1) According to you, what characterises a healthy child?

* What does a child need to grow?
* If a child doesn't grow well, what could be the causes?

2) Could you briefly tell me about any health issues that (name) had previously and how you decided to seek treatment?

* How often has (name) had (name health issue)?
* Where did you take (name) for treatment?
* How long did you wait before seeking treatment?

3) How do you know that (name) is sick?

* How does what you feed (name) change when he/she's sick?

4) Is undernutrition a health issue among children in your area? Yes/No

* Why do you think or not think undernutrition is an issue?
* How do you recognize an undernourished child?
* What do you think can be done to prevent a child from getting malnourished?

5) What do you do to prevent your children from getting sick?

6) Are there illnesses during which a particular food is given/not given to (name)?
* What do you do when (name) has diarrhoea? Do you increase/decrease feeding or feed as usual?

* Which foods and/or liquids do you feed/don't feed (name) when he/she has diarrhoea?
* Why?

Section 4: Availability of community/social support

1) Could you briefly tell me about the different types of support that you get (either from your family, friends or neighbours) which helps you in child feeding matters?

2) What community group are you (or you husband) a member of?

3) Families with young children are sometimes supported in many ways. Is your family being supported by the government, church, NGOs, etc.? Yes/No
* If Yes, what the type of support does your family receive from (name source of support)?

4) Many villages have programmes such as Parents' Evening and Village Nutrition School. Do these programmes exist in your village? Yes/No

* If Yes, are you attending? (ask how many times she attended in the last month)
* Can you tell me the benefits of these programmes?
* If No, why are you not attending?

5) Is there anything else you would like to tell me about feeding children and how to keep them healthy?

END – Thank you very much for your time and for your answers.

Appendix 11: Massey University Ethics Approval

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

Date: 15 December 2017

Dear Theogene Dusingizimana

Re: Ethics Notification - **SOA 17/67** - **An investigation of factors determining optimal child nutrition in Rwanda**

Thank you for the above application that was considered by the Massey University Human Ethics Committee: **Human Ethics Southern A Committee** at their meeting held on **Friday, 15 December.**

Approval is for three years. If this project has not been completed within three years from the date of this letter, reapproval must be requested.

If the nature, content, location, procedures or personnel of your approved application change, please advise the Secretary of the Committee.

Yours sincerely

Dr Brian Finch
Chair, Human Ethics Chairs' Committee and Director (Research Ethics)

Research Ethics Office, Research and Enterprise
Massey University, Private Bag 11 222, Palmerston North, 4442, New Zealand **T** 06 350 5573; 06 350 5575 **F** 06 355 7973
E humanethics@massey.ac.nz **W** http://humanethics.massey.ac.nz

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

Date: 31 August 2018

Dear Theogene Dusingizimana

Re: Ethics Notification - **SOA 18/50 - An investigation of the determinants of child nutrition status in Rwanda.**

Thank you for the above application that was considered by the Massey University Human Ethics Committee: **Human Ethics Southern A Committee** at their meeting held on **Friday, 31 August, 2018**.

Approval is for three years. If this project has not been completed within three years from the date of this letter, reapproval must be requested.

If the nature, content, location, procedures or personnel of your approved application change, please advise the Secretary of the Committee.

Yours sincerely

Professor Craig Johnson
Chair, Human Ethics Chairs' Committee and Director (Research Ethics)

Research Ethics Office, Research and Enterprise
Massey University, Private Bag 11 222, Palmerston North, 4442, New Zealand T 06 350 5573; 06 350 5575 F 06 355 7973
E humanethics@massey.ac.nz W http://humanethics.massey.ac.nz

Appendix 12: University of Rwanda Institutional Review Board Ethics approval

UNIVERSITY OF RWANDA

COLLEGE OF MEDICINE AND HEALTH SCIENCES

CMHS INSTITUTIONAL REVIEW BOARD (IRB)

Kigali, 4th /01/2018

DUSINGIZIMANA Theogene
College of Agriculture And Veterinary Medicine, UR

Approval Notice: No 003 /CMHS IRB/2017

Your Project Title ***"An Investigation Of Factors Determining Optimal Child Nutrition In Rwanda."*** has been evaluated by CMHS Institutional Review Board.

		Involved in the decision		
		Yes	No (Reason)	
Name of Members	**Institute**		**Absent**	**Withdrawn from the proceeding**
Prof Kato J. Njunwa	UR-CMHS		X	
Prof Jean Bosco Gahutu	UR-CMHS	X		
Dr Brenda Asiimwe-Kateera	UR-CMHS	X		
Prof Ntaganira Joseph	UR-CMHS	X		
Dr Tumusiime K. David	UR-CMHS	X		
Dr Kayonga N. Egide	UR-CMHS	X		
Mr Kanyoni Maurice	UR-CMHS	X		
Prof Munyanshongore Cyprien	UR-CMHS		X	
Mrs Ruzindana Landrine	Kicukiro district		X	
Dr Gishoma Darius	UR-CMHS	X		
Dr Donatilla Mukamana	UR-CMHS	X		
Prof Kyamanywa Patrick	UR-CMHS		X	
Prof Condo Umutesi Jeannine	UR-CMHS		X	
Dr Nyirazinyoye Laetitia	UR-CMHS	X		
Dr Nkeramihigo Emmanuel	UR-CMHS		X	
Sr Maliboli Marie Josee	CHUK	X		
Dr Mudenge Charles	Centre Psycho-Social	X		

After reviewing your protocol during the IRB meeting of where quorum was met and revisions made on the advice of the CMHS IRB submitted on 26th December 2017, **Approval has been granted to your study.**

EMAIL: *researchcenter@ur.ac.rw* P.O. Box: 3286, Kigali, Rwanda WEBSITE: http://cmhs.ur.ac.rw/

Please note that approval of the protocol and consent form is valid for **12 months**.

You are responsible for fulfilling the following requirements:

1. Changes, amendments, and addenda to the protocol or consent form must be submitted to the committee for review and approval, prior to activation of the changes.
2. Only approved consent forms are to be used in the enrolment of participants.
3. All consent forms signed by subjects should be retained on file. The IRB may conduct audits of all study records, and consent documentation may be part of such audits.
4. A continuing review application must be submitted to the IRB in a timely fashion and before expiry of this approval
5. Failure to submit a continuing review application will result in termination of the study
6. Notify the IRB committee once the study is finished

Sincerely,

Date of Approval: The 4th January 2018

Expiration date: The 4th January 2019

For Professor Kato J. NJUNWA
Chairperson Institutional Review Board,
College of Medicine and Health Sciences, UR

Cc:
- Principal College of Medicine and Health Sciences, UR
- University Director of Research and Postgraduate Studies, UR

UNIVERSITY OF RWANDA *COLLEGE OF MEDICINE AND HEALTH SCIENCES*

CMHS INSTITUTIONAL REVIEW BOARD (IRB)

Kigali, 06/August/2018

DUSINGIZIMANA Theogene
College of Agriculture and Veterinary Medicine, UR

Notice of Renewal of Approval for Research Project: No 290 /CMHS IRB/2018

Your Project Title ***"An Investigation Of The Factors Determining Optimal Child Nutrition In Rwanda."*** Has Been Evaluated By CMHS Institutional Review Board.

		Involved in the decision		
		Yes	No (Reason)	
Name of Members	**Institute**		**Absent**	**Withdrawn from the proceeding**
Prof Kato J. Njunwa	UR-CMHS		X	
Prof Jean Bosco Gahutu	UR-CMHS	X		
Dr Brenda Asiimwe-Kateera	UR-CMHS	X		
Prof Ntaganira Joseph	UR-CMHS	X		
Dr Tumusiime K. David	UR-CMHS	X		
Dr Kayonga N. Egide	UR-CMHS	X		
Mr Kanyoni Maurice	UR-CMHS	X		
Prof Munyanshongore Cyprien	UR-CMHS	X		
Mrs Ruzindana Landrine	Kicukiro district		X	
Dr Gishoma Darius	UR-CMHS	X		
Dr Donatilla Mukamana	UR-CMHS	X		
Prof Kyamanywa Patrick	UR-CMHS		X	
Prof Condo Umutesi Jeannine	UR-CMHS		X	
Dr Nyirazinyoye Laetitia	UR-CMHS	X		
Dr Nkeramihigo Emmanuel	UR-CMHS		X	
Sr Maliboli Marie Josee	CHUK	X		
Dr Mudenge Charles	Centre Psycho-Social	X		

After reviewing your protocol, **Continuation of Approval has been granted to your study.**

Please note that approval of the protocol and consent form is valid for **12 months**.
You are responsible for fulfilling the following requirements:

1. Changes, amendments, and addenda to the protocol or consent form must be submitted to the committee for review and approval, prior to activation of the changes.
2. Only approved consent forms are to be used in the enrollment of participants
3. All consent forms signed by subjects should be retained on file. The IRB may conduct audits of all study records, and consent documentation may be part of such audits.
4. A continuing review application must be submitted to the IRB in a timely fashion and before expiry of this approval.
5. Failure to submit a continuing review application will result in termination of the study.
6. Notify the Rwanda National Ethics committee once the study is finished.

Sincerely,

Date of Approval: August 6th, 2018
Expiration date: August 6th, 2019

for Professor Kato J. NJUNWA
Chairperson Institutional Review Board,
College of Medicine and Health Sciences, UR

Cc:
- Principal College of Medicine and Health Sciences, UR
- University Director of Research and Postgraduate Studies, UR

Appendix 13: Variables used to construct household wealth index

Variable		***n***	***%***
Land ownership			
HH has a homestead land	Yes	273	72
HH has a kitchen garden	Yes	201	53
HH has an additional plot of land (other than homestead land)	Yes	191	50.4
HH has grows foods on someone's land (rental or shared)	Yes	240	63.3
HH purchased commercial fertilizer (previous cropping season)	Yes	125	33
Source of lighting			
	None	33	8.7
	Candle/petrol lamp	209	55.1
	Electricity/solar	137	36.1
House construction materials			
Floor	Earth	301	79.4
	Bricks	14	3.7
	Cemented	64	16.9
Wall	Wood/mud	296	78.1
	Bricks	3	0.8
	Cemented	80	21.1
Roofing	Thatch/plastic shitting	2	0.5
	Local tiles	356	93.9
	Iron sheets	21	5.5
Durable asset ownership			
Radio	Yes	102	26.9
Mattress	Yes	197	52
Umbrella	Yes	176	46.4
Thermos flask*	Yes	95	25.1
Crowdedness (number of persons per sleeping room)			
	≥ 4 persons	63	16.6
	≤ 3 persons	316	83.4
Livestock ownership			
Cows	Yes	156	41.2
	Yes, but not own cow	78	20.6
Goats	Yes	60	15.8
	Yes, but not own goat	26	6.9
Sheep	Yes	28	7.4

Variable		***n***	***%***
	Yes, but not own sheep	12	3.2
Pigs*	Yes	51	13.5
	Yes, but not own pig	36	9.5
Chickens	Yes	57	15
Rabbits	Yes	9	2.4
Guinea pigs	Yes	11	2.9
Health insurance for all HH members	Yes	239	63.1

HH= household

* Difference between household with non-stunted and those with stunted is statistically significant at 5% (χ^2 test).

Appendix 14: Household survey questionnaire (Chapter 4 & 5)

HOUSEHOLD SURVEY QUESTIONNAIRE

I. GENERAL INFORMATION

1. Household ID number: _____
2. Household contact number: _____
3. Study zone

    i. South East
    ii. North East
    iii. West

1. Sector_____
2. Cell: _____
3. Village: _____
4. Marital status
    1. Single
    2. Married
    3. Divorced
    4. Widowed
    5. Living with parents
5. [If married] Is your husband currently living with you?
    1. Yes
    2. No
6. Mother's/caregiver's age [Ask respondent for identity card and record year of birth] _____years
7. What was your age (in years) when you first had a child?_____ years
8. [If married] What is your husband's year of birth? [record 999 if this information is not available]
9. What is your highest completed grade?

    1. No education
    2. Informal - know to read and write
    3. 1st primary (P1)
    4. 2nd primary (P2)
    5. 3rd primary (P3)
    6. 4th primary (P4)
    7. 5th primary (P5)
    8. 6th primary (P6)
    9. Above P6

1. [If married] What is your husband's highest completed grade?

    1. No education
    2. Informal - Know to read and write
    3. 1st primary (P1)
    4. 2nd primary (P2)
    5. 3rd primary (P3)
    6. 4th primary (P4)
    7. 5th primary (P5)

8. 6th primary (P6)
9. Above P6

10. How many persons live in your household? _____ (number of persons)
11. How many children are under 5 years old in your household? _____ (number of children < 5 years)
12. Target CHILD sex

    1. Male
    2. Female

13. When was (TARGET CHILD) born? [Ask for child's health card for verification]
14. At what gestational age was (CHILD) born?
15. Where was (CHILD) born?

    1. Hospital/health centre
    2. Other

16. Childbirth order

    1. First
    2. Second
    3. Third
    4. Fourth
    5. Fifth
    6. Sixth
    7. Seventh and above

17. [If child is not first born] Ask When was the preceding child born? …../…./……

II. CHILD FEEDING PRACTICES

Now I would like to ask you about how you fed (CHILD) since he/she was born till today

(1) Is (CHILD) still breastfeeding?

1. Yes
2. No

(2) How long (in months) did you exclusively breastfeed (CHILD)? [Exclusively breastfeeding means feeding a child breastmilk with no other foods or liquids]

(3) How old was (CHILD) when you first introduce him/her to the first complementary foods? [CF means solid, semi-solid or soft-foods in addition to breastmilk]

(4) Now I would like to describe ALL the foods that (CHILD) was fed since yesterday as the same time as now. This is to enable us to find out what your child has eaten the previous day. So you will need to recall all that your child has eaten, including foods, drinks, sauces, and snacks. There

is no right or wrong answer in answering the question; you will only need to tell me what your child has actually eaten.
To start with, about what time did (CHILD) wake up? Continue asking what did (CHILD) eat?
[Quickly note the time/eating occasions. Don't interrupt unnecessarily. When respondent stops, ask: Anything else?]

Based on eating occasions, quickly write:

The number of meals [record number of meals (CHILD) received]: _____

Number of snacks [Record number of snacks that the child received]: _____

(5) Types of food child consumed in the last 24 hours.

Now I would like to know what (CHILD) was fed since yesterday as the time as now.
Did (CHILD) eat any of the following foods, even if it was combined with other foods?

1. Maize, maize pap (kawunga)
2. Cassava or cassava ugali
3. Irish potatoes
4. White sweet potatoes
5. Taro (amateke)
6. Bread
7. Rice, noodles or macarroni
8. Cereal porridge
9. None

(6) Child was fed grains, roots or tubers

1. Yes
2. No

(7) Did (CHILD) eat any of the following foods, even if it was combined with other foods?

1. Beans
2. Soy beans
3. Peas
4. Groundnut
5. Groundnut or soybean flour
6. Soy milk or tofu
7. Other foods made from legumes or nuts
8. None

(8) Child ate legumes or nuts

1. Yes
2. No

(9) Did (CHILD) eat any of the following foods, even if it was combined with other foods?

1. Fresh milk
2. Traditional fermented milk (Ikivuguto)
3. Yoghurt, cheese or any other dairy products
4. None

(10) Child was fed milk or dairy products

1. Yes
2. No

(11) Did (CHILD) eat any of the following foods, even if it was combined with other foods?

1. Meat
2. Fish (Indagara, Isambaza)
3. Poultry, liver, organ meats
4. None

(12) Child was fed flesh foods

1. Yes
2. No

(13) Did (CHILD) eat eggs?

1. Yes
2. No

(14) Did (CHILD) eat any of the following foods, even if it was combined with other foods?

1. Carrots
2. Papaya
3. Orange-fleshed sweet potatoes
4. Ripe mangoes
5. Pumpkin
6. Squash
7. None

(15) Child was fed Vitamin A rich fruits and vegetables

1. Yes
2. No

(16) Did (CHILD) eat any of the following foods, even if it was combined with other foods?

1. Banana
2. Orange
3. Passion fruits
4. Pineapple
5. Guyava
6. Lemon
7. Amaranths
8. Cassava leaves
9. Cabbage
10. Pumpkin leaves
11. Celery
12. Eggplant
13. Green banana (igitoki)
14. Spinach
15. Onions, cucumber, tomato, coliflower
16. None

(17) Child was fed other fruits and vegetables

1. Yes
2. No

(18) Show image of 5 step ladder of child appetite level.
Here is a 5 step ladder. At the bottom, the first step, stand children who have very poor appetite, and on the highest step, the fifth, stand children with excellent appetite. On this ladder, could you indicate at which step is (CHILD) appetite in relation to his/her usual intake?

1. Very poor

2. Poor
3. Good
4. Very good
5. Excellent

(19) Could you tell me about the reasons for your choice?

(20) Responsive feeding:

Sometimes children have poor appetite and refuse to eat. Can briefly you tell me how you usually feed (CHILD) when he/she has poor appetite and refuses to eat food?

(21) Are there foods that are eaten by everyone else in your households that are not given to (CHILD)?

1. Yes
2. No

(22) What are these foods? *Why? what else?*

(23) What does (CHILD) eat when you have cooked these foods?

(24) How many days did you cook these foods in the last 7 days? _____ (number of days)

(25) CHILD CONSUMPTION OF MICRONUTRIENT SUPPLEMENTS

Some households with young children receive a micronutrient sprinkles called ONGERA to add to their children's food

1) Have you used Ongera (MNP) in the last 7 days to feed (CHILD)?

1. Yes
2. No

2) [If No] Have you ever received ONGERA before?

1. Yes
2. No

3) Could you briefly tell me the reasons why you did not feed (CHILD) ONGERA in the last 7 days?

4) How long (in months) have you been adding ONGERA to (CHILD's) food?

5) Did you receive ONGERA consistently throughout (period mentioned by respondent)

1. Yes
2. No

6) How many times per week does (CHILD) gets ONGERA? [Record number] _____

7) Does (CHILD) share ONGERA with other children?

1. Yes

2. No

(26) CHILD CONSUMPTION OF FORTIFIED SUPPLEMENTARY FOODS (SHISHA)

Some households with young children receive a micronutrient sprinkles (also known as ONGERA) to add to their children's food.

1) Are you currently receiving the micronutrient-fortified flour or SHISHA rations that you feed (CHILD)?
1. Yes
2. No

2) [IF NO] Could you briefly tell me the reasons for not receiving SHISHA?

3) Have you ever received SHISHA before?
1. Yes
2. No

4) How long (in months) have you been feeding (CHILD) SHISHA? _____ (months)

5) Did you receive SHISHA rations for (CHILD) consistently throughout (period mentioned by respondent)
1. Yes
2. No

6) Does (CHILD) share SHISHA porridge with other children?
1. Yes
2. No

(27) Now I would like to ask you about your experience with feeding a sick child (e.g when he/she has diarrhoea).
I will read statements and, based on what you usually do, you will tell me which one best reflects what you usually do.

1) When your child has diarrhoea,
1. you give him/her more foods than usual
2. you give him/her the same amount as usual
3. you give him/her less foods than usual
4. you breastfeed him/her only and wait until she/he is recovered before you give him/her foods
5. Child never had diarrhoea

2) When your child has diarrhoea,
1. you give him/her more fluids than usual
2. you give him/her the same amount of fluids as usual
3. you give him/her less fluids than usual
4. you wait until s/he is recovered before giving him/her fluids.
5. Child never had diarrhoea

3) Are there foods or liquids that you usually stop feeding your child when he/she has diarrhoea?
1. Yes
2. No

4) Which foods or liquids do you usually stop giving your child when he/she had diarrhoea? Why?
Write the types/names of the food (s) mother stops feeding child

_____

5) Are there foods or liquids that you usually feed your child when he/she has diarrhoea?

1. Yes
2. No

6) Which foods or liquids do you usually feed your child when he/she had diarrhoea?
Write name/type of the foods _____

7) Some mothers usually feed their children leftovers from a previous day. Do you usually feed (CHILD) leftovers?

1. Yes
2. No

8) Do you reheat leftovers before you feed it to (CHILD)?

1. Yes
2. No

9) How often do you reheat leftovers before giving it to (CHILD)?

1. Almost always
2. Sometimes
3. Almost never

10) [If almost never] Are there barriers that prevent you from reheating the food?
Write barriers faced by mothers _____

III. MATERNAL CONSUMPTION OF FORTIFIED COMPLEMENTARY FOODS

Some pregnant and lactating mothers receive micronutrient-fortified blended flour from the health centre.

1) Did you receive such flour when you were expecting (CHILD)?

1. Yes
2. No

2) Did you consistently receive the fortified flour during pregnancy?

1. Yes
2. No

3) Did you receive the flour after (CHILD) birth?

1. Yes
2. No

4) Did you consistently receive the flour after (CHILD) birth?

1. Yes
2. No

5) Do/did you share the fortified supplementary flour with any one in your household?

1. Yes
2. No

IV. HOUSEHOLD FOOD SECURITY

Now I would like to ask you about your household food situation.

1) In the past 4 weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food?

1. Yes
2. No

2) [If Yes] How often did this happen?

1. Rarely (once or twice in the past 4 weeks)
2. Sometimes (3-10 times in the past 4 weeks
3. Often (more than 10 times in the past 4 weeks)

3) In the past four weeks, did you or any of your household members go to sleep at night hungry because there was not enough food?

1. Yes
2. No

4) [if Yes] How often did this happen?

1. Rarely (once or twice in the past 4 weeks)
2. Sometimes (3-10 times in the past 4 weeks
3. Often (more than 10 times)

5) In the past four weeks, did you or any of your household members go a whole day and night without eating anything because there was not enough food?

1. Yes
2. No

6) [If yes] How often did this happen?

1. Rarely (once to twice in the past 4 weeks)
2. Sometimes (3-10 times in the past 4weeks
3. Often (more than 10 times in the past 4 weeks)

V. COMMUNITY RESOURCES AND SUPPORT SYSTEM

Now I would like to ask you about the types of resources and support available to you and your household.

1) Are you or your husband (if married) currently a recipient of the Vision 2020 Umurenge Programme (VUP) direct support Programme?

1. Yes – respondent
2. Yes – husband
3. Yes – both
4. None

2) [If Yes – respondent/husband/both] Which VUP programme are you or your husband benefiting from?

1. VUP Direct support
2. VUP Public Works
3. VUP Microcredit

3) How long (in months) have you/your husband been a recipient of the programme?
Record the longest duration if both are recipients _____years

4) How much money per month do you (or your husband) earn from the VUP programme?

5) How many days per week are you engaged in the programme?

6) Are you or your husband currently receiving support from any non-governmental organizations (NGO)?

1. Yes
2. No

7) How does (the organization mentioned) support you/your husband?
Record type of support received _____

8) Are you or your husband currently a member of any social support group? An example may be a saving/credit group, a cooperative/tontine or a religious group.

1. Yes
2. No

Ask about the type of social group _____

9) Have you participated in the parents' evening forum in the last month?

1. Yes
2. No

10) Have you participated in the village cooking session in the last month?

1. Yes
2. No

11) Are there reasons why you didn't participate in the village cooking session? Reasons:_____

VI. MATERNAL AUTONOMY IN DECISION MAKING

1) Is confidentiality assured?

1. Yes
2. No

2) Who usually decides about how your own earnings will be used?

1. Myself
2. My husband/people I live with
3. Jointly decide
4. I never work for income

3) Who usually decides about how your husband's earnings will be used?

1. Myself
2. My husband
3. Jointly decide
4. Husband never earns income

4) Who usually decides about selling something from your household such as crop harvest or a livestock?

1. Myself
2. My husband/people I live with
3. Jointly decide

5) Who usually decides about when and where to go for treatment when you are sick?

1. Myself

2. My husband/people I live with
3. Jointly decide

6) Who usually makes decisions about when and where to take a sick child for treatment?

1. Myself
2. My husband/people I live with
3. Jointly decide

7) Who usually makes decisions about what to feed the child everyday?

1. Myself
2. My husband/people I live with
3. Jointly decide

VII. HEALTH-SEEKING BEHAVIOURS

Now I would like to ask you about the health practices in your household.

1) When you were pregnant with (target CHILD), did you go to hospital/health centre to check your health and that of (CHILD)?

1. Yes
2. No

2) [If Yes] How many times did you go to the hospital/health centre to check your health and that of (CHILD)?
Record number of times _____ [or 999 if she doesn't remember]

3) Has (CHILD) been taken to growth monitoring programme in the last month?

1. Yes
2. No

4) How much did (CHILD) weigh last time you took him/her to growth monitoring? [Ask health card to verify]
_____ kg [or 999 if mother does not remember]

5) Who took (CHILD) to the growth monitoring programme?

1. Mother
2. Father
3. Sibling
4. Another relative
5. Someone else

6) [If Sibling] How old is the sibling who took the child to growth monitoring? _____ years

7) Did (CHILD) receive vitamin A capsule in the last 6 months?

1. Yes
2. No
3. I don't remember

8) Did (CHILD) receive deworming tablets/drugs in the last 6 months?

1. Yes
2. No
3. I don't remember

9) Did (CHILD) sleep under insecticide treated mosquito net last night?

1. Yes
2. No

VIII. HEALTH CARE RESOURCES

1) Are all your household's members covered by Mutuelle de Santé/Community Health Insurance?

1. Yes
2. No

2) How long (in minutes) does it take you to get to the nearest health centre/post?

3) Do you and any of your household members always seek health care when it is needed?

1. Yes
2. No

4) Why would you and/or any of your household members not seek health care when it is needed?

Write reasons _____

IX. HYGIENE PRACTICES

Now I would like to ask you some questions about hygiene.

1) Could you tell me the critical times that you know mothers in this village must wash their hands?

1. Before food preparation
2. Before eating
3. Before feeding the child
4. After handling child's feces or cleaning child's bottom
5. After using toilet
6. Other (specify)

Write other critical times for handwashing _____

2) Record the number of critical times mentioned by respondents _____

3) Do you think it is necessary to wash your hands with soap at all these critical times?

1. Yes
2. No

4) [If Yes] Why do you think it is necessary to wash your hands with soap at these critical times?

1. Health related reasons
2. Non-health related reasons

5) With your current resources and knowledge, do you think you can wash your hands with a soap at all these critical times?

1. Yes
2. No

6) [If No] What are the difficulties would you have washing your hands at these critical times?
Write the difficulties mentioned by mothers _____

X. TARGET CHILD HEALTH RELATED INFORMATION

1) Did (CHILD) receive all vaccines? Ask the respondent to show child vaccination card

1. Yes
2. No

2) Did (CHILD) have diarrhoea in the past 4 weeks?
[Having diarrhoea means passing 3 or more loose stools per day]

1. Yes
2. No

3) [If Yes] How often did (CHILD) have diarrhoea in the past 4 weeks?

1. Once
2. Twice
3. 3 times
4. 4 times
5. More than 4 times

4) How do you usually treat diarrhoea of (CHILD)?

1. Oral Rehydration Solution
2. Traditional/home remedy
3. Child taken to hospital/health centre
4. Consult health worker
5. None/wait for diarrhoea to go away

5) Did (CHILD) have fever in the past 4 weeks? [fever means body temperature above normal]

1. Yes
2. No

6) How often did (CHILD) have fever [body temperature above normal] in the past 4 weeks?

1. Once
2. Twice
3. 3 times
4. 4 times
5. More than 4 times

7) Did (CHILD) have illness with persistent cough, difficult breathing, or pneumonia in the past 4 weeks?

1. Yes
2. No

8) How often did (CHILD) have illness with persistent cough, difficult breathing, or pneumonia in the past 4 weeks?

1. Once
2. Twice
3. 3 times
4. 4 times
5. More than 4 times

9) Did (CHILD) have any other illness in the past 4 weeks?

1. Yes
2. No

10) Which other illness did the child have in the past 4 weeks?_____

11) How often did (CHILD) have (illness mentioned) in the past 4 weeks?

1. Once
2. Twice
3. 3 times
4. 4 times
5. More than 4 times

12) Does the child have a health record book?

1. Yes
2. No

Check health record book and Write the number of visits to health centre/hospital for treatment.
Number of hospital visits _____

XI. RESPONDENT & HUSBAND OCCUPATION

1) What is your main occupation?

1. Farmer
2. Irregular day laborer
3. Regular worker
4. No occupation

2) [If Regular worker] Write type of employment _____

3) How many days were you engaged in this occupation in the past 2 weeks?

4) [If irregular laborer/farmer/regular worker] Could you tell me how (CHILD) was taken care of when you went to work?

How many hours is the child is left home: _____

Ask about who takes care of the child? _____
Does the mother take the child with her? _____

5) [If Married] What is the main occupation of your husband?

1. Farmer
2. Irregular day worker
3. Regular worker
4. No occupation

6) [If husband is a regular worker] Write the type of employment _____

XII. HOUSEHOLD ASSET OWNERSHIP

1) How many rooms in your house are used for sleeping? _____

2) How many of the sleeping rooms have mosquito bed nets? _____

3) Construction materials – wall

1. Wood/mud

2. Bricks/stones
3. Cemented
4. Tent

4) Construction materials – floor

1. Earth
2. Dung
3. Cement
4. Bricks
5. Other (specify)

Other construction materials (floor) _____

5) Construction material – roofing

1. Local tiles
2. Grass/thatch
3. Metal/iron sheet
4. Plastic sheeting
5. Other (specify)

Other construction material (roofing)_____

6) What is your main source of drinking water?

8. Piped into the premises
9. Public tap/standpipe
10. Protected well/spring
11. Unprotected well/spring
12. Surface water (lake/river/swamp/dam/irrigation channel)
13. Rainwater
14. Other (specify)

Other source of drinking water _____

7) How long (in minutes) does it take you to go to the source, collect water and come back?
Record time _____ minutes

8) How do you usually treat water prior to drinking?

1. Boiling
2. Use of water treatment products (sureau, waterguard)
3. Filtering
4. Let water stand and settle
5. Strain water through a cloth
6. Other
7. Don't treat drinking water

Other methods used to treat water before drinking _____

9) Does your household have treated drinking water at this moment?

1. Yes

2. No

10) What is your main source of lighting?

1. Electricity
2. Torch
3. Kerosene lamp
4. Candles
5. Solar system
6. Other

Other source of lighting _____

11) What is your main cooking fuel?

1. Firewood
2. Straw/shrubs/crop residues
3. Charcoal
4. Biogaz

12) Is the place of cooking inside the main house?

1. Yes
2. No

13) Does your household have a radio?

1. Yes
2. No

14) Does your household have a bicycle?

1. Yes
2. No

15) Does your household have a mattress?

1. Yes
2. No

16) Does your household have an umbrella?

1. Yes
2. No

17) Does your household have a hoe?

1. Yes
2. No

18) Does your household have a jerrycan? [used for water fetching]

1. Yes
2. No

19) Does your household have a thermos?

1. Yes
2. No

20) Does your household have a TV?

1. Yes
2. No

21) Does your household have a boat?

1. Yes
2. No

22) Land ownership: Does your household have a homestead land?

1. Yes
2. No

23) Does your household have a kitchen garden? [Check around to confirm]

1. Yes
2. No

24) Does your household have additional plot of land?

1. Yes
2. No

25) Does your household grow crops on someone's land? [Ask about current/last season]

1. Yes
2. No

26) Did your household grow orange-fleshed sweet potatoes in the past 6 months?

1. Yes
2. No

27) Did your household grow any iron-rich beans in the past 6 months?

1. Yes
2. No

28) Did your household grow any maize hybrids in the past 6 months?

1. Yes
2. No

29) Did your purchase any agro-chemical fertilizer in the past cropping season?

1. Yes
2. No

30) Does your household own a cow?

1. Yes
2. Yes, and cow belongs to someone else
3. No

[If Yes] Number of cows _____

31) Was the cow received from One Cow per Poor Family Programme?

1. Yes
2. No

32) Does your household have goats?

1. Yes
2. Yes, and goat belongs to someone else
3. No

[If Yes] Number of goats_____

33) Does your household have sheep?

1. Yes
2. Yes, and sheep belong to someone else
3. No

[If Yes] Number of sheep _____

34) Does your household have chickens?

1. Yes
2. No

[If Yes] Number of chickens _____

35) Does your household have pigs?

1. Yes
2. Yes, and pigs belong to someone else
3. No

[If Yes] Number of pigs _____

36) Does your household have rabbits?

1. Yes
2. No

[If Yes] Number of rabbits_____

37) Does your household own guinea pigs?

1. Yes
2. No

[If Yes] Number of guinea pigs_____

XIII. ANTHROPOMETRIC MEASUREMENTS

First, record:

- Child ID _____ (same as Household ID)
- Date of birth _____ [Ask for child's health card to confirm]
- Birth weight _____ (in g) [Ask for a health card/vaccination records to confirm]
- [If not known] Ask mother: How would you classify (CHILD) weight at birth?
    1) Child weight was normal
    2) Child weight was heavier than normal
    3) Child weight was lighter than normal
    4) I don't know
- Sex
    1. Male
    2. Female

Then, take measurements of:

1) Child's weight _____ (in kg)

2) Child's height _____ (in cm)

3) Mother's weight _____ (in kg)

4) Mother's height _____ (in cm)

XIV. HOUSEHOLD ALTITUTDE AND LOCATION (GPS readings)

1) Altitude _____ (metres above sea level)
2) Location coordinates S'_____ E' _____

XV. SPOT-CHECK HYGIENE OBSERVATION

Household ID _____

(1) Child face is clean
   i. Yes
   ii. No
   iii. Not observed

(2) Child clothes are clean
   1. Yes
   2. No
   3. Not observed

(3) Child nails are clean
   1. Yes
   2. No
   3. Not observed

(4) Visible dirty or food particles in the kitchen required
   1. Yes
   2. No
   3. Not observed

(5) Presence of unwashed utensils
   1. Yes
   2. No
   3. Not observed

(6) Presence of uncovered food
   1. Yes
   2. No
   3. No food was observed

(7) Visible dirt or food particles on the floor
   1. Yes
   2. No
   3. Not observed

(8) Child porridge container is visibly clean. *Choose No if porridge container is a water or soft drink plastic bottle
   1. Yes
   2. No
   3. Porridge container not observed

(9) Animals live inside the main house (where people sleep)
   1. Yes
   2. No/animals live in a pen
   3. Household has no animals

(10) Presence of visible dirt or garbage on the compound
   1. Yes

2. No

(11) Presence of animal or human feces
1. Yes
2. No

(12) Presence of stagnant water around the home
1. Yes
2. No
3. Irrelevant/rainy season

(13) Drinking water container is visibly clean
1. Yes
2. No
3. Not observed

(14) Toilet facility is clean *There is no visible dirt, no human excreta*
1. Yes
2. No
3. Household has no toilet facility
4. Not observed

(15) What type of toilet facility does the household have?
1. Ventilated improved pit latrine
2. Traditional latrine/pit with slab
3. Traditional latrine pit without slab
4. No toilet facility
5. Other
6. Not observed

Other type of toilet facility _____

(16) Household has hand washing station
1. Yes
2. No

END - Thank you for your cooperation!

Appendix 15: Statement of Contribution to doctoral thesis containing publications

DRC 16

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

GRADUATE RESEARCH SCHOOL

STATEMENT OF CONTRIBUTION
DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of candidate:	Theogene Dusingizimana
Name/title of Primary Supervisor:	Dr Louise Brough
In which chapter is the manuscript /published work:	Chapter 3

Please select one of the following three options:

(●) The manuscript/published work is published or in press

- Please provide the full reference of the Research Output:

Dusingizimana, T., Weber, J., Ramilan, T., Iversen, P., & Brough, L. (2020). A qualitative analysis of infant and young child feeding practices in rural Rwanda. Public Health Nutrition, 1-10. doi:10.1017/S1368980020001081

( ) The manuscript is currently under review for publication – please indicate:

- The name of the journal:

- The percentage of the manuscript/published work that was contributed by the candidate:

- Describe the contribution that the candidate has made to the manuscript/published work:

( ) It is intended that the manuscript will be published, but it has not yet been submitted to a journal

Candidate's Signature:	Theogene Dusingizimana Digitally signed by Theogene Dusingizimana Date: 2021.01.20 16:28:17 +13'00'
Date:	20-Jan-2021
Primary Supervisor's Signature:	Louise Brough Digitally signed by Louise Brough DN: cn=Louise Brough, c=NZ, ou=Massey University, email=l.brough@massey.ac.nz Date: 2021.01.21 10:05:50 +13'00'
Date:	21-Jan-2021

This form should appear at the end of each thesis chapter/section/appendix submitted as a manuscript/ publication or collected as an appendix at the end of the thesis.

GRS Version 5 – 13 December 2019
DRC 19/09/10

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

GRADUATE RESEARCH SCHOOL

STATEMENT OF CONTRIBUTION
DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of candidate:	Theogene Dusingizimana
Name/title of Primary Supervisor:	Dr Louise Brough
In which chapter is the manuscript /published work:	Chapter 4

Please select one of the following three options:

(●) The manuscript/published work is published or in press

- Please provide the full reference of the Research Output:

Dusingizimana, T., Weber, J., Ramilan, T., Iversen, P., & Brough, L. (2020). An empirical study of factors associated with height-for-age z-scores of children aged 6–23 months in northwest Rwanda: The role of care practices related to child feeding and health. British Journal of Nutrition, 1-12. doi:10.1017/S0007114520004961

( ) The manuscript is currently under review for publication – please indicate:

- The name of the journal:

- The percentage of the manuscript/published work that was contributed by the candidate:

- Describe the contribution that the candidate has made to the manuscript/published work:

( ) It is intended that the manuscript will be published, but it has not yet been submitted to a journal

Candidate's Signature:	Theogene Dusingizimana — Digitally signed by Theogene Dusingizimana Date: 2021.01.20 16:30:43 +13'00'
Date:	20-Jan-2021
Primary Supervisor's Signature:	Louise Brough — Digitally signed by Louise Brough DN: cn=Louise Brough, c=NZ, ou=Massey University, email=l.brough@massey.ac.nz Date: 2021.01.21 10:06:14 +13'00'
Date:	21-Jan-2021

This form should appear at the end of each thesis chapter/section/appendix submitted as a manuscript/ publication or collected as an appendix at the end of the thesis.

GRS Version 5 – 13 December 2019
DRC 19/09/10

Appendix 16: Published version of Paper I (Chapter 3)

Public Health Nutrition: page 1 of 10 doi:10.1017/S1368980020001081

A qualitative analysis of infant and young child feeding practices in rural Rwanda

Theogene Dusingizimana[1,2], Janet L Weber[1], Thiagarajah Ramilan[3], Per O Iversen[4,5,6] and Louise Brough[1,*]

[1]School of Food and Advanced Technology, Massey University, Palmerston North 4442, New Zealand: [2]Department of Food Science and Technology, College of Agriculture, Animal Sciences and Veterinary Medicine, University of Rwanda, Musanze, Rwanda: [3]School of Agriculture and Environment, Massey University, Palmerston North, New Zealand: [4]Department of Nutrition, Institute of Basic Medical Sciences, University of Oslo, Oslo, Norway: [5]Department of Hematology, Oslo University Hospital, Oslo, Norway: [6]Division of Human Nutrition, Faculty of Medicine and Health Sciences, Stellebosh University, Tygerberg, South Africa

Submitted 21 October 2019: Final revision received 11 March 2020: Accepted 20 March 2020

Abstract

Objective: To explore and gain an in-depth understanding of the factors influencing child feeding practices among rural caregivers in Rwanda.

Design: In-depth semi-structured qualitative interviews were conducted. Purposive sampling was used to recruit participants. Interviews were audio-recorded, transcribed verbatim and coded. Data were analysed inductively using thematic analysis.

Setting: Rutsiro District, Western Province, Rwanda.

Participants: Participants included twenty-four mothers (median age 32 years) with children 6–23 months old.

Results: We identified five key themes: (i) breast-feeding practices and role in food supply; (ii) family *v.* children's food preparations; (iii) food classification systems and their influence on child feeding decisions; (iv) child feeding during diarrhoeal episodes and (v) influence of poverty on child feeding practices and child care.

Conclusions: Mothers' infant and young child feeding decisions are informed by information both from health workers and from traditional/own knowledge. Navigating through this information sometimes creates conflicts which results in less than optimal child feeding. A nutrition educational approach that is cognisant of maternal perceptions should be employed to improve child feeding practices. Efforts to improve child feeding practices must be complemented by programmes that enhance household economic opportunities and access to foods.

Keywords
Child feeding
Perceptions
Undernutrition
Qualitative analysis
Rutsiro
Rwanda

Undernutrition among children under 5 years of age remains a global public health concern. Globally, 150·8 million (22·2 %) children under 5 years of age are stunted (i.e. low height-for-age)[(1)], a marker of chronic undernutrition. Chronic undernutrition in childhood increases risk of morbidity and mortality, impaired growth and cognitive development, poor school performance, reduced economic potential as well as the risk of chronic illness in adulthood. It has been estimated that undernutrition is associated with 45 % of deaths among children under 5 years[(2)], and more than 90 % of these deaths occur in sub-Saharan Africa and South Asian countries.

Rwanda has significantly improved maternal and child health. The maternal mortality ratio fell from 1071 per 100 000 live births in 2000 to 210 per 100 000 live births in 2015[(3)]. Over the same period, under-five child mortality fell from 152 per 1000 live births in 2005 to 50 per 1000 live births. However, child undernutrition remains a serious public health concern in Rwanda. The most recent data from Rwanda estimated that 35 % of children under 5 years of age are stunted[(4)]. Although the prevalence of undernutrition among Rwandan children under 5 years has declined over the past two decades from 48 % in 2000[(5)] to 35 % in 2018[(4)], the rate of reduction has not been enough to achieve the national targets of reducing stunting prevalence from 44 % (2012) to 18 % (2018)[(6)]. This calls for more efforts to reach the national nutrition targets.

*Corresponding author: Email L.Brough@massey.ac.nz

Evidence suggests that undernutrition in low-income countries, particularly in Africa and Asia, is linked to poor infant and young child feeding (IYCF) practices[7,8]. To improve child nutrition, the WHO recommends exclusive breast-feeding for the first 6 months, after which age-appropriate, safe, nutritionally adequate and responsive complementary feeding should commence[9,10]. In Rwanda, the prevalence of exclusive breast-feeding for the first 6 months is high (87 %)[3], but complementary feeding at 6–23 months remains sub-optimal. The national reports show that the number of children 6–23 months old who meet the recommended minimum acceptable diet in terms of sufficient diversity and frequency of feeding has remained the same between 2010 and 2018 (17 %)[3,4]. This suggests gaps in optimal IYCF practices. Although poverty and food insecurity are often considered the main determinants of undernutrition[4], studies in Rwanda[11], and elsewhere[12], have reported high rates of child stunting even in the richest households. The authors suggested that cultural factors, inadequate knowledge and feeding behaviours could be limiting children from getting adequate diets[12].

Past studies on the risk factors underlying child undernutrition in Rwanda have mainly focused on socio-economic and demographic factors[13–16]. Other studies[17–19] examined the influence of access to health care on child stunting. These studies have used quantitative approaches that do not provide detailed information on IYCF practices from a local sociocultural context. While qualitative research on IYCF practices in Rwanda is limited, studies in other countries show that a qualitative approach can provide valuable insights on the drivers of IYCF practices which can help inform the development of more culturally relevant interventions[20,21]. A qualitative study conducted in one Rwandan district to explore the drivers of caregivers' food choices found that local perceptions about certain foods limited mothers from feeding children locally available foods[22]. However, participants in that study were from urban and pre-urban populations whose feeding practices may not reflect the practices in rural areas where the majority of undernourished children live. The present study was thus designed to contribute to the limited information on IYCF practices in rural Rwanda. The primary objective of this study was to explore and gain in-depth of understanding of the factors influencing IYCF feeding practices in rural Rwanda from mothers' perspectives.

Methods

Setting

This study was conducted in Rutsiro District, Northwest of Rwanda, approximately 140 km from Rwandan capital city, Kigali. The Rutsiro district is one of Rwanda's rural districts with the highest prevalence of child stunting (54 %) among children under 5 years[4]. The district population is largely rural (approximately 98 %), and subsistence farming and traditional rearing of animals are the primary livelihood activities[23]. The main subsistence crops are maize, beans, banana plantain, cassava, sweet and Irish potatoes. Data from national statistics show that 51·4 % of the district population are poor and 24 % live in extreme poverty (i.e. the poorest)[24]. Administratively, Rutsiro district is divided into thirteen sectors. Each sector is divided into cells, and each cell is divided into villages (a village is the lowest administrative unit in Rwanda). This study was conducted in Gihango sector from December 2017 to January 2018. Gihango sector was selected based on the study objectives. Although the sector was deemed to have a relatively good crop diversity compared with other sectors, it was the sector with the second highest number of children under 5 years of age with acute malnutrition (at the time the study was conducted). Additionally, the sector was accessible to the researcher.

Study design

This study was intended to be descriptive and exploratory. A descriptive qualitative methodology was used to explore IYCF practices among mothers. The study was conceptualised within the context of high prevalence of child undernutrition and inadequate IYCF practices among children 6–24 months in Rwanda. The study design draws from a biocultural model[25], which focuses on physical, socio-economic and cultural environments that influence child feeding.

Participant selection and sample size

The selection of participants was designed to capture information-rich cases in order to obtain in-depth understanding of IYCF practices[26]. A purposeful sample of twenty-four mothers with children 6–24 months old were identified in four villages using lists of eligible mothers compiled from growth monitoring records with the assistance of the village community health workers. Mothers were eligible if: (1) they had a child aged 6–24 months old; (2) had lived in the area for at least 6 months; (3) their child was apparently healthy and (4) the mother was in the first or second lowest socio-economic group as per the Rwandan government classification. Approximately half of the eligible mothers from each list were selected. As we aimed for diverse perspectives on IYCF practices, attempts were made to include young and older mothers with children at different age stages. The interviewer approached the mothers to explain the aim of the study, confirm eligibility and invite her to participate in the study. Two mothers were not at home; all mothers spoken to agreed to participate. Recruitment ceased when data saturation had been reached, that is, no new information was generated[27].

Data collection

Data were collected through in-depth interviews using a semi-structured interview guide. The guide consisted of a

set of open and closed questions, and the major topics covered were: (i) child feeding practices, including breastfeeding, complementary feeding and type of foods given/not given to young children and reasons for these choices, (ii) challenges related to child feeding, (iii) health practices and (iv) child care arrangements. To ensure clarity of the questions, community health workers from the study settings and a Rwandan nutritionist were consulted during the development of the interview guide. The interview guide was first developed in English, translated into Kinyarwanda (the local language) and then back translated into English by a Rwandan nutritionist. The final Kinyarwanda version was refined after back translation to maintain the original English meaning. Prior to data collection, the interview guide was pre-tested with six women from another community and adjustments were made accordingly. Interviews were conducted by the first author, who is fluent in Kinyarwanda, and had prior experience in qualitative research methods and data collection in rural Rwanda. Interviews were conducted in the participants' homes. To ensure confidentiality, the data were anonymised by assigning an identification number to each record, transcript and field notes. Each interview lasted 30–60 min and was audio-recorded. During the interview, specific questions or probes were asked to the mothers to seek further clarifications if necessary[28]. Field notes were also taken and later used for data triangulation. The notes also provided a means to clarify the interviewer's thoughts, which helped to minimise the bias during data analysis[29]. The authors held online meetings throughout the data collection to review preliminary findings. These meetings allowed us to review questions at the time of data collection and to develop new aspects of the questions[30].

Data analysis

The recorded interviews were transcribed verbatim in Kinyarwanda and then translated into English. Transcripts were checked against the interview records and triangulated with field notes taken during each interview. The data were manually coded by the first author (T.D.). Analysis was performed inductively following the steps outlined by Braun and Clarke[31] for thematic analysis. Briefly, the first author read all the transcripts multiple times to familiarise himself with the data. An initial list of descriptive codes and relevant quotes pertaining each code was generated from a subsample of transcripts (n 5). The codes were then reviewed and discussed by the three authors (T.D., L.B. and J.L.W.). Final codes were agreed upon, which were applied to all subsequent transcripts. New codes that emerged from the subsequent transcripts were integrated into the final list of codes. Final codes were reviewed again, organised in a table, grouped into categories and then into themes using a pattern and focused coding method[32]. Quantitative data including demographic characteristics were analysed using Microsoft Excel. In presenting the data, relevant verbatim quotes were used to aid data interpretation. Methods and findings are reported as per the consolidated criteria for reporting qualitative research (COREQ) checklist (see supplementary material)[33].

Results

Participants and sample characteristics

Mean age of our study respondents was 30 years (range 24–42) (Table 1). Mean age of children was 16 months (range 6–22). Eighty-three percentage (n 20) were married. The median household size was 5 (range 3–9); about a half (n 10) had two or three children under 5 years old. Self-reported child illnesses in the previous 2 weeks included diarrhoea (50 %), fever (33 %) and other illness (58 %) (e.g. respiratory infections, eye and skin infections). All children had received all vaccines appropriate for their age.

Table 1. Characteristics of mothers and children (n 24) interviewed in the present qualitative study on infants and young child feeding practices in Gihango sector, Rutsiro District, Rwanda, December 2017–January 2018

Characteristics	Mean	SD	*n*	%
Child's age (months)	16·1	4·7		
Mother's age (years)	30·5	5·0		
Household size	4·8	1·6		
Child's age group				
6–11 months			6	25
12–17 months			8	33
18–22 months			10	42
Child's sex				
Female			15	63
Males			9	37
Child's illness in the past 2 weeks				
Diarrhoea			12	50
Fever			8	33
Other illnesses			14	58
Mother's age group				
≤25 years			3	12
26–30 years			6	25
31–34 years			6	25
≥35 years			9	37
No. of children (parity)				
1 child			7	29
2–3 children			11	46
4–5 children			6	25
Marital status				
Married			20	83
Unmarried			4	17
Mother's education				
None			3	13
Some primary			20	83
Some secondary			1	4
Health seeking practices				
Possession of community-based health insurance			20	83
Child fully immunised			24	100
Child taken to growth monitoring (last month)			18	75

Breast-feeding practices and role in the food supply

Nearly all mothers reported that they exclusively breastfed for the first 6 months. Only two mothers reported giving their children foods before 6 months, but they pointed out that giving child foods before 6 months was contrary to the recommendations. Our data indicate that mothers knew the recommended age for introduction of complementary foods. Breast-feeding is regarded as a child's rights, a sign of love and a way to improve mother–child emotional bond, in addition to source of nutrition/goodness.

Prolonged breast-feeding is also a strategy to deal with anxiety experienced by some mothers who have insufficient food to feed their children. One mother with five children explained her choice to reserve food for the older non-breastfed child because the youngest child had a back-up option – the breast milk.

> If possible, she will breastfeed until 4 years. You cannot refuse to breastfeed a child. Breastmilk has something that is beneficial for child. And for us who are poor, even if you don't have foods but breastfeed your child, the child feels that you are closer, which creates and maintain good relationship between you and your child. **Participant 12, 38 years, child 11 months.**

> She [youngest child] eats when there is enough food. Because, as a mother, you tell yourself, at least she will get something from her mother's breasts. So, the little food that is there is reserved for her older sibling. **Participant 11, 35 years, child 14 months.**

Most mothers mentioned that their children started receiving foods or fluids other than breast milk between 6 and 7 months. The first and most common complementary food reported by all mothers was thin porridge. Sorghum flour is most commonly used to make the porridge. Mothers desired to give their children a more nutritious porridge made from a commercial mixed-grain cereal flour (locally known as SOSOMA), and they knew ingredients such as soya flour and milk could be used to prepare a nutritious porridge for their children. However, many mothers said that SOSOMA and most of these ingredients were not affordable. At around 8 months, children start to receive modified family foods. Fruits, biscuits and Irish potatoes are the foods that are procured specifically for young children.

Family v. children's food preparations

We engaged mothers in discussion about how they prepared foods for their family and children. Mothers first described how they prepared family meals, and then how these foods were fed to young children. The narratives indicate that a typical family meal usually contains two major components: (i) a staple/starchy component (e.g. cassava, sweet potatoes and taro) and (ii) a legume (often beans) and/or vegetables. The two components are usually boiled in one pot in a mixed dish – locally known as *'imvange.'* When cooked separately, the starchy component is often served with a stew/sauce made from vegetables and/or beans. Sometimes, groundnut powder is added to flavour the stew/sauce. Mothers with economic means buy small dried fish (*indagara*), soya flour and cooking oil to add to the stew/sauce. The narratives suggest that, regardless of whether the two components were cooked together or separately, the starchy component is viewed as adult foods and may not be given to young children below 2 years because it is considered too 'hard' for them. Instead, children are given vegetables (except cabbage), porridge, beans, sauces or stews. If the starchy component was ever fed to the child, the child would be given a trivial amount. Irish potatoes are an exception because they can be easily mashed into soft foods.

> When I have cooked cassava and beans in a mixed dish for us adults, I also have to look for vegetables. I cook them together, and then I mash these vegetables and beans to feed her. Normally a child like this should eat soft foods. If there are no beans, we add [to the family pot] some vegetables for her. **Participant 5, 42 years, child 21 months.**

> When we [adults] eat sweet potatoes, he [child] eats vegetables and tops up with porridge. **Participant 8, 39 years, child 17 months.**

Mothers are encouraged by health professionals to have a side pot (locally known as *agakono k'umwana*) for young children[34]. We asked mothers about this practice. Our data suggest that the practice is not a common practice. Rather, the preparation of children's foods in a side pot is used as a compensatory mechanism when the child was sick or has lost weight.

> I usually prepare her food in a side pot when she isn't in a good health. When she is well, I cook all the food in one [family] pot. I know she is not well when I take her to the growth monitoring site and they tell me that she lost weight. **Participant 18, 32 years, child 19 months.**

Food classification systems and their influence on child feeding decisions

Mothers had two distinct food classification systems that influence their feeding decisions. In the first classification system, mothers classified foods into three broad categories based on what nutrients the foods bring to the body. In their narratives, over three quarters of the mothers use the 'balanced diet' concept to refer to a meal that contains the three categories of foods: '*body building foods*', '*energy foods*' and '*disease protective foods*.' Some mothers said that a balanced diet provides vitamins, while others gave reasons why it was important to feed their children a balanced diet: 'so that a child gets all nutrients.'

> Well, they teach us that a child should be given body building foods, disease protective foods and energy

foods. Vegetables are disease protective; Irish potatoes are among the starchy foods and I know that milk is also good for a child. Banana is also important. **Participant 3, 24 years, child 18 months.**

In the second classification system, mothers classified foods into three categories, namely *hard, soft* and *oily/fatty foods* primarily based on physical characteristics. Foods such as cassava, sweet potatoes, maize grains, banana plantain and taro are referred to as *hard foods* and therefore not suitable for children below 2 years of age. Mothers also described *soft foods* as foods with a soft or watery consistency such as thin porridge or vegetables (except cabbage), cassava leaves, sauces and stews. Other foods were referred to as *oily foods* because they are regarded as containing oil. Examples of *oily foods* included cow's milk, avocado, vegetable cooking oil and two flours – groundnut flour and soya flour – that might seem at first to be surprising candidates for inclusion in the oily food category.

In their narratives, mothers made statements which suggested conflicts between the two classification systems.

Sweet potatoes and taro are things you can't give your child. In my opinion, sweet potatoes and taro are foods that provide energy for adults. But children can get that energy from vegetables and some other supplementary foods. Those other foods [sweet potatoes/taro] are for adults. **Participant 6, 28 years, child 18 months**

Hard foods are like cassava and sweet potatoes. Would you say that your child has eaten when you have fed him/her sweet potato? No, it does not contain any nutrients. Perhaps if you have peeled it, added some vegetables . . . that is when you can say: I have fed my child a balanced meal. **Participant 2, 33 years, child 7 months.**

A child is not eating well . . . , that means feeding her unbalanced diet. Like giving her those energy foods while she is still young and yet those kinds of foods provide her with nothing that can help her body. **Participant 10, 32 years, child 15 months**

Contrary to the *hard foods*, mothers had a strong preference for feeding *soft foods* and they considered these foods as the most suitable for young children.

She [child] cannot eat cassava. This one needs soft foods. It is because she does not have teeth to chew cassava. **Participant 1, 35 years, child 13 months.**

When we are lucky and manage to get sweet potatoes, because it is a hard food and she cannot eat it, she just breastfeeds, or we give her some vegetables. **Participant 4, 25 years, child 16 months.**

A few mothers said that preparing *hard foods* in a different way would allow the child to eat these foods.

Cassava . . . ? Yes, it is also possible. You can chop them, add some vegetables, but then you need to make the food very soft. What is bad is cooking them in a mixed dish like we usually do, and just feed the child like that. When they [cassava] are soft, I think there is no problem. **Participant 2, 33 years, child 7 months.**

While soft foods are considered the most suitable for young children, these foods have a watery consistency that, according to some mothers, makes them unsuitable to mix with the micronutrients sprinkles which mothers receive through the home fortification programme. Some mothers felt it was against the recommendations if they added micronutrients sprinkles (*Ongera*) to the soups and stews that they usually feed their children.

There are even something called *Ongera* that they give us. We add it to foods that are not hot. But we don't add it to those soft foods like soups. They told us that we must not mix *Ongera* with soft foods. **Participant 3, 24 years, child 18 months.**

Child feeding during diarrhoeal episodes

If you take your child to health centre every time she/he has diarrhoea, then you will spend your whole life at the health centre. **Participant 11, 35 years, child 14 months.**

This statement illustrates how frequently children from the study area are experiencing diarrhoea. Some mothers mentioned that diarrhoea lasted several days up to a week. There was a common belief among participants that eating sweet potatoes causes worms – a term which is also used to denote diarrhoea. Other mothers attributed diarrhoea to child developmental stages such as child learning to walk, stand alone or teething. While *soft* and *oily foods* are the most preferred food for young children, many mothers avoid these foods when their children have diarrhoea because of the perceptions that these foods loosen stools and worsen diarrhoea.

When she has diarrhoea, I don't give foods with a lot of soup . . . Foods mixed with groundnut or soya flour. I can't even give her milk. It is because those foods contain a lot of oil. Those foods loosen stools and increase diarrhoea. Diarrhoea is not oil friendly. **Participant 21, 30 years, child 10 months**

Normally sweet potatoes cause worms (diarrhoea). Even us adults, when you eat them two times, the worms get activated. So, if you keep feeding your child sweet potatoes, the child will end up malnourished. **Participant 8, 39 years, child 17 months.**

> They [community health workers] warned me saying that sweet potatoes cause '*bwakî*' (malnutrition). **Participant 18, 32 years, child 19 months.**

Instead, some mothers feed their children thick foods in attempt to stop diarrhoea.

> When a child has diarrhoea, I just stop those soft foods that I usually give him. I stop them and give him thick foods. I try to cook for him *Mazizi* and *Kamara* [green banana varieties]. When I do that, diarrhoea stops. I don't know how this works, but I guess they [green banana] are not quick to get out of the body. **Participant 11, 35 years, child 14 months.**

Influence of poverty on child feeding practices and child care

Poverty and lack of employment opportunities were mentioned by many of the mothers as the main challenges faced by the mothers in their feeding practices. Most mothers highlighted that these challenges translated into lack of nutritious foods and fewer meals for their children. Less than a half of the mothers mentioned that they could afford three meals a day, while others mentioned providing one or two meals a day.

> Honestly I can't lie; many times they [children] spend the whole day without eating. I wake up in the morning and then go work for food. So, they eat when I am back in the evening. **Participant 18, 32 years, child 19 months.**

The narratives indicate that, poverty not only limits mothers' access to foods, but it also has an impact on other aspects of childcare. For example, some mothers mentioned that chances to get a farm employment are limited for a breast-feeding mother. Thus, to increase chance to get a job, some mothers leave their children under the care of young siblings, though they doubted their caregiving capacity.

> When you find a job at the road construction site, you just leave the child with her older siblings. But when you are back, you may find that they [older siblings] have eaten the food you left for the child. And you get back feeling tired and not even being able to take care for the child. **Participant 10, 32 years, child 14 months.**

Discussion

In many cultures, child feeding decisions are taken by mothers[35] and most of these decisions result from complex interactions between many factors, including mothers' cultural beliefs and perceptions, resources and support available to the mothers as well as child health status and characteristics[36,37]. Understanding these factors in a local context is a key step towards improving complementary feeding practices[20].

Our results show that mothers have a good understanding of and positive attitude towards exclusive breast-feeding for the first 6 months. Mothers also believed that a child should be breastfed together with complementary feeding for as long as possible. The prevalence of exclusive breast-feeding up to 6 months is high in Rwanda (87 %)[3]. The benefits of breast-feeding on maternal and child health outcomes are well documented[38,39]. Thus, the positive attitudes of mothers about exclusive breast-feeding present an opportunity to promote and sustain child breast-feeding in Rutsiro District. However, further investigation is warranted to assess if the positive attitude towards breast-feeding results from lack of adequate food resources.

In this study, we found that mothers have two systems of food classification which influence their feeding decisions. The first classification system, by which mothers classify foods into three categories: 'energy foods', 'body building foods' and 'disease protective foods', is widely used by health professionals in Rwanda[40] to teach caregivers child feeding. This suggests that mothers had been exposed to and learned nutrition messages. The second classification system reflected mothers' perceptions about the ability of young children to eat the foods or the perceived effects of the food on children's health especially in the presence of diarrhoea. This finding is supported by earlier studies[41–43] showing that caregivers in different contexts and cultures classify food differently and that child feeding is conceptualised around caregivers' food classification systems[43].

In relation to child feeding, our data indicate a disconnect between the two classification systems used by mothers. While mothers frequently used the concept of 'balanced diet' to suggest diet diversity, conflicting beliefs were identified. For example, some mothers viewed starchy staples (classified under energy foods category) as adult foods, while others doubted whether these staples have nutrients that are beneficial for young children. We found that child feeding decisions are largely influenced by the mothers' traditional/own knowledge about foods and their suitability to young children. These findings suggest that young children may be deprived or given insufficient amount of staple foods such as cassava, sweet potatoes and green banana, and hence limiting children's dietary diversity and energy intake. It is logical if mothers do not provide children with foods that they perceive to be harmful. However, where these decisions are based on misperceptions, it calls for an improved effort to address alternative beliefs held by mothers.

While studies on maternal perceptions and beliefs around IYCF practices are limited in Rwanda, studies from other African countries have documented maternal and cultural perceptions that limited children from consuming locally available foods. For example, in Ethiopia, it was found that vegetables and meat or other animal source foods were not given to young children due to the

perceptions that they are difficult to digest and cause stomach illness[44]. Paul *et al.*[45] also found that, in Tanzania, children were not given fish because of the perceptions by mothers that fish cause tooth decay. In the present study, a few mothers felt that changes in how cassava or sweet potatoes are traditionally prepared could allow children to eat these staples. Possibly, these mothers fed children with these foods. In a previous study conducted in Nyanza district, South province of Rwanda, Lee *et al.*[22] found that although their study households (*n* 28, child age range: 10–47 months) had purchased and eaten sweet potato several times in the past 7 d, sweet potato was completely absent from the 24-h recall of their children's diet. In the present study, a few mothers felt that changes in how cassava or sweet potatoes are traditionally prepared could allow children to eat these staples. Possibly, these mothers fed children with these foods. Thus, if mothers are to maximise the diets of their children using foods that are within their reach, nutrition educators should work with mothers to identify acceptable methods of food preparations that can be used to prepare staple foods in a way that is appropriate for young children.

We also explored mothers' feeding practices during diarrhoea. Research shows that mothers adopt different care practices due to beliefs about children's illness, with implications on child's nutrition[37]. In the present study, we found that mothers have a strong preference for soft/thin foods in the absence of diarrhoea because of the perceptions that young children up to 2 years cannot eat hard foods. In the presence of diarrhoea, mothers avoid soft foods because of perceived adverse effects of these foods on child diarrhoea. In the context of the study setting where diarrhoea may be common in children, avoidance of foods during diarrhoea is likely to reduce children's food intake[46,47] and to precipitate nutritional deficiencies[48,49]. Interestingly, some mothers reported preparing thick foods (e.g. thick porridges) for children with diarrhoea and two of them reported using oral rehydration solution in attempt to stop diarrhoea. Our findings encourage further research to better understand the practices and motivations of mothers who adopt positive practices during child illness. Once these are understood and trialled, it could help in formulating clear nutrition educational messages that promote existing positive practices[50].

Our findings also suggest that current feeding practices have implications for other nutrition programmes. For example, in Rwanda, caregivers with children 6–23 months receive micronutrient sprinkles (locally known as Ongera) as part of the government's home fortification programme to prevent stunting and anaemia. Caregivers are expected to add these micronutrients to children's semi-solid or solid foods before consumption[34,51]. The instructions of using the micronutrients sprinkles are that mothers should mix the product with semi-solid or solid foods[34]. However, mothers considered the consistency of complementary foods that they usually feed their children was inappropriate to mix with the micronutrients, suggesting that the children may not be receiving the recommended dose of the micronutrients. Moreover, the widely held belief that sweet potato is not suitable for young children is likely to interfere with the consumption of the vitamin-A-rich sweet potato variety that is currently being promoted in Rwanda[52]. Thus, our findings underline the importance of understanding local contexts in which nutrition programmes take place.

Finally, poverty and food insecurity appeared to be significant barriers to appropriate child feeding practices. This may not be surprising given the high level of household poverty (51·4 %)[24] and food insecurity (49 %) in Rutsiro district[4]. As stated above, mothers expressed how poverty and food insecurity impacted their feeding practices and child care through: (1) reduced number of meals received by children; (2) inability for mothers to procure the ingredients required to prepare nutritious foods for their children; (3) breast-feeding younger children as a means to maximise foods for other household members, but limiting the complementary foods recommended in this age group's diet; (4) trade-offs involved between finding employment and child care and (5) inability of mothers to implement nutrition advice from health workers (e.g. having a side pot of nutritious foods (*agakono k'umwana*) for young children). Some studies suggest that maternal education or behaviour change communication strategies, with or without foods, can improve IYCF practices[53]. However, other researchers argue that such strategies must be part of more comprehensive approaches that address contextual factors such as poverty and food insecurity[54]. The government of Rwanda has been implementing various social protection programmes targeting the most vulnerable households to enable them purchase more nutritious foods[55]. Research shows that, if implemented adequately, these programmes represent important opportunities for supporting caregivers' ability to care for their children[56]. Additional efforts to enhance economic opportunities and access to foods by caregivers in Rutsiro should be explored.

The strength of the present study lies in its qualitative approach, which allowed us to gain a deeper understanding of IYCF practices and mothers' rationale within the sociocultural context. This information is often not captured in quantitative surveys. However, there are limitations to this study. First, our findings are based on a purposive sample recruited from one sector in Rutsiro District, which may limit the transferability to populations outside this area. However, we included mothers whose children were at different age stages and that represented a wide range of maternal age and parity in order to obtain a rich data set, which is prerequisite for the nature of the study[26]. Second, the interpretation of our findings must consider that we did not collect dietary data. Third, social desirability

bias may have influenced the participants' responses (e.g. breast-feeding practices) or participants may have overemphasised the influence of poverty and food insecurity on child feeding. Mothers were encouraged to answer questions based on their own experiences. The interviewer also emphasised that there was no right or wrong answer and promised confidentiality. Finally, we acknowledge that interviewer's gender (male) is a potential limitation in interviewing mothers. However, in Rwanda, mothers are used to interact with community health workers (both males and females) who provide them with nutrition education, and we have no prior evidence or perception that mothers in this area were hesitant to speak with a male. Moreover, the interviewer took care to establish good rapport with the participants through courteous behaviour.

Conclusions

The findings from this study showed that mothers have positive attitudes towards breast-feeding and a good understanding of its health benefits. However, sub-optimal complementary feeding practices may result from the complex beliefs, perceptions and food classification systems which appear to have a strong influence on mothers' feeding decisions; this is in spite of the mothers appearing to have some nutrition knowledge received from nutrition counselling on IYCF. The views identified in this study, that certain foods are (un) suitable for young children, or that certain foods must be avoided during child diarrhoea, are likely to negatively affect the diversity and the amount of foods received by children. If these views are not recognised, the current nutrition education will not be effective in improving IYCF practices. We recommend further research to examine to which extent the beliefs, perceptions and food classification systems are shared with mothers in other districts of Rwanda. Such research could inform the design of culturally relevant interventions to improve IYCF practices. In addition, there is a need to support mothers and caregivers through improving household income and access to foods so that they can implement recommendations.

Acknowledgements

Acknowledgements: The authors would like to thank the study participants and community health workers. We also thank the Titulaire of the Congo-Nil health centre and the researcher assistant, Mr Ntirushwa Paulin, for their logistic support to the first author during the data collection. We thank Mrs Auleria Karayire for her suggestions on interview guide and James Lee for his comments on the first draft of the manuscript. *Financial support:* This study was part of doctoral research (T.D.) funded by the New Zealand Scholarships and the School of Food and Advanced Technology, Massey University. The sponsors had no role in the study design, data collection or writing of the findings. *Conflict of interest:* None. *Authorship:* T.D., J.L.W., T.R., P.O.I. and L.B. designed the study. T.D. collected data and wrote the original draft; T.D., L.B. and J.L.W. conducted the analysis. All authors critically reviewed, commented on and edited the subsequent drafts of the manuscript. *Ethics of human subject participation:* This study received ethical approval from the Massey University Human Ethics Committee (reference: SOA 17/67) and the Institutional Review Board of the University of Rwanda's College of Medicine and Health Sciences (reference: 003/CMHS IRB/2017). A permission to collect data was also obtained from the Rutsiro District Public Health Office. This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving human subjects were approved by the Massey University Human Ethics Committee and the Institutional Review Board of the University of Rwanda's College of Medicine and Health Sciences. A permission to collect data was also obtained from the District public health office. Written informed consent was obtained from all participants. Each participant received US $10 to compensate for their time.

Supplementary material

For supplementary material accompanying this paper visit https://doi.org/10.1017/S1368980020001081

References

1. Development Initiatives (2018) *2018 Global Nutrition Report: Shining a Light to Spur Action on Nutrition*. Bristol: Development Initiatives.
2. Black RE, Victora CG, Walker SP *et al.* (2013) Maternal and child undernutrition and overweight in low-income and middle-income countries. *Lancet* **382**, 427–451.
3. National Institute of Statistics of Rwanda (NISR) [Rwanda], Ministry of Health (MOH) [Rwanda] & ICF International (2015) *Rwanda Demographic and Health Survey 2014–15*. Rockville, MD, USA: NISR, MOH, ICF International.
4. National Institute of Statistics Rwanda (2018) Rwanda: Comprehensive Food Security and Vulnerability Analysis 2018. https://docs.wfp.org/api/documents/WFP-0000103863/download/ (accessed July 2019).
5. Institut National de la Statistique (NISR) & ORC Marco (2006) *Rwanda Demographic and Health Survey 2005*. Calverton, MD: INSR and ORC Macro.
6. Ministry of Health (MOH) (Rwanda) (2012) *Third Health Sector Strategic Plan July 2012–June 2018*. Kigali: Ministry of Health.
7. Lamichhane DK, Leem JH, Kim HC *et al.* (2016) Association of infant and young child feeding practices with under-nutrition: evidence from the Nepal Demographic and Health Survey. *Paediatr Int Child H* **36**, 260–269.
8. Lutter CK, Daelmans BM, de Onis M *et al.* (2011) Undernutrition, poor feeding practices, and low coverage of key nutrition interventions. *Pediatrics* **128**, e1418–e1427.

9. World Health Organization (2005) *Guiding Principles for Feeding Non-breastfed Children 6–24 Months of Age*. Geneva: WHO.
10. Dewey KG & Adu-Afarwuah S (2008) Systematic review of the efficacy and effectiveness of complementary feeding interventions in developing countries. *Matern Child Nutr* **4**, 24–85.
11. Lung'aho M, Birachi E, Butare L *et al.* (2015) Rwanda Nutrition, Markets and Gender Analysis 2015: an integrated approach towards alleviating malnutrition among vulnerable populations in Rwanda. Nairobi: Government of Rwanda/ International Center for Tropical Agriculture (CIAT).
12. White JM, Bégin F, Kumapley R *et al.* (2017) Complementary feeding practices: current global and regional estimates. *Matern Child Nutr* **13**, e12505.
13. Habyarimana F, Zewotir T, Ramroop S *et al.* (2016) Spatial distribution of determinants of malnutrition of children under five years in Rwanda: simultaneous measurement of three anthropometric indices. *J Hum Ecol* **54**, 138–149.
14. Mukabutera A, Thomson DR, Hedt-Gauthier BL *et al.* (2016) Risk factors associated with underweight status in children under five: an analysis of the 2010 Rwanda Demographic Health Survey (RDHS). *BMC Nutr* **2**, 40.
15. Nkunzimana T, Custodio E, Pérez-Hoyos A *et al.* (2016) Assessing MDG achievements through under-5 child stunting in the east African community: some insights from urban versus rural areas in Burundi and Rwanda using DHS2010. In *Poverty and Well-being in East Africa*, pp. 61–86 [A Heshmati, editor]. Cham, Switzerland: Springer.
16. Nsereko E, Mukabutera A, Iyakaremye D *et al.* (2018) Early feeding practices and stunting in Rwandan children: a cross-sectional study from the 2010 Rwanda demographic and health survey. *Pan Afr Med J* **29**, 157–157.
17. Aoun N, Matsuda H & Sekiyama M (2015) Geographical accessibility to healthcare and malnutrition in Rwanda. *Soc Sci Med* **130**, 135–145.
18. Binagwaho A, Condo J, Wagner C *et al.* (2014) Impact of implementing performance-based financing on childhood malnutrition in Rwanda. *BMC Public Health* **14**, 1132.
19. Chunling L, Mejia-Guevara I, Hill K *et al.* (2016) Community-based health financing and child stunting in rural Rwanda. *Am J Public Health* **106**, 49–55.
20. Roesler A, Smithers LG, Winichagoon P *et al.* (2018) Local perspectives and context in relation to feeding practices of children under 2 years in the mountain villages of northern Thailand. *Public Health Nutr* **21**, 2989–2997.
21. Arts M, Geelhoed D, De Schacht C *et al.* (2011) Knowledge, beliefs, and practices regarding exclusive breastfeeding of infants younger than 6 months in Mozambique: a qualitative study. *J Hum Lact* **27**, 25–32.
22. Lee J, Dusingizimana T & Umutoni F (2016) Understanding Consumer Demand for Nutritious Food in Nyanza District, Rwanda. https://www.usaid.gov/sites/default/files/documents/1860/GAIN%20Summary%20Focused%20Ethnographic%20Survey%20Report.pdf (accessed June 2019).
23. National Institute of Statistics of Rwanda (NISR) [Rwanda], Ministry of Health (MOH) [Rwanda] & ICF International (2012) *Rwanda Demographic and Health Survey 2010*. Calverton, MD: NISR, MOH, and ICF International.
24. National Institute of Statistics of Rwanda (2015) Integrated Household Living Conditions Survey 4 (EICV 4). http://www.statistics.gov.rw/publication/rwanda-poverty-profile-report-results-eicv-4 (accessed January 2020).
25. Pelto GH, Goodman AH & Dufour DL (2000) The biocultural perspective in nutritional anthropology. In *Nutritional Anthropology: Biocultural Perspectives on Food and Nutrition*, pp. 1–10 [AH Goodman, GH Pelto & DL Dufour, editors]. Mountain View, CA: Mayfield Publishing.
26. Patton MQ (2002) *Qualitative Research and Evaluation Methods*. Thousand Oaks, CA: Sage Publications.
27. Saunders B, Sim J, Kingstone T *et al.* (2018) Saturation in qualitative research: exploring its conceptualization and operationalization. *Qual Quant* **52**, 1893–1907.
28. Given LM (2008) *The SAGE Encyclopedia of Qualitative Research Methods*. Thousand Oaks, CA: SAGE Publications.
29. Fook J & Gardner F (2007) *Practising Critical Reflection: A Resource Handbook*. Maidenhead: Open University Press.
30. DiCicco-Bloom B & Crabtree BF (2006) The qualitative research interview. *Med Educ* **40**, 314–321.
31. Braun V & Clarke V (2006) Using thematic analysis in psychology. *Qual Res Psychol* **3**, 77–101.
32. Saldaña J (2013) *The Coding Manual for Qualitative Researchers*, 2nd ed. London: SAGE Publications.
33. Tong A, Sainsbury P & Craig J (2007) Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *Int J Qual Health Care* **19**, 349–357.
34. Ministry of Health (MOH) (Rwanda) (2013) *National Food and Nutrition Strategic Plan (NFNSP 2013–2018)*. Kigali: Ministry of Health.
35. Pelto GH, Levitt E & Thairu L (2003) Improving feeding practices: current patterns, common constraints, and the design of interventions. *Food Nutr Bull* **24**, 45–82.
36. Alderman H & Headey DD (2017) How important is parental education for child nutrition? *World Dev* **94**, 448–464.
37. Engle PL, Menon P & Haddad L (1999) Care and nutrition: concepts and measurement. *World Dev* **27**, 1309–1337.
38. Ip S, Chung M, Raman G *et al.* (2007) Breastfeeding and maternal and infant health outcomes in developed countries. *Evid Rep Technol Assess (Full Rep)* **153**, 1–186.
39. Kramer MS & Kakuma R (2012) Optimal duration of exclusive breastfeeding. *Cochrane Database Syst Rev*, Cd003517.
40. Ministry of Health (MOH) (Rwanda) (2014) 1000 Days to a Healthy Rwanda. https://rwanda.thecompassforsbc.org/first-1000-days-healthy-rwanda (accessed December 2019).
41. Sukkary-Stolba S (1987) Food classifications and the diets of young children in rural Egypt. *Soc Sci Med* **25**, 401–404.
42. Laderman C (1981) Symbolic and empirical reality: a new approach to the analysis of food avoidances. *Am Ethnol* **8**, 468–493.
43. Zobrist S, Kalra N, Pelto G *et al.* (2017) Results of applying cultural domain analysis techniques and implications for the design of complementary feeding interventions in northern Senegal. *Food Nutr Bull* **38**, 512–527.
44. Alive & Thrive (2010) *IYCF Practices, Beliefs and Influences in Tigray Region, Ethiopia*. Addis Ababa: Alive & Thrive.
45. Paul KH, Muti M, Khalfan SS *et al.* (2011) Beyond Food Insecurity: how context can improve complementary feeding interventions. *Food Nutr Bull* **32**, 244–253.
46. Zeitlyn S, Rowshan R, Mahalanabis D *et al.* (1993) The ethnophysiology of digestion and diarrhoea in a Bangladeshi hospital population. *J Diarrhoeal Dis Res* **11**, 243–248.
47. Assis AM, Barreto ML, Santos LM *et al.* (2005) Growth faltering in childhood related to diarrhea: a longitudinal community based study. *Eur J Clin Nutr* **59**, 1317–1323.
48. Shubh KKR, Ruchira N & Bhattarai S (1997) *Child Care Practices Associated with Positive and Negative Nutritional Outcomes for Children in Bangladesh: A Descriptive Analysis*. Washington, DC: International Food Policy Research Institute.
49. Ali NS, Azam SI & Noor R (2003) Women's beliefs regarding food restrictions during common childhood illnesses: a hospital based study. *J Ayub Med Coll Abbottabad* **15**, 26–28.
50. Berggren WL & Wray JD (2002) Positive deviant behavior and nutrition education. *Food Nutr Bull* **23**, 7–8.
51. McLean J, Northrup-Lyons M, Reid RJ *et al.* (2019) From evidence to national scale: an implementation framework for micronutrient powders in Rwanda. *Matern Child Nutr* **15**, e12752.

52. Feed the Future (2018) Postharvest Loss Assessment of Orange-Fleshed Sweet Potatoes in Rwanda. https://horticulture.ucdavis.edu/sites/g/files/dgvnsk1816/files/extension_material_files/Postharvest%20Loss%20Assessment%20of%20OFSP%20in%20Rwanda.pdf (accessed December 2019).
53. Bhutta ZA, Ahmed T, Black RE *et al.* (2008) What works? Interventions for maternal and child undernutrition and survival. *Lancet* **371**, 417–440.
54. Jones AD, Cruz Agudo Y, Galway L *et al.* (2012) Heavy agricultural workloads and low crop diversity are strong barriers to improving child feeding practices in the Bolivian Andes. *Soc Sci Med* **75**, 1673–1684.
55. Ministry of Local Government (2011) National Social Protection Strategy. https://www.minaloc.gov.rw/fileadmin/documents/Minaloc_Documents/National_Social_Protectiion_Strategy.pdf (accessed June 2019).
56. Roelen K, Shelmerdine H, Delap E *et al.* (2014) *Researching the Linkages between Social Protection and Children's Care in Rwanda: The VUP and Its Effects on Child Wellbeing, Care and Family Reunification*. London: Family for Every Child.

Public Health Nutrition

Appendix 17: Published version of Paper II (Chapter 4)

British Journal of Nutrition, page 1 of 12 doi:10.1017/S0007114520004961

An empirical study of factors associated with height-for-age *z*-scores of children aged 6–23 months in northwest Rwanda: the role of care practices related to child feeding and health

Theogene Dusingizimana[1,2*], Janet L. Weber[1], Thiagarajah Ramilan[3], Per Ole Iversen[4,5,6] and Louise Brough[1]

[1]*School of Food and Advanced Technology, Massey University, Palmerston North 4442, New Zealand*
[2]*Department of Food Science and Technology, College of Agriculture, Animal Sciences and Veterinary Medicine, University of Rwanda, PO Box 210, Musanze, Rwanda*
[3]*School of Agriculture and Environment, Massey University, Palmerston North 4442, New Zealand*
[4]*Department of Nutrition, Institute of Basic Medical Sciences, University of Oslo, 0317 Oslo, Norway*
[5]*Department of Hematology, Oslo University Hospital, 0424 Oslo, Norway*
[6]*Division of Human Nutrition, Faculty of Medicine and Health Sciences, Stellenbosch University, 7505 Tygerberg, South Africa*

(Submitted 12 August 2020 – Final revision received 20 November 2020 – Accepted 1 December 2020)

Abstract

We aimed to identify the factors influencing child height-for-age *z*-scores (HAZ) as a measure of child nutritional status in Rwanda, and to examine the role of child feeding and health practices. We conducted a cross-sectional study involving 379 children (aged 6–23 months) and their mothers in northwest Rwanda. Data were collected using a pre-tested, structured questionnaire. An infant and young child feeding practices index (ICFI) and health practices index (HPI) were developed and categorised into tertiles, and linear regression analyses were performed to assess their association with child HAZ. Overall, mothers of non-stunted children exhibited better feeding and health practices than those of stunted children. ICFI was positively associated with child HAZ. We found an adjusted mean HAZ difference of 0·14 between children whose mothers were in high ICFI tertile compared with those in low tertile. Neither HPI nor any of its components were significantly associated with child HAZ. Other factors that were positively associated with child HAZ were infant birth weight ($P < 0·001$) and maternal height ($P < 0·001$). Child age, sex (male) ($P < 0·05$) and altitude ($P < 0·05$) were negatively associated with child HAZ. Diarrhoea ($P < 0·05$) and respiratory infections ($P < 0·05$) were negatively associated with HAZ in younger children aged 6–11 months. Policies to reduce stunting in this population must focus on both pre- and postnatal factors. Appropriate child feeding practices, particularly breast-feeding promotion and improvement in children's dietary diversity combined with measures to control infections should be given priority.

Key words: **Care practices: Child feeding practices: Health practices: Indexes: Stunting**

Stunting, or low height-for-age[1], also referred to as growth retardation, is the most common form of undernutrition among children under 5 years[2]. With an estimated 149 million (22 %) of children affected[3], stunting has been identified as a global public health priority. Stunting is associated with an increased risk of morbidity and mortality, poor cognitive and physical development, with significant educational and economic consequences[4] as well as an increased risk of non-communicable diseases in adulthood[4,5]. The World Health Assembly has set targets to reduce stunting by 40 % between 2010 and 2025[6]; however, at the current rate of reduction, several countries, especially low- and middle-income countries, are unlikely to achieve the targets[2].

For many years, policies to reduce child undernutrition in low- and middle-income countries, particularly in sub-Saharan Africa, have often focused on improving household income and food security[7,8]. However, evidence shows that increasing household income and food security, though necessary, is not sufficient for improved child nutritional status[9]. Research also shows that interventions to improve child nutritional status through improved household income and/or food security depend largely on child care practices within the household[10,11].

Abbreviations: HAZ, height-for-age *z*-score; HPI, health practices index; ICFI, infant and child feeding index.

* **Corresponding author:** Theogene Dusingizimana, email T.Dusingizimana@massey.ac.nz; dusingizetheo@yahoo.fr

British Journal of Nutrition

Several studies showed that better care practices related to feeding and preventive health practices can significantly improve child nutritional status, even in households with limited economic and food resources[12–14].

In Rwanda, 35 % of children younger than 5 years were stunted in 2018[15]. Data on prevalence of stunting in Rwanda show a national downward trend (48·3 % in 2000 to 35 % in 2018); however, the reduction has not been consistent across the country. For example, in fourteen out of thirty districts of Rwanda, 40–54 % of children under 5 years are stunted[15]. Based on the WHO thresholds[16], these rates of stunting are of very high public health significance and require urgent actions. Thus, research is needed to understand the factors underlying the persistence of child stunting in Rwanda. Given the significant disparity in stunting prevalence, a greater understanding of subnational level factors is needed to inform the design of more targeted programmes and policies to effectively address child stunting in Rwanda.

Studies[17,18] have documented gaps in care practices related to child feeding practices in Rwanda. For example, the number of children aged 6–23 months who met the minimum acceptable diet remained unchanged (17 %) between 2010 and 2018[15]. Increasing evidence also suggests that poor care practices, including sub-optimal child feeding practices, are potentially contributing to the high rates of child undernutrition in Rwanda[15,19,20]. In addition, studies indicate inadequate health practices such as low utilisation of child growth monitoring for screening of child nutritional status[21]. However, research is limited on the influence of child feeding patterns on child nutrition status. A few studies examining the relationship between infant and young child feeding (IYCF) practices and child nutrition status in Rwanda have assessed single indicators of feeding practices and produced mixed results. Uwiringiyimana *et al.*[22] found that exclusive breast-feeding was significantly positively associated with height-for-age *z*-scores (HAZ) in children aged 5–30 months (*n* 138). Conversely, Matsiko[23] found that achieving minimum dietary diversity, minimum meal frequency and acceptable diet were not significantly associated with HAZ in children aged 6–12 months (*n* 192). Given that child feeding has several dimensions (e.g. the type, quality and variety of foods, the quantity of foods, responsive feeding, etc.), studies examining the association between single feeding practices and child nutrition status may not provide a comprehensive picture of the association between overall child feeding patterns and nutritional outcomes[24]. Ruel & Menon[25] proposed a novel approach of assessing the relationship between child feeding patterns and nutritional status using an index that combined various dimensions of child feeding. Drawing from Ruel and Menon's approach, Condo *et al.*[26] examined the association between a feeding index and nutritional status in Rwanda. The authors found no association between the feeding index and child nutritional status; however, their findings may not apply to all children because the study focused on HIV-infected children whose caregivers' feeding practices may differ from those of caregivers with healthy children.

The objectives of the present study were to identify the factors associated with child stunting in Rwanda, including the relationship between indices of child feeding and health practices and child stunting. Our assumption was that better feeding and health practices are positively associated with better child HAZ and that mothers of non-stunted children have better child feeding and health practices than those of stunted children. This study contributes to the knowledge on the determinants of child stunting in Rwanda and extends the literature on the usefulness of indices of child feeding and health practices in relation to child nutritional status in the Rwandan context.

Methods

Settings

The study was conducted in Rutsiro district, northwest of Rwanda, 150 km from the capital city, Kigali. The inhabitants of the district are predominantly rural and engaged in subsistence agriculture[15]. About 50 % of the population in Rutsiro are food insecure, and the prevalence of stunting increased from 46 % in 2015 to 54 % in 2018[15]. The public health system of the district consists of a network of seventeen health centres and one district hospital[27].

Design and sample size

This was a cross-sectional study involving mother–child pairs. The sample size was calculated using the Cochrane formula for estimation of a single proportion[28]. Although our focus was not to estimate the proportion of stunted children, this would allow us to analyse the determinants of child nutritional status with a 95 % confidence of having an anticipated prevalence of stunting.

$$n = Z^2pq/d^2$$

where n is the sample size, Z is 1·96, p is the proportion of stunting (46 % at the time of the survey[29]), q is $1-p$ and d is the relative desired precision of 5 %. The calculated sample size (n 382) was increased by 5 % to account for contingencies such as recording error, resulting in a final sample of 400. Because of the variability in geographical landscape, it was assumed that child feeding and/or health practices might differ across the district. Therefore, the district was divided into three zones based on the main roads connecting Rutsiro district to its neighbouring districts. Health centres were used as an entry point to facilitate access to the community, and community health workers who work under supervisions of the health centres assisted in identifying potential participants. Three health centres (nine in total across the district) were purposively selected in each zone to maximise geographic distribution. Within each health centre's catchment area, two administrative entities (i.e. cells) were selected. The cell containing the health centre was automatically selected, and the next was randomly selected among distant cells. In each cell, one village was randomly selected, a list of all potentially eligible mothers with children aged 6–23 months were compiled using growth monitoring records obtained from community health workers and children were randomly selected from the lists. Eligibility criteria were: (1) child aged 6–23 months; (2) child was apparently healthy and (3) being in the lowest socio-economic categories. All participants gave oral

British Journal of Nutrition

informed consent prior to data collection. The survey was undertaken from September 2018 to January 2019.

Ethical approval

All study guidelines were in accordance with the guidelines laid down in the Declaration of Helsinki. The study procedures were also approved by the Massey University Human Ethics Committee (reference: SOA 17/67) and the Institutional Review Board of the University of Rwanda's College of Medicine and Health Sciences (reference: 003/CMHS IRB/2017). Permission to collect data was also obtained from the District public health office. Oral informed consent was obtained from all participants, after the purpose of the study was explained. Each participant received five soap bars (~$US 1) as a recognition for their participation.

Face-to-face interviews were conducted with mothers, and data were collected using a structured questionnaire digitally preprogrammed on the CommCare platform[30]. The data were captured on a handheld tablet. Information on socio-demographic characteristics, maternal and child characteristics were collected. Mothers also reported infant birth weight, child morbidities in previous 4 weeks: diarrhoea (defined as ≥3 watery or loose stools per day), upper respiratory infections (coughing, runny nose or wheezing), fever and other illnesses. In addition, household socio-economic characteristics such as size, number of children under 5 years, ownership of agricultural land and other household assets, and source of drinking water were reported. Altitude and location of the household premises were recorded using a handheld Global Positioning System (Tremble Juno SB Handheld).

Measures

Anthropometry

Anthropometric measurements were taken following standard procedures[31]. Child height was measured to the nearest 1 mm in a recumbent position using a UNICEF designed length board. The height of mothers was measured using a wall-mounted portable stadiometer to the nearest 0·1 cm. The weight of both mother and child was measured to the nearest 100 g using an electronic scale (SECA model 874).

Feeding and health practices

Breast-feeding and complementary feeding practices, and health practices (antenatal care visits during the last pregnancy, attendance at growth monitoring, use of deworming tablets, child immunisation status, use of vitamin A supplements) were reported by the mother. Birth certificates and immunisation records were used to verify information on birth weight and immunisation status, respectively.

Infant and child feeding index

We adapted the methodology used by Ruel & Menon[25] and others[32–34] to construct an infant and child feeding index (ICFI). The ICFI consisted of five child feeding practice components: current breast-feeding (yes/no), duration of exclusive breast-feeding (i.e. whether the mother exclusively breastfed for the first 6 months), dietary diversity indicator, feeding frequency and responsiveness during feeding. Dietary diversity and meal frequency were calculated using 24-h dietary recall data[35]. The feeding practice components and the scoring system used to create the ICFI for the different age groups are described in the online Supplementary Table S1. Briefly, a score of 1 or 2 was assigned for a positive practice, and a score of 0 was assigned for a potentially negative practice. The practices were judged positive or negative based on child feeding recommendations[36] as well as evidence about their potential benefits or risks[37].

For children aged 6–8 months and 9–11 months, a score of 2 was assigned for mothers whose children were still breast-feeding. For children aged 12–23 months, a score of 1 was assigned for mothers whose children were still breast-feeding. For all children, a score of 0 was assigned for mothers whose children were not breast-feeding. A score of 1 was also assigned for mothers who reported exclusive breast-feeding for the first 6 months, and a score of 0 was given to those who introduced complementary foods to their children prior to 6 months.

A dietary diversity indicator was created using information collected on the number of food groups consumed by the child in the previous 24 h. Following the guidelines for young child feeding[35], seven food groups, adapted from the Rwanda's Demographic and Health Survey[29], were considered: grains/roots/tubers, legumes/nuts, milk or dairy products, flesh foods (meat/fish/poultry), eggs, vitamin A fruits and vegetables, and other fruits and vegetables. A score of 1 was given for each food group consumed, resulting in a dietary diversity score ranging from 0 to 7 which was divided into three categories: low, medium and high. For all age groups, low category included children who had not received any foods. For both 6–8 months and 9–11 months age groups, a child was classified into medium category if a child received 1–2 food groups, or into high category if a child received three or more food groups. For children 12–23 months, a medium category composed of children who had received 2–3 food groups, whereas a high category comprised those receiving ≥4 food groups.

Feeding frequency scoring criteria used information collected on the number of meals received by the child in the past 24 h. This indicator reflects the WHO recommended minimum meal frequency for breastfed and non-breastfed children (i.e. breastfed children aged 6–8 months and 9–23 months should receive solid or semi-solid or soft foods at least two times/d and two times/d, respectively). Thin/watery porridges and trivial snacks were not counted[35].

Indicator of responsive feeding was based on current young child feeding recommendation[36], and it was informed by a previous study[38] conducted in the same population. It was defined as caregiver's self-report of encouraging food intake of children who refuse to eat due to loss of appetite or during diarrhoea[10]. A score of 1 was assigned for an action to encourage food intake, and a score of 0 if the action potentially restricted/discouraged child's food intake.

The ICFI was created by adding up the scores obtained from all the component practices. For each age group, the minimum ICFI score was 0 and maximum possible ICFI score was 9. The

British Journal of Nutrition

scores were ranked, and tertiles were created to form three categories: low, medium and high. Grouping the ICFI score into tertiles, although arbitrary, was done to allow comparison with other studies that have examined the relationship between ICFI and child HAZ.

Health practices index

A methodology used by Ruel *et al.*[13] was adapted to develop a health practices index (HPI). Five health practices were considered: attendance at growth monitoring in the past month, the number of antenatal care visits when pregnant with the study child, child diarrhoea treatment methods, vitamin A supplementation (whether the child received vitamin A supplements in the previous 6 months) and immunisation status (whether the child received all age-specific vaccines). The scoring system for the different health practices is described in the online Supplementary Table S2.

Household hunger level

Household hunger level was assessed and categorised using a validated cross-cultural household hunger scale[39]. Following the household hunger scale measurement guide, a six-point household hunger score was generated and categorised into three levels of household hunger: little or no hunger (score: 0–1 score); moderate hunger (score: 2–3) and severe hunger (score: 4–6). The moderate and severe hunger level categories were combined to form one category, that is, moderate/severe, as there were few households (4·2 %, *n* 16) in the severe hunger category.

Household wealth index

A household wealth index – a proxy measure of household socio-economic status – was constructed using a principal component analysis[40], with the following twelve variables: access to agricultural land, purchase of commercial fertilizer in the previous cropping season, the quality of housing (type of floor, wall), degree of household crowding, that is, the number of persons sleeping in a room (1 if ≤ 3 persons/room and 0 if ≥ 4 persons/room), source of lighting (none, petrol lamp or solar/electricity), ownership of durable assets (radio, thermos, mattress, umbrella), ownership of health insurance for all household members and a measure of animal ownership expressed in tropical livestock units. The tropical livestock unit is a metric combining multiple species of livestock into a weighted measure representing total body weight and potential market value[41]. The tropical livestock unit variable was skewed and, therefore, three categories were created. All variables were thus categorical and were ranked in ascending order, that is, from the worst to the best. The scores of the first two extracted components of the principal component analysis were used as a measure of household wealth index and included as covariates in multivariable regression analyses.

Statistical analysis

The WHO Anthro software version 3.2.2 was used to calculate HAZ[42]. A child was classified as stunted if his/her HAZ was 2 SD below the median of the WHO reference population[43]. A binary indicator of stunting (stunted/non-stunted) was used to allow comparison between care practices and other characteristics of mothers of non-stunted and those of stunted children. Continuous variables were summarised using means and standard deviations or medians and interquartile ranges for non-normally distributed variables. Categorical variables were summarised using frequencies and percentages. The Mann–Whitney *U* test or independent *t* test (continuous variables) and χ^2 test (categorical variables) were used to test differences in care practices and other characteristics between non-stunted and stunted children. Multiple linear regression analyses were used to examine the relationship between various factors and child HAZ (dependent variable). To identify variables to include in the regression models, we first represented hypothetical assumptions about the causal relationships between various factors and child HAZ using DAGitty software[44]. The software was used to construct directed acyclic graphs which specify the relationships among factors based on *a priori* evidence, theoretical knowledge and researcher's subject matter expertise[45], while enabling identifying covariates to adjust for in multiple regression models[45]. Although we aimed to examine association between various factors and child HAZ, ICFI and HPI were particularly of interest because feeding and health practices are modifiable factors often targeted by interventions to prevent stunting. Therefore, two different regression models containing ICFI and HPI as main independent variables were fitted. The first model (model 1) examined association between ICFI and child HAZ, adjusting for all other covariates at child, maternal and household level included in the model. The second model (model 2) examined association between HPI and child HAZ, adjusting for the same covariates as in model 1. Since feeding practices are linked to child food intake, which is a direct determinant of child HAZ (besides illnesses), we also adjusted for ICFI in model 2. Because of age-related variability in child feeding practices[36], we ran separate regression analyses: for all children, and for those aged 6–11 months and 12–23 months. All assumptions were assessed for all models. Multicollinearity was checked using the variance inflation factor of ten for all explanatory variables[46]. Homoscedasticity was assessed by visual inspection of a plot of standardised residuals *v.* standardised predicted values. Variables with $P < 0{\cdot}05$ were considered statistically significant. All analyses were performed using SPSS version 25 (IBM).

Results

Of the 400 child–mother pairs recruited, twenty-one children (5 %) were excluded from the analysis due to preterm birth or lack of health cards to verify birth weight information. Thus, the descriptive analysis was performed on 379 children. Of these, thirty-five mothers (9 %) had no height measurements, whereas 10 (2·5 %) had no data on education. The final sample considered for regression analyses was thus 334 (~84 %) mother–child pairs. The median age was significantly lower ($P < 0{\cdot}001$) for non-stunted children than for stunted children (Table 1). Mothers of non-stunted children were older and taller than those of stunted children. Approximately 60 % of the

Table 1. Child-, maternal- and household-level characteristics, by child nutritional status*
(Frequencies and percentages; means and standard deviations; medians and interquartile ranges (IQR))

	Full sample		Non-stunted		Stunted		
Characteristics	*n*	%	*n*	%	*n*	%	*P*
Number of children	379	100	233	61·5	146	38·5	
Child level							
Age (months)							<0·001
Median	15·1		13·3		17·2		
IQR	10·9, 19·4		9·7, 18·5		13·5, 20·8		
Age group (years)							<0·001
6–11	120	31·7	95	79·2	25	20·8	
12–23	259	68·3	138	53·3	121	46·7	
Sex							0·13
Males	184	48·5	106	57·6	78	42·4	
Females	195	51·5	127	65·1	68	34·9	
Birth weight (kg)							<0·001
Median	3·2		3·3		2·8		
IQR	3·0, 3·6		3·0, 3·6		3·0, 3·5		
HAZ							<0·001
Mean	−1·69		−0·97		−2·83		
SD	1·3		0·9		0·8		
Maternal level							
Age (years)							0·02
Median	28		30		27		
IQR	24, 34		25, 35		23, 33		
Height (cm)							<0·001
Mean	156·0		157·3		153·8		
SD	5·9		5·5		5·7		
Marital status							0·06
Married	304	80·0	194	64·0	110	36·0	
Unmarried/widowed	75	20·0	39	52·0	36	48·0	
Number of ANC visits							0·58
<4	248	65	150	60·0	98	40·0	
≥4	131	35	83	63·0	48	37·0	
Education level							0·54
None/incomplete primary	219	59·3	132	60·3	87	39·7	
Completed primary	88	23·8	53	60·2	35	39·8	
Some secondary	62	16·8	20	67·7	42	32·3	
Household level							
Household size							0·22
Median	4		5		4		
IQR	3, 6		3, 6		3, 5		
Number of children < 5 years							0·42
Median	1		1		1		
IQR	1, 2		1, 2		1, 2		
Altitude (masl)							0·003
Median	1977·2		1913		2023·5		
IQR	1729·0, 2198·0		1726·5, 2137·5		1760·3, 2229·8		
Wealth index							0·11
Lowest tertile	126	33·2	78	61·9	48	38·1	
Middle tertile	126	33·2	69	54·8	57	45·2	
Upper tertile	127	33·5	86	67·7	41	32·3	
Hunger level							0·10
Little/no hunger	215	56·7	140	65·1	75	34·9	
Moderate/severe	164	43·3	93	56·7	71	43·3	
Source of drinking water†							0·92
Improved	222	58·6	136	63·3	86	38·7	
Unimproved	157	41·4	97	61·8	60	38·2	
Zone							0·19
Zone 1	100	26·4	55	55·0	45	45·0	
Zone 2	100	26·4	60	60·0	40	40·0	
Zone 3	179	47·2	118	65·9	61	34·1	

HAZ, height-for-age *z*-score; ANC, antenatal care; masl, metres above sea level.
* Data are missing for maternal education (*n* 10) and maternal height (*n* 36).
† Source of drinking water defined according to UNICEF/WHO[47]: improved = public taps, standpipes, tube wells, boreholes, protected well and springs, rainwater; unimproved = unprotected well and spring, surface water.

Table 2. Distribution of the infant and child feeding index (ICFI) and its components by child nutritional status (Frequencies and percentages; ranges; means and standard deviations)

	Full sample		Non-stunted		Stunted		
	n	%	*n*	%	*n*	%	*P*
Current breast-feeding							<0·001
Yes	362	95·5	230	63·5	132	36·5	
No	17	4·5	3	17·6	14	82·4	
Child was exclusively breastfed to 6 months							0·20
Yes	231	60·9	148	64·1	56	35·9	
No	148	39·1	85	57·4	63	42·6	
Dietary diversity score*							0·043
Low	28	7·4	18	64·3	10	35·7	
Medium	172	45·4	94	54·7	78	45·3	
High	179	47·2	121	67·3	58	32·4	
Meal frequency score†							0·58
Low	43	11·3	28	65·1	15	34·9	
Medium	195	61·5	115	59·0	80	41·0	
High	141	37·2	90	63·8	51	36·2	
Responsive feeding when child refuses foods							0·50
Yes	262	69·1	164	62·6	98	37·4	
No	117	30·9	69	59·0	48	41·0	
Food restriction during diarrhoea							0·11
Yes	175	46·2	100	57·1	75	42·9	
No	204	53·8	133	65·2	71	34·8	
ICFI score							
Range	1–9		1–9		1–9		
Mean	5·7		6·0		5·4		<0·001
SD	1·6		1·6		1·6		
ICFI tertiles							0·001
Low (1–4)	82	21·6	41	50·0	41	50·0	
Medium (5–6)	165	43·5	95	57·6	70	42·2	
High (7–9)	132	34·8	97	73·5	35	26·5	

* For age 12–23 months, medium = 2–3 food groups/d and high = 4 or more food groups/d.
† For age 12–23 months, medium = 1–2 meals/d and high = 4+ meals/d.

mothers had either never attended school or did not complete primary education; 16 % had some secondary education, and 65 % did not achieve the recommended number of ≥ 4 antenatal care visits. Of the households, 43 % had experienced moderate to severe hunger in the past 4 weeks.

Nutritional status

The mean HAZ was −1·69 (SD 1·3). Of the children, 38 % were stunted (Table 3), and the stunting prevalence in older children was more than twice that in younger children (47 *v.* 21 %, $P < 0·001$). There was no significant difference in the prevalence of stunting between males and females or between household wealth index categories.

Child feeding practices

Almost all children (96 %) were still breastfed at the time of the survey. However, over one-third of the mothers (39 %) introduced complementary foods to their children before the recommended age (i.e. 6 months) (Table 2). Approximately half (54 %) of the children were fed at the recommended minimum frequency; however, the diversity of foods consumed was low. On average, children consumed three food groups and only 36 % met the WHO recommended minimum dietary diversity (≥4 food groups) (online Supplementary Table S3). As compared with children aged 12–23 months, children in the age group of 6–11 months were less likely to achieve the recommended minimum dietary diversity (23 *v.* 42 %, $P = 0·001$) (data not shown). Nearly all children (93 %) consumed staples (grains, roots or tubers), whereas the consumption of animal source foods was low (27 %) (online Supplementary Table S3). The mean ICFI score for all children was 5·8 (SD 1·6.) Non-stunted children had significantly higher ICFI score than stunted children (6·0 *v.* 5·4, $P = 0·001$) (Table 2).

Child morbidity and health practices

Morbidity among children during the previous 4 weeks was high: 47 % had experienced diarrhoea, 78 % had symptoms of respiratory infections, 43 % had fever and 11 % had other illness (online Supplementary Table S3). No significant difference was observed in the prevalence of morbidity between non-stunted and stunted children. However, results from sub-analyses (data not shown) showed that, in younger children (6–11 months), stunted children were more likely to have diarrhoea than non-stunted (64 *v.* 42 %, $P = 0·05$). About half (46 %) of the mothers whose children had suffered from diarrhoea reported either never seeking treatment or using home remedies to treat their child diarrhoea. The prevalence of stunting was higher among children whose mothers did not seek treatment or used home remedies for child diarrhoea than among children whose mothers sought diarrhoea treatment from a health centre or health worker (58 *v.* 48 %, $P = 0·057$). The mean HPI was 4·5 (SD 1·0),

Table 3. Distribution of the health practices index (HPI) and its components by nutritional status of children aged 6–23 months, Rutsiro district, Rwanda, September 2018 to January 2019
(Frequencies and percentages; ranges; means and standard deviations)

	Full sample		Non-stunted		Stunted		
	n	%	*n*	%	*n*	%	*P*
Attendance at growth monitoring (past month)							0·67
Yes	318	83·9	197	61·9	121	38·1	
No	61	16·1	36	59·0	25	41·0	
Antenatal care							0·66
Poor (0–1)	148	39·1	85	57·4	63	42·6	
Average (2–3 visits)	231	60·9	148	64·1	56	35·9	
Good (≥4 visits)							
Diarrhoea treatment method							0·06
No treatment/home remedy	174	45·9	98	56·3	76	43·7	
Health centre/health worker	205	54·1	135	65·9	70	34·1	
Child received vitamin A supplements (past 6 months)							0·07
Yes	362	95·5	219	60·5	143	39·5	
No	17	4·5	14	82·4	3	17·6	
Child fully immunised							0·26
Yes	357	94·2	217	60·8	140	39·2	
No	22	5·8	16	72·7	6	27·3	
HPI score							
Range	1–6		2–6		1–6		
Mean	4·5		4·5		4·5		0·58
SD	1·0		1·0		1·0		
HPI tertiles							0·043
Low (score: 1–3)	58	15·3	37	63·8	21	36·2	
Medium (score: 4)	127	33·5	67	52·8	60	47·2	
High (score: 5–6)	194	51·2	129	66·5	65	33·5	

with no significant difference between non-stunted and stunted children ($P = 0·58$) (Table 3).

Association between infant and child feeding index, health practices index and child nutritional status

Results from bivariate analyses showed that ICFI was associated with child nutritional status. We found a significant difference of 0·34 in mean HAZ between children in the highest compared with the lowest ICFI tertiles ($P < 0·001$) (data not shown). Additionally, the prevalence of stunting was significantly lower among children whose mothers were in the high ICFI tertile compared with those in the lowest tertile (27 *v.* 50 %, $P = 0·001$) (Table 2). In bivariate analysis, the association between HPI and HAZ was not statistically significant ($P = 0·10$) (data not shown). The prevalence of stunting was also not as expected; it was significantly higher among children whose mothers were in the medium HPI tertile as compared with low and high tertiles (Table 3). However, when the two lowest tertiles (low and medium) were combined and compared with the high tertile, the prevalence of stunting was significantly lower among children in the highest tertile compared with the lowest tertile (33·5 *v.* 43·8 %, $P = 0·04$).

Results from multiple linear regression analyses are shown in Table 4. There was a significant and positive association between ICFI and HAZ, after controlling for potential confounders at child, maternal and household level. We found a mean difference of 0·14 HAZ between children of mothers in the high ICFI tertile compared with those in the low ICFI tertile ($P = 0·039$) (Table 4, model 1). When analysis was stratified by age, the association between ICFI and HAZ remains significant ($\beta = 0·16$, $P = 0·025$) only in older children (12–23 months) (online Supplementary Table S4). The association between HPI and HAZ was not statistically significant, neither when all age groups were combined (Table 4, model 2) nor in stratified analysis (online Supplementary Table S5). We also analysed individual components of ICFI and HPI, while controlling for variables as in ICFI or HPI models (data not shown). Among the components of ICFI, a significant and positive association was observed between breast-feeding and child HAZ ($\beta = 0·13$, $P = 0·011$). The association between dietary diversity indicator and child HAZ also approached statistical significance ($\beta = 0·17$, $P = 0·087$). None of the components of HPI was significantly associated with HAZ.

In both model 1 and model 2, child's birth weight and maternal height were positively associated with HAZ. By contrast, child's age, sex (male) and altitude were negatively associated with HAZ. In models including all children (6–23 months), respiratory infections tended to be significant and negatively associated with HAZ, but no association was observed between diarrhoea and HAZ. When analysed by age group, we found a statistically significant and negative association between both diarrhoea and respiratory infections and HAZ only in younger children (6–11 months) (online Supplementary Tables S4 and S5).

Discussion

Findings from the present study indicate that the burden of stunting among children aged 6–23 months in Rutsiro district is high (39 %). National estimates show that the prevalence of stunting increases from 18 % among children 6–8 months to 21 % among

Table 4. Factors associated with height-for-age *z*-score (HAZ) of children aged 6–23 months in Rutsiro district, Rwanda, September 2018–January 2019* (Standardised coefficients and 95 % confidence intervals)

	Model 1			Model 2		
	β	95 % CI	*P*	*β*	95 % CI	*P*
ICFI tertiles (Ref. = Low)						
Medium	0·07	−0·13, 0·47	0·27	0·06	−0·16, 0·45	0·35
High	0·14	0·02, 0·72	0·039	0·13	−0·01, 0·72	0·06
HPI (Ref. = Low)						
Medium	–	–	–	0·03	−0·29, 0·42	0·71
High	–	–	–	0·09	−0·13, 0·57	0·22
Age (months)	−0·29	−0·10, −0·05	< 0·001	−0·30	−0·10, −0·05	< 0·001
Birth weight (kg)	0·22	0·29, 0·72	< 0·001	0·22	0·29, 0·72	< 0·001
Sex (Ref.= female)						
Male	−0·12	−0·53, −0·08	0·008	−0·13	−0·54, −0·9	0·007
Diarrhoea – yes	−0·04	0·32, 0·14	0·45	−0·03	−0·30, 0·17	0·58
Respiratory infection – yes	−0·09	−0·51, 0·04	0·09	−0·09	−0·53, 0·02	0·07
Maternal height (cm)	0·28	0·04, 0·08	<0·001	0·28	0·04, 0·08	< 0·001
Maternal education (Ref. = none/incomplete primary)						
Complete primary	0·07	−0·08, 0·49	0·16	0·08	−0·07, 0·50	0·13
Some secondary	0·08	−0·03, 0·63	0·08	0·09	−0·05, 0·61	0·10
Altitude (1000 m above sea level)	−0·15	−1·06, 0·25	0·002	−0·14	−1·00, −0·18	0·005
Household hunger (Ref. = little/no hunger)						
Mild/severe	−0·05	−0·37, 0·13	0·34	−0·05	−0·37, 0·14	0·37
Wealth index						
1st Factor	−0·01	−0·14, 0·11	0·82	−0·02	−0·16, 0·10	0·65
2nd Factor	−0·03	−0·16, 0·09	0·58	−0·04	−0·17, 0·08	0·49
Adjusted R^2	0·31			0·31		

β, Standardised coefficient; ICFI, infant and child feeding index; Ref., reference category; HPI, health practices index.
* Model 1 included ICFI as the main independent variable. Model 2 included HPI as the main independent variable. Both models included the same covariates, except that model 2 also included ICFI. (–) means that HPI was not included in model 1.

those aged 9–11 months to 49 % among those aged 18–23 months[29]. Our results showed a similar trend and are comparable to those observed in other studies showing that the odds of stunting increases with age[48].

In the present study, we found a feeding pattern that is similar to what has been observed in other studies conducted in Rwanda. For example, 39 % of the mothers reported introducing complementary foods to their children before 6 months. In a cross-sectional study[22] and a longitudinal study[23] conducted in northern and southern provinces of Rwanda, respectively, researchers found that only 50 % of children were exclusively breastfed for the first 6 months. These results suggest that national estimates of exclusive breast-feeding prevalence (87 %)[29] may be an overestimation in rural Rwanda. In addition, the diet of children was less diverse, with majority of children (64 %) consuming less than the recommended four food groups, and the consumption of animal sources foods was extremely low. Other studies conducted in rural Rwanda have reported that 65–70 % of children younger than 24 months do not meet the WHO recommended dietary diversity[22,29]. Although monotonous diets are correlated with household poverty in low- and middle-income countries[49], several studies conducted in Rwanda revealed other important factors underlying poor child feeding practices, including maternal beliefs and food restrictions, especially during child illness[18,38].

Our finding of a positive association between ICFI and child HAZ is consistent with other studies that have investigated the relationship between a summary of child feeding practices and child HAZ in rural[32,34,50] and urban populations[13,51]. However, our result contrasts those of Ntab *et al.*[52] who found no association between ICFI and child HAZ in rural Senegalese children (*n* 500, age 12–42 months). These inconsistent results are probably due to differences in feeding practices. For example, contrary to our observation, breastfed children in the Senegalese study had lower mean HAZ than non-breastfed children because mothers prolonged breast-feeding for stunted children. Our findings of an association between ICFI and child HAZ only in older children are consistent with those of Ruel & Menon[25] who found a positive association between ICFI and HAZ in older children (12–36 months). These authors suggested that the cumulative effect of improved care practices on child health may increase over time, and therefore, the effect of better child feeding practices may become more apparent in older children than in younger children[25].

In the present study, two components of ICFI, that is, breast-feeding and dietary diversity indicators, were associated with child HAZ. Other studies in Rwanda[22] and Kenya[53] have reported positive associations between breast-feeding and linear growth among children < 24 months. However, our results regarding breast-feeding should be interpreted with caution because only a small number (5 %) of children were not breast-feeding. Our finding of a positive association between dietary diversity and child HAZ is also supported by findings from several countries in Africa (including Rwanda), Asia and Latin America[54,55]. This result underscores the use of the dietary diversity as a better proxy of feeding practices and suggests that interventions to diversify children's diet have potential to improve child nutritional status of young children in Rwanda. However, studies found that complementary foods in Rwanda may be source of mycotoxins[56,57]. Consumption of mycotoxins,

British Journal of Nutrition

particularly aflatoxins, through complementary foods was found to be associated with child stunting in children (9–60 months)[58]. This could be one of the reasons why the relationship of ICFI with child HAZ was not as strong as might be expected, but further investigation is needed in this area. Thus, to maximise the benefits of dietary diversification on children's nutritional status, interventions should focus not only on improving the diversity of complementary foods, but also the safety of these foods.

The lack of association between HPI and child HAZ in the present study contrasts findings of Liu *et al.*[59] who reported a significant and positive association between a health practices index (measured by access to prenatal care, timing and frequency of prenatal care visits) and child HAZ in a multi-country/pooled analysis of longitudinal data from four low- and middle-income countries. The discrepancy between our results and those of Liu *et al.* may be due to methodological differences. Our health index included five aspects of health practices, whereas that of Liu *et al.* included only indicators related to antenatal care. Additionally, some components (e.g. growth monitoring and antenatal care) used to construct the HPI serve as an entry point to nutrition services (e.g. counselling on IYCF practices and micronutrient supplementation); therefore, the effect of HPI in the present study on child nutritional status may be much more dependent on the quality of services provided to mothers. It was found in India and Bangladesh that growth monitoring programmes had little or no effect on child nutritional status because of failure to identify growth faltering among children or ineffective nutritional counselling to mothers[60].

Research shows that health promoting practices tend to cluster. That is, a mother who, for example, exclusively breastfeeds is more likely to engage in other positive practices[24]. So, it has been suggested that summary indices may be useful to comprehensively assess the cumulative effect of various dimensions of child feeding and/or health practices on child nutritional status, while accounting for the interrelationships between these practices[51]. Thus, conceptually, one would expect the effect size (i.e. adjusted mean HAZ difference between high and low categories) of the index on child HAZ to be higher than that of single practices. However, in the present analysis, only a few components (i.e. breast-feeding and dietary diversity) were associated with child HAZ and the effect size of each of these components on child HAZ was comparable to that of the ICFI. Moreover, the addition or removal of the ICFI from the model did not significantly change the adjusted R^2 (data not shown). These results suggest that, at least in this sample, these indices did not perform better than individual practices. Although indices have some advantages, such as summarising information on child feeding or health practices, they can also mask the individual practices they include[34]. In addition, while composite indices have previously been used to examine associations between feeding/health practices and child nutritional status in various settings, there still no consensus on methodology to construct these indices. Therefore, further research is needed to validate these indices and to address their limitations. Such research could, for example, examine the performance of ICFI constructed by including other aspects of child feeding such as hygiene practices during food preparations, the types or amounts of foods as opposed to food groups.

Among covariates, child age, sex (male) and altitude were negatively associated with HAZ. These factors have been found to be associated with child stunting in Rwanda[61,62] and other sub-Saharan African countries[63]. In addition, maternal height and infant birth weight were positively associated with child HAZ. This relationship has been described in previous studies showing that both maternal height and child birth weight reflect the prenatal environment and strong determinants of subsequent child nutritional status[64,65]. The association between maternal height and child HAZ may be explained by two mechanisms: shorter mothers have small uterine volume which constrains fetal growth[66], and/or placental transport mechanisms that limit provision of nutrients to the fetus and growth[67]. It is also suggested that this association could reflect shared genetic factors and/or common environmental factors that affect a mother during her early childhood and subsequently the growth of her offspring[68]. However, studies indicated that, in early childhood, the effect of environmental factors on child linear growth is stronger than that of genetic factors, especially in poorer regions where adverse environmental conditions, such as poor quality of diet and diseases, may not permit full expression of height potential[68–70]. A significant negative association was observed between child morbidities (diarrhoea and respiratory infection) and child HAZ, but only in younger children. This finding corroborates the previous aforementioned longitudinal study[23] that also found a significant negative association between days with diarrhoea or respiratory infection with decreased child linear growth among children aged < 12 months.

Strengths and limitations

One of the strengths of the present study is the use of summary indices to comprehensively examine the relationship between a variety of feeding and health practices and child HAZ. There are some limitations to the present study. First, the cross-sectional nature of the present study means that our analysis cannot establish causal relationships. A longitudinal study design is recommended to somewhat address this limitation. Second, the study was conducted in one district only and was limited to the lowest socio-economic groups, which limits the generalisability of our findings. Third, most of the information on feeding and health practices was obtained from mothers' recall which is prone to recall bias and social desirability. Fourth, although we used the standard 24-h recall method to assess child feeding practices, dietary information may not represent the usual diet of children because certain foods may be infrequently consumed. For example, the consumption of animal source foods may be rare, whereas some fruits may be available only in certain seasons. Last, even though we controlled for several covariates, we cannot rule out the influence of unmeasured variables, such as hygiene and sanitation which are known to influence child nutritional status, particularly in resource-limited settings[53].

Conclusion

Findings from the present study indicated that stunting among children 6–23 months in Rutsiro district remains of high public health concern and that child HAZ is associated with both pre- and postnatal factors. The results on the relationship

between ICFI, HPI and child HAZ provided a mixed picture, making the overall conclusion regarding the role of care practices less clear cut. On one hand, the finding of a positive association between ICFI and child HAZ supports our assumption that better feeding practices are positively associated with better child HAZ in this setting. On the other hand, however, the fact that only a few components of the ICFI were significantly associated with child HAZ (findings also observed in other studies), and given the lack of a significant association between HPI and child HAZ, the findings of the present study raise questions on the usefulness of the composite indices and call for further research to validate such indices. Such research could help elucidate the strengths and weaknesses of using indices *v.* individual components. In the context of the present study, breastfeeding and child dietary diversity appear to have potential to improve child HAZ.

Acknowledgements

We are grateful to the mothers and their children involved in the study for their willingness to participate. We would like to thank the community health workers and Mr Jules Ihorere (research assistant) for their logistical support during data collection. This study was conducted as part of T. D.'s doctoral research funded by the New Zealand (NZ) Scholarships. Additional funding was obtained from Massey University. The funders had no role in the study design, analysis or writing of this article.

Authors' contributions: T. D., J. L. W., T. R., P. O. I. and L. B. designed the study. T. D. collected data, analysed the data, interpreted the results and wrote the first draft of the manuscript. L. B., J. L. W. and T. R. advised on data analysis. All authors contributed to the results' interpretation and critical revision of subsequent drafts of the manuscript. All authors approved the manuscript.

There are no conflicts of interest.

Supplementary material

For supplementary material/s referred to in this article, please visit https://doi.org/10.1017/S0007114520004961

References

1. de Onis M (2006) WHO Child Growth Standards based on length/height, weight and age. *Acta Paediatr* **95**, 76–85.
2. Development Initiatives (2018) *2018 Global Nutrition Report: Shining a Light to Spur Action on Nutrition*. Bristol: Development Initiatives.
3. United Nations Children's Fund (UNICEF), World Health Organization International Bank for Reconstruction and Development/The World Bank (2020) *Levels and trends in child malnutrition: Key Findings of the 2020 Edition of the Joint Child Malnutrition Estimates*. Geneva: World Health Organization.
4. Victora CG, Adair L, Fall C, *et al.* (2008) Maternal and child undernutrition: consequences for adult health and human capital. *Lancet* **371**, 340–357.
5. Gluckman PD, Hanson MA & Beedle AS (2007) Early life events and their consequences for later disease: a life history and evolutionary perspective. *Am J Hum Biol* **19**, 1–19.
6. World Health Organization (2014) *Global Nutrition Targets 2025: Stunting Policy Brief (WHO/NMH/NHD/14.3)*. Geneva: World Health Organization.
7. Amugsi DA, Mittelmark MB, Lartey A, *et al.* (2014) Influence of childcare practices on nutritional status of Ghanaian children: a regression analysis of the Ghana Demographic and Health Surveys. *BMJ Open* **4**, e005340.
8. Kennedy E & Haddad L (1992) Food security and nutrition, 1971–91: lessons learned and future priorities. *Food Policy* **17**, 2–6.
9. Engle PL, Bentley M & Pelto G (2007) The role of care in nutrition programmes: current research and a research agenda. *Proc Nutr Soc* **59**, 25–35.
10. Engle PL, Lhostika L & Armstrong H (1997) *The Care Initiative: Assessment, Analysis and Action to Improve Care for Nutrition*. New York: United Nations Children's Fund.
11. Kennedy E & Peters P (1992) Household food security and child nutrition: the interaction of income and gender of household head. *World Dev* **20**, 1077–1085.
12. Brown LV, Zeitlin MF, Peterson KE, *et al.* (1992) Evaluation of the impact of weaning food messages on infant feeding practices and child growth in rural Bangladesh. *Am J Clin Nutr* **56**, 994–1003.
13. Ruel MT, Levin CE, Armar-Klemesu M, *et al.* (1999) Good care practices can mitigate the negative effects of poverty and low maternal schooling on children's nutritional status: evidence from Accra. *World Dev* **27**, 1993–2009.
14. Zeitlin M (1991) Nutritional resilience in a hostile environment: positive deviance in child nutrition. *Nutr Rev* **49**, 259–268.
15. National Institute of Statistics of Rwanda (2018) Comprehensive Food Security and Vulnerability Analysis 2018. https://www.wfp.org/publications/rwanda-comprehensive-food-security-vulnerability-analysis-december-2018 (accessed July 2020).
16. de Onis M, Borghi E, Arimond M, *et al.* (2019) Prevalence thresholds for wasting, overweight and stunting in children under 5 years. *Public Health Nutr* **22**, 175–179.
17. Ministry of Health (Rwanda) & United Nations Children's Fund (UNICEF) (2014) *Knowledge, Attitudes and Practices Assessment on Early Nurturing of Children Report*. Kigali: Ministry of Health & UNICEF Rwanda.
18. Lee J, Dusingizimana T & Umutoni F (2016) Understanding consumer demand for nutritious food in Nyanza district, Rwanda. https://www.usaid.gov/sites/default/files/documents/1860/GAIN%20Summary%20Focused%20Ethnographic%20Survey%20Report.pdf (accessed June 2020).
19. Lung'aho M, Birachi E, Butare L, *et al.* (2015) *Rwanda Nutrition, Markets and Gender Analysis 2015: An Integrated Approach Towards Alleviating Malnutrition Among Vulnerable Populations in Rwanda*. Nairobi: Government of Rwanda/International Center for Tropical Agriculture (CIAT).
20. Ministry of Health (2014) *Rwanda National Food and Nutrition Policy*. Kigali: Ministry of Health, Government of Rwanda.
21. Ngirabega JD, Leonard W, Munyanshongore C, *et al.* (2010) Utilization of community based growth monitoring services by eligible children in rural Rwanda. *Rwanda Med J* **68**, 40–47.
22. Uwiringiyimana V, Ocké MC, Amer S, *et al.* (2019) Predictors of stunting with particular focus on complementary feeding practices: a cross-sectional study in the northern province of Rwanda. *Nutrition* **60**, 11–18.
23. Matsiko E (2019) Exploring linear growth retardation in Rwandan children: ecological and biological factors. PhD Thesis, Wageningen University.
24. Arimond M & Ruel MT (2001) *Assessing Care: Progress Towards the Measurement of Selected Childcare and Feeding Practices, and Implications for Programs. Discussion Paper 119*. Washington, DC: International Food Policy Research Institute.

25. Ruel MT & Menon P (2002) Child feeding practices are associated with child nutritional status in Latin America: innovative uses of the demographic and health surveys. *J Nutr* **132**, 1180–1187.
26. Condo JU, Gage A, Mock N, *et al.* (2015) Sex differences in nutritional status of HIV-exposed children in Rwanda: a longitudinal study. *Trop Med Int Health* **20**, 17–23.
27. National Institute of Statistics of Rwanda (2012) *2012 Rwanda Fourth Population and Housing Census. District Profile: Rutsiro*. Kigali: National Institute of Statistics of Rwanda.
28. Cochran WG (1977) *Sampling Techniques*, 3rd ed. Wiley Series in Probability and Mathematical Statistics. New York: John Wiley & Sons Inc.
29. National Institute of Statistics of Rwanda (NISR) (Rwanda), Ministry of Health (MOH) (Rwanda) & ICF International (2015) *Rwanda Demographic and Health Survey 2014–15*. Rockville, MD: NISR, MOH and ICF International.
30. Dimagi CommCare (2019) Dimagi CommCare home page. https://www.dimagi.com/commcare/ (accessed January 2019).
31. Cogill B (2003) *Anthropometric Indicators Measurement Guide*. Washington, DC: Food and Nutrition Technical Assistance (FANTA) Project, FHI 360.
32. Jones AD (2015) The production diversity of subsistence farms in the Bolivian Andes is associated with the quality of child feeding practices as measured by a validated summary feeding index. *Public Health Nutr* **18**, 329–342.
33. Arimond M & Ruel M (2002) *Progress in Developing an Infant and Child Feeding Index: An Example Using the Ethiopia Demographic Health Survey 2000*. Washington, DC: International Food Policy Research Institute.
34. Sawadogo PS, Martin-Prevel Y, Savy M, *et al.* (2006) An infant and child feeding index is associated with the nutritional status of 6-to 23-month-old children in rural Burkina Faso. *J Nutr* **136**, 656–663.
35. World Health Organization (2010) *Indicators for Assessing Infant and Young Child Feeding Practices: Part 2: Measurement*. Geneva: WHO.
36. Dewey KG (2003) *Guiding Principles for Complementary Feeding of the Breastfed Child*. Washington, DC: Pan American Health Organization/World Heath Organization.
37. Brown K, Dewey K & Allen L (1998) *Complementary Feeding of Young Children in Developing Countries: A Review of Current Scientific Knowledge*. Geneva: WHO.
38. Dusingizimana T, Weber JL, Ramilan T, *et al.* (2020) A qualitative analysis of infant and young child feeding practices in rural Rwanda. *Public Health Nutr* (epublication ahead of print version 2 July 2020).
39. Ballard T, Coates J, Swindale A, *et al.* (2011) *Household Hunger Scale: Indicator Definition and Measurement Guide*. Washington, DC: Food and Nutrition Technical Assistance II Project, FHI 360.
40. Vyas S & Kumaranayake L (2006) Constructing socio-economic status indices: how to use principal components analysis. *Health Policy Plan* **21**, 459–468.
41. Mosites EM, Rabinowitz PM, Thumbi SM, *et al.* (2015) The relationship between livestock ownership and child stunting in three countries in Eastern Africa using national survey data. *PLOS ONE* **10**, e0136686.
42. World Health Organization (2011) *WHO Anthro for Personal Computers, Version 3.2.2: Software for Assessing Growth and Development of the World's Children*. Geneva: World Health Organization.
43. World Health Organization (2006) *Multicentre Growth Reference Study Group. WHO Child Growth Standards: Length/Height-for-Age, Weight-for-Age, Weight-for-Length, Weight-for-Height and Body Mass Index-for-Age: Methods and Development*. Geneva: World Health Organization.
44. Textor J, Hardt J & Knüppel S (2011) DAGitty: a graphical tool for analyzing causal diagrams. *Epidemiology* **22**, 745.
45. Greenland S, Pearl J & Robins JM (1999) Causal diagrams for epidemiologic research. *Epidemiology* **10**, 37–48.
46. James G, Witten D, Hastie T, *et al.* (2013) *An Introduction to Statistical Learning*, vol. 112. New York: Springer.
47. World Health Organization & United Nations Children's Fund (2015) *Joint Monitoring Programme (JMP) for Water Supply and Sanitation*. Geneva: WHO.
48. Binagwaho A, Rukundo A, Powers S, *et al.* (2020) Trends in burden and risk factors associated with childhood stunting in Rwanda from 2000 to 2015: policy and program implications. *BMC Public Health* **20**, 83.
49. Onyango AW (2003) Dietary diversity, child nutrition and health in contemporary African communities. *Comp Biochem Physiol A Mol Integr Physiol* **136**, 61–69.
50. Qu P, Mi B, Wang D, *et al.* (2017) Association between the infant and child feeding index (ICFI) and nutritional status of 6- to 35-month-old children in rural western China. *PLOS ONE* **12**, e0171984.
51. Moursi MM, Trèche S, Martin-Prével Y, *et al.* (2008) Association of a summary index of child feeding with diet quality and growth of 6–23 months children in urban Madagascar. *Eur J Clin Nutr* **63**, 718–724.
52. Ntab B, Simondon KB, Milet J, *et al.* (2005) A young child feeding index is not associated with either height-for-age or height velocity in rural Senegalese children. *J Nutr* **135**, 457–464.
53. Onyango AW, Esrey SA & Kramer MS (1999) Continued breastfeeding and child growth in the second year of life: a prospective cohort study in western Kenya. *Lancet* **354**, 2041–2045.
54. Arimond M & Ruel MT (2004) Dietary diversity is associated with child nutritional status: evidence from 11 demographic and health surveys. *J Nutr* **134**, 2579–2585.
55. Menon P, Bamezai A, Subandoro A, *et al.* (2015) Age-Appropriate infant and young child feeding practices are associated with child nutrition in India: insights from nationally representative data. *Matern Child Nutr* **11**, 73–87.
56. Grosshagauer S, Milani P, Kraemer K, *et al.* (2020) Inadequacy of nutrients and contaminants found in porridge-type complementary foods in Rwanda. *Matern Child Nutr* **16**, e12856.
57. Matsiko F, Kanyange C, Ingabire G, *et al.* (2017) Detection and quantification of aflatoxin in cassava and maize flour sold in Kigali open markets, Rwanda. *Int Food Res J* **24**, 459–464.
58. Gong Y, Hounsa A, Egal S, *et al.* (2004) Postweaning exposure to aflatoxin results in impaired child growth: a longitudinal study in Benin, West Africa. *Environ Health Perspect* **112**, 1334–1338.
59. Liu X, Behrman JR, Stein AD, *et al.* (2017) Prenatal care and child growth and schooling in four low- and medium-income countries. *PLOS ONE* **12**, e0171299.
60. Ashworth A, Shrimpton R & Jamil K (2008) Growth monitoring and promotion: review of evidence of impact. *Matern Child Nutr* **4** 86–117.
61. Habyarimana F, Zewotir T, Ramroop S, *et al.* (2016) Spatial distribution of determinants of malnutrition of children under five years in Rwanda: simultaneous measurement of three anthropometric indices. *J Hum Ecol* **54**, 138–149.
62. Uwiringiyimana V, Veldkamp A & Amer S (2019) Stunting spatial pattern in Rwanda: an examination of the demographic, socio-economic and environmental determinants. *Geospat Health* **14**.

63. Wamani H, Åstrøm AN, Peterson S, *et al.* (2007) Boys are more stunted than girls in Sub-Saharan Africa: a meta-analysis of 16 demographic and health surveys. *BMC Pediatr* **7**, 17.
64. Young MF, Nguyen PH, Gonzalez Casanova I, *et al.* (2018) Role of maternal preconception nutrition on offspring growth and risk of stunting across the first 1000 days in Vietnam: a prospective cohort study. *PLOS ONE* **13**, e0203201.
65. Schmidt MK, Muslimatun S, West CE, *et al.* (2002) Nutritional status and linear growth of Indonesian infants in west Java are determined more by prenatal environment than by postnatal factors. *J Nutr* **132**, 2202–2207.
66. Zhang X, Cnattingius S, Platt RW, *et al.* (2007) Are babies born to short, primiparous, or thin mothers "normally" or "abnormally" small? *J Pediatr* **150**, 603–607.e603.
67. Price KC & Coe C (2000) Maternal constraint on fetal growth patterns in the rhesus monkey (*Macaca mulatta*): the intergenerational link between mothers and daughters. *Hum Reprod* **15**, 452–457.
68. Hernandez-Diaz S, Peterson K, Dixit S, *et al.* (1999) Association of maternal short stature with stunting in Mexican children: common genes vs common environment. *Eur J Clin Nutr* **53**, 938–945.
69. Jelenkovic A, Sund R & Hur YM, *et al.* (2016) Genetic and environmental influences on height from infancy to early adulthood: an individual-based pooled analysis of 45 twin cohorts. *Sci Rep* **6**, 28496.
70. Liu Q, Yu C, Gao W, *et al.* (2015) Genetic and environmental effects on weight, height, and BMI under 18 years in a Chinese population-based twin sample. *Twin Res Hum Genet* **18**, 571–580.

British Journal of Nutrition

Appendix 18: Published version of Paper III (Chapter 5)

GLOBAL HEALTH: SCIENCE AND PRACTICE
Dedicated to what works in global health programs
OPEN ACCESS

ORIGINAL ARTICLE

A Mixed-Methods Study of Factors Influencing Access to and Use of Micronutrient Powders in Rwanda

Theogene Dusingizimana,[a,b] Janet L. Weber,[a] Thiagarajah Ramilan,[c] Per Ole Iversen,[d,e,f] Louise Brough[a]

Key Findings

- In Rutsiro district, the unavailability of multiple micronutrients powder (MNP) was mentioned as a major barrier to accessing it. Factors that appeared to limit the use of MNP included perceived side effects and the perceptions that MNP is designed for undernourished children, coupled with inappropriate child feeding practices, particularly feeding thin/watery complementary foods.
- Mothers of older children (aged 12–23 months) had about 4 times higher odds of using MNP than mothers of younger children (aged 6–11 months), while mothers whose children participated in the supplementary food program had about 3 times higher odds of using MNP than mothers whose children have never participated in the program. Food insecurity, as indicated by increasing household hunger score, was significantly associated with reduced odds of using MNP.

Key Implications

MNP program implementers should:

- Ensure uninterrupted MNP supply and make MNP available to mothers while enhancing their understanding of the health benefits of MNP.
- Address gaps in complementary feeding practices by emphasizing timely introduction of diverse complementary foods of adequate consistency and supporting mothers' access to adequate complementary foods.

[a] School of Food and Advanced Technology, Massey University, Palmerston North, New Zealand.
[b] Department of Food Science and Technology, College of Agriculture, Animal Sciences and Veterinary Medicine, University of Rwanda, Musanze, Rwanda.
[c] School of Agriculture and Environment, Massey University, Palmerston North, New Zealand.
[d] Department of Nutrition, Institute of Basic Medical Sciences, University of Oslo, Oslo, Norway.
[e] Department of Hematology, Oslo University Hospital, Oslo, Norway.
[f] Division of Human Nutrition, Faculty of Medical Health Sciences, Stellebosh University, Tygerberg, South Africa.
Correspondence to Theogene Dusingizimana (T.Dusingizimana@massey.ac.nz).

Résumé en français à la fin de l'article.

ABSTRACT

The World Health Organization recommends point-of-use fortification with multiple micronutrients powder (MNP) for foods consumed by children aged 6–23 months in populations where anemia prevalence among children under 2 years or under 5 years of age is 20% or higher. In Rwanda, anemia affects 37% of children under 5 years. The MNP program was implemented to address anemia, but research on factors affecting the implementation of the MNP program is limited. We conducted a mixed-methods study to examine the factors influencing access to and use of MNP among mothers (N=379) in Rutsiro district, northwest Rwanda. Inductive content analysis was used for qualitative data. Logistic regression analysis was used to determine factors associated with the use of MNP. Qualitative results indicated that the unavailability of MNP supplies and distribution issues were major barriers to accessing MNP. Factors influencing the use of MNP included mothers' perceptions of side effects and health benefits of MNP, as well as inappropriate complementary feeding practices. Mothers of older children (aged 12–23 months) were more likely to use MNP than those of younger children (aged 6–11 months) (adjusted odds ratio [aOR]=3.63, $P<.001$). Mothers whose children participated in the supplementary food program were nearly 3 times more likely to use MNP than those whose children had never participated in the program (aOR=2.84, $P=.001$). Increasing household hunger score was significantly associated with lower odds of using MNP (aOR=0.80, $P=.038$). Mechanisms to monitor MNP supply and program implementation need to be strengthened to ensure mothers have access to the product. MNP program implementers should address gaps in complementary feeding practices and ensure mothers have access to adequate complementary foods.

INTRODUCTION

Inadequate intake of micronutrients is recognized as one of the most important contributors to the global burden of diseases.[1] An estimated 2 million children worldwide die (19% of total child deaths) each year due to insufficient intake of micronutrients, mainly iron, vitamin A, and zinc.[1] Iron deficiency is the most common micronutrient deficiency worldwide,[2] and it has numerous functional consequences on child health, including impaired physical growth and poor neurocognitive development.[3,4]

In Rwanda, the prevalence of anemia among children under 5 years of age declined significantly from 52% in 2005 to 38% in 2010,[5] but the most recent

Demographic and Health Survey (DHS) found that 37% of children under 5 years of age had anemia in 2019–2020.[6] The same survey showed that children aged 6–23 months were the most affected. For example, anemia affects 70% of children aged 6–8 months and 64% of those aged 9–11 months.[6] Although other factors, such as parasite infections, may contribute to the high rates of anemia, evidence suggests that iron deficiency, resulting from inadequate dietary iron intake and/or low bioavailability and increased needs for iron during child growth, is a major cause.[7] As in many other low- and middle-income countries, Rwandan children consume predominantly plant-based diets, which contain low bioavailable iron.[8] A recent study conducted in Rwanda found that >60% of children aged 6–23 months do not meet their requirements for iron and other minerals such as calcium and zinc due to low nutrient density for these micronutrients in complementary foods.[9] The consumption of iron-rich foods, such as animal-source foods, and commercial fortified infant foods is low among children aged 6–23 months (20% and 2%, respectively).[5] As a consequence, it's difficult for young children to meet their requirements for iron and other micronutrients during the critical development stages.[10]

The Rwandan food and nutrition policy[11] recognizes the severity of anemia among Rwandan children and has proposed several solutions, including dietary diversity promotion, food fortification, point-of-use fortification with micronutrient powders, use of biofortified crops (e.g., high-iron beans), and deworming.[11] The Rwandan government also implements a supplementary food program that aims to address undernutrition in the child's first 1,000 days of life. The program provides fortified complementary blended porridge flour (locally known as *Shisha Kibondo*) to pregnant and lactating mothers as well as young children aged 6−23 months from the most vulnerable households.[12] Moreover, in 2011, the government of Rwanda, with support from the United Nations Children's Fund (UNICEF), introduced a point-of-use fortification program using multiple micronutrients powder (MNP) as a measure to improve the nutritional quality of complementary foods consumed by children aged 6–23 months and to prevent micronutrient deficiencies among these children.[13]

The point-of-use fortification of complementary foods with iron-containing MNP is recommended when anemia prevalence among young children is 20% or more.[14] Studies conducted in many countries, including Rwanda, with high burden of anemia demonstrated efficacy of MNP in reducing the prevalence of anemia and iron deficiency among children aged 6–24 months.[15,16] While MNP interventions have been shown to be efficacious in many studies, they are often conducted in controlled trials using resources that are not usually available during a national implementation or scale-up.[17] In some settings, MNP programs have thus been ineffective due, in part, to factors that may affect actual implementation.[18,19] For example, a study in Uganda[19] found that mothers cooked foods with soda ash to reduce cooking time. The authors argued that the ash might have negatively influenced the bioavailability and absorption of micronutrients, making the MNP program ineffective. In addition, contextual factors such as beliefs, resource constraints, and so forth can have an influence on the coverage and utilization of nutrition programs targeting infants and young children.[20] A review[21] of 11 studies on coverage of nutrition programs in 5 countries, including MNP programs, reported significant variability in message coverage (i.e., whether respondents have ever heard of the product), contact coverage (i.e., whether the product has ever been fed to the child), or effective coverage (i.e., whether the product has been utilized as per the pre-established program recommended frequency and quantity) due to different real-world delivery/implementation conditions in which the programs were implemented. The review concluded that achieving impact at scale of such programs requires a better understanding of the factors affecting coverage and utilization.[21] The need for research to understand the factors influencing MNP program implementation in a variety of contexts has been recognized.[22,23]

The purpose of the present study was to examine the factors influencing access to and use of MNP among mothers in Rwanda. In the context of the current study, the MNP program is of interest because the prevalence of anemia has barely changed between 2010 and 2020 in a group of children aged 6–23 months with the highest anemia prevalence,[6,11] despite the MNP program being introduced in Rwanda in 2011, adopted by the 2013 national food and nutrition strategic action plan to address anemia in children aged 6–23 months,[11] and scaled up in all 30 districts of Rwanda in 2017.[13]

The purpose of the present study was to examine the factors influencing access to and use of MNP among mothers in Rwanda.

The point-of-use fortification of complementary foods with iron-containing MNP is recommended when anemia prevalence among young children is 20% or more.

METHODS

This study was conducted in Rutsiro district, northwest Rwanda, approximately 140 km from the capital city, Kigali. The district has the highest prevalence of child stunting (54%) among children under 5 years.[24] The majority (~98%) of the district's population is rural, and agriculture on small plots of land is the main livelihood.[25]

The main subsistence crops are maize, beans, banana plantain, cassava, and sweet and Irish potatoes. The health system in the district consists of 1 hospital and 17 health centers.[26] Each health center oversees community health workers (CHWs) who provide community-based nutrition and other health services to an average of 23,000 inhabitants living within the health center's catchment area.[27]

The services provided by CHWs include distribution of MNP, locally known as *Ongera*, to caregivers with children aged 6–23 months. In Rwanda, the Ministry of Health or UNICEF deliver MNP to district hospitals, which then distribute MNP supplies to health centers. MNP is then distributed by the health centers to CHWs, who in turn distribute MNP to caregivers during monthly child growth monitoring and promotion activities. Some nongovernmental organizations, mainly World Vision International (Rwanda) and Caritas Rwanda, support the MNP program implementation through training of CHWs and awareness activities related to child feeding. Every caregiver with a child aged 6–23 months is entitled to 30 sachets of MNP per month, which they receive free of charge. Using cooking demonstrations, CHWs also counsel caregivers on optimal complementary feeding practices, such as age-specific dietary diversity, consistency and quantity of complementary foods, and on MNP usage.[8,13]

Every caregiver with a child aged 6–23 months is entitled to 30 sachets of MNP per month, which they receive free of charge.

Study Design and Participants

This study used a cross-sectional convergent mixed-methods design,[28] combining both quantitative and qualitative data. The data used in this study were collected as part of a survey conducted between September 2018 and January 2019 to investigate the factors associated with nutritional status of children aged 6–23 months. Details on the survey sample size estimation and participants recruitment are described elsewhere.[29] Briefly, the district was first divided into 3 zones based on main roads connecting the district to its neighboring districts. In each zone, 3 health centers were purposely selected to maximize geographic distribution, for a total of 9 health centers. Within each of the selected health center's catchment area, 2 villages were randomly selected. In these villages, monthly growth monitoring lists were obtained from CHWs and used to compile a sampling frame from which participants were randomly selected. Mothers who refused to participate and those who were not found in their homes were replaced (11 mothers in total) by selecting the next name on the list. Eligibility criteria were (1) having a child aged 6–23 months; (2) child was apparently healthy (i.e., no overt signs of illness); and (3) being in the 2 lowest socioeconomic categories. Of the 400 survey participants, 21 (5%) of the children were excluded from the analysis due to premature birth (i.e., before 37 weeks of gestation) or low birthweight (i.e., less than 2.5 kg). The remaining 379 participants formed the basis of the present study.

Data Collection

Quantitative and qualitative data were collected concurrently using a survey questionnaire. The questionnaire was developed in English, translated into Kinyarwanda, and programmed into a handheld tablet (Samsung Galaxy Tab 8.0 T295, Korea). It was pretested, and data were collected through face-to-face interviews. Qualitative data were audio-recorded.

Ethics

This study was approved by the Massey University Human Ethics Committee (reference: SOA 17/67) and the Institutional Review Board of the University of Rwanda's College of Medicine and Health Sciences (reference: 003/CMHS IRB/2017). Permission to collect data was also obtained from the Rutsiro District Public Health Office. Oral informed consent was obtained from all participants.

Quantitative Data

Outcome Variable

"Ever using MNP" was the primary outcome variable. Mothers were asked if they added (yes/no) MNP to the target child's foods in the last 7 days prior to the survey. Mothers who had not used MNP were asked whether they had ever used MNP before (yes/no). A mother was categorized as "ever used MNP" if she had used MNP in the previous 7 days or before, and those who had not used MNP either within 7 days prior to the survey or before were categorized as "never used MNP."

Other Variables

Information related to participants' demographics, socioeconomic, household food security, and indicators of health system engagement were obtained through mothers' recall. Health cards were used for verification (e.g., child age and heath information). Demographic information reported by mothers included the child's age and sex and the maternal age at first birth. Mothers

also reported presence of symptoms of child diarrhea (defined as ≥3 watery or loose stools per day) and upper respiratory infections (runny nose, coughing, or wheezing) in the previous 4 weeks. Socioeconomic variables included maternal education level (coded as none/incomplete primary education, complete primary education, secondary education) and household asset ownership (e.g., radio, land, domestic animals, housing characteristics). Fourteen household assets were used to create a household wealth index using principal component analysis.[30] The first component was taken to represent the household wealth index and divided into terciles (lower, middle, and upper). A household hunger score—a proxy of a household's ability to access food—was measured using a validated cross-cultural household hunger scale (HHS).[31] Adhering to HHS measurement guide, mothers were asked 3 questions intended to capture 3 situations (i.e., lack of food of any kind in the house; going to sleep hungry because there was not enough food; and going a whole day and night without eating) reflecting a household's experience of insufficiency of food supply and intake and physical consequences. Each question was followed by the frequency-of-occurrence question (i.e., how often the reported situation was experienced). The responses were coded and used to generate a household hunger score that ranged from 0 (indicating no hunger) to 6 (indicating severe hunger). Indicators of health system engagement are (1) attendance at growth monitoring site in the previous month (coded as yes/no); (2) the number of antenatal care visits when pregnant with the study child (coded as <4 visits or ≥4 visits; a minimum of 4 visits is recommended in Rwanda[5]); and (3) whether the child ever participated in the supplementary food program (coded as yes/no).

Qualitative Data

The questionnaire included an open-ended question that was used to collect in-depth information on the reasons for not using MNP. Mothers who had not used MNP in the previous 7 days (i.e., those who used MNP but not in the previous 7 days, and those who never used MNP) were asked to provide reasons for not using MNP. Probes (either open-ended or specific to the mothers' comments) were used to obtain additional information.[32]

Data Analysis

Quantitative Data

Median (interquartile range [IQR]) values were determined for continuous data and percentages for categorical data. Bivariate and multiple logistic regression analyses were performed to examine factors associated with using MNP. The full model adjusted for the presence of diarrhea and respiratory infection in the past 4 weeks. We adjusted for these variables because our previous research in the same population showed that child illness has negative effects on how mothers feed their children, including withholding or restricting some foods from children's diets.[33] Unadjusted and adjusted odds ratios (OR) and 95% confidence intervals (CI) were computed. Variables with a P value of $<.05$ were considered significant predictors. We did not perform a Bonferroni correction because, although the correction decreases the probability for type I error, such adjustment is vulnerable to type II error and can obscure important findings.[34,35] All statistical analyses were performed using SPSS version 25.0 (IBM Corp., Armonk, NY).

A household hunger score—a proxy of a household's ability to access food—was measured using a validated cross-cultural household hunger scale.

Qualitative Data

Mothers' responses were audio-recorded, transcribed verbatim in Kinyarwanda, and translated into English. Content analysis[36] was used to analyze the data. An inductive content analysis approach, which is recommended when there is no prior research or little is known about the studied phenomenon, was used. The data analysis had 3 phases: preparation, organization, and reporting.[37] The first phase consisted of careful reading of the data several times to become immersed in and familiar with the data. In the organization phase, each transcript was read carefully by the first author, highlighting the text (words or phrases) that appeared to describe the phenomenon under study (i.e., access to and/or use of MNP). The highlighted texts were openly and manually coded by giving each text a descriptive code. The second author read the data to confirm the descriptive codes. These codes were revised, and the codes that emerged from the revision were jointly reviewed before integrating them into the analysis. Final codes were examined, compared, and grouped into categories that represented similar meaning.[38] The first, second, and last authors reviewed, discussed, and agreed on the final code categories. In the final phase of analysis, SPSS (version 25) was used to quantify the frequency of major categories and subcategories.[39] To interpret and report the findings, examples of original textual responses representing specific code or category are presented.

RESULTS

Quantitative Results

Characteristics of the participants (N=379) are presented in Table 1. The median (IQR) age of children was 15 (11–19) months, whereas the median (IQR) age of mothers at first birth was 22 (20–24) years. More than a half (59%) of the mothers had either no education or did not complete primary education, and only 35% of the mothers had ≥4 antenatal care visits during their last pregnancy. The median (IQR) household size was 4 (3–6) members.

The majority of the mothers (64%) reported ever adding MNP to their children's food, but only 38% used it in the previous 7 days.

The majority of the mothers (64%) reported ever adding MNP to their children's food, but only 38% added it to their children's food in the previous 7 days (Table 2). The proportion of mothers using MNP to feed their children was significantly lower among mothers with children aged 6–11 months than among those with children aged 12–23 months (39% vs. 76%, $P<.001$) (results not shown).

Table 3 shows that mothers of older children (aged 12–23 months) had about 4 times higher odds of using MNP than those of younger children (aged 6–11 months) (aOR=3.63, $P<.001$). Similarly, mothers whose children ever participated in the supplementary food program had about 3 times higher odds of using MNP than the mothers whose children have never participated in the program (aOR=2.84, $P<.001$). Conversely, as the household hunger score increases by 1 unit, the odds of using MNP decreased significantly by about 20% (aOR=0.80, $P=.038$). Even though attendance to growth monitoring in the last month was a significant predictor of the use of MNP, this variable was not significant in the adjusted model (the multivariable model adjusted for the presence of diarrhea and respiratory infections in the past 4 weeks).

Qualitative Results

Some mothers reported that they stopped using MNP to feed their children because it caused side effects or made food unpalatable.

Factors influencing access to and use of MNP are summarized into 9 categories. Below we present results for 6 major categories. A summary of these 6 categories, as well as other 3 minor categories are presented in a Supplement.

Limited Availability of MNP Supplies

A frequently reported barrier to accessing MNP was the lack of supplies.

A frequently reported barrier to accessing MNP was the lack of supplies. Many mothers (n=72) reported getting information from CHWs that there was no MNP stock at their health centers. For example, one mother said:

> *I don't have Ongera (MNP) now. We get it from health workers but this month they said they don't have Ongera in the stock at the health center. They told us to come on 13th of November when we take children for growth monitoring.*

CHWs–Mother Interactions

Most mothers reported receiving MNP from CHWs through monthly growth monitoring activities while others reported occasionally receiving MNP from health centers (e.g., when mothers took children there for immunization). However, information received from CHWs in the study area indicated that, if mothers ran out of MNP prior to the next distribution date, the mothers were encouraged to contact CHWs and acquire more MNP sachets, if available. However, some mothers (n=33) said that they preferred to wait for routine distribution of MNP, which they felt was the responsibility of CHWs:

> *I don't have Ongera [MNP]. We used all the sachets that we had received at the village kitchen. I am waiting for our CHW to distribute Ongera. I don't go to her house to ask for Ongera because they [CHWs] are supposed to distribute. Many times, we were told: wait, wait. So, I prefer to wait, and if I don't have Ongera, it's their fault.*

The narratives also suggested that interactions between mothers and CHWs may be limited, by nonattendance to growth monitoring sites due to competing obligations (n=6), such as the need to work for income to meet family needs. One mother said:

> *I received Ongera once; we used them up all. It's been a while without attending growth monitoring session. Most of the days for growth monitoring are days that I am working. Working is most important. It's how we get money to survive.*

Limited Information

Some mothers (n=16) explicitly said that they did not know about MNP. A few mothers reported having heard about but not seen MNP (n=4); others mentioned that they were unaware of the distribution schedules or eligibility criteria (n=6). One mother said:

> *I have never received Ongera. I think there are some children who are eligible . . . may be those that can feed themselves . . ., and others who are not eligible.*

Perceived Side Effects

Some mothers (n=19) reported that they stopped using MNP to feed their children because of side

effects experienced by their children after consumption of MNP. Diarrhea was the most frequently reported side effect experienced, while other side effects included vomiting and fever. While most mothers who reported side effects spoke from their own children's experiences, a few mothers decided not to use MNP because of the comments by other mothers in their community about the negative side effects of MNP:

> *I received Ongera this month when he just turned 9 months. I fed him Ongera, like 3 times, and then he started having diarrhea. So, I stopped adding it to his foods.*

> *I received 30 sachets of Ongera last month. I just kept them. I heard from other mothers that Ongera causes diarrhea, so I never fed it to my child.*

Several mothers (n=20) also linked MNP with changes in taste of food, stating that their children disliked foods that were prepared with MNP. One mother said:

> *We have used all the sachets [of Ongera] that we received this month. But even when it was still available, he did not really like the foods when it was mixed with Ongera. I used to give him and skipped some days.*

Incompatibility Between MNP Program Recommendations and Current Child-Feeding Practices

Several mothers (n=33), especially those with younger children (aged 6–8 months), reported never using MNP due to reasons related to feeding practices. For example, many of these mothers (n=27) said that their "child had just started eating" complementary foods or that the "child was still adapting to complementary foods." Others (n=6) mentioned that they had not yet introduced complementary foods to the child:

> *I obtained Ongera a week ago, but I have not yet started giving it to my child. She is not yet ready for all foods. She is only 7 months. We give her things like a spoon of porridge or soft Irish potatoes. I mash them with my fingers. We don't add Ongera in the porridge. We add sugar, not Ongera.*

MNP Was Perceived as Intended for Malnourished Children

Some mothers (n=11) perceived that MNP is intended for malnourished children, and children who appeared healthy did not require MNP. When asked to justify their judgment regarding the healthiness of their children, the mothers explained that their child was visually not sick or did not show any signs of malnutrition. Physical appearance, weight loss, and hair discoloration were the most common signs used to describe healthiness of the children:

> *I know I can get Ongera from our village health worker. I don't have them now because I never asked. These [Ongera] are intended for malnourished children. My child has no health issues. He is healthy.*

Some mothers perceived that MNP is intended for malnourished children, and children who appeared healthy did not require MNP.

TABLE 1. Sociodemographic and Nutritional Characteristics of Participants (N=379) in a Study on Access to and Use of MNP in Rutsiro District, Rwanda, September 2018–January 2019

Characteristic	
Child age, months, median (IQR)	15 (11–19)
Child age group, No. (%)	
6–11 months	120 (32)
12–23 months	259 (68)
Sex, No. (%)	
Male	184 (49)
Female	195 (51)
Child had diarrhea (past 4 weeks), No. (%)	179 (47)
Child had respiratory infection (past 4 weeks), No. (%)	297 (78)
Child ever participated in the supplementary food program, No. (%)	283 (75)
Mother's age at first birth, years, median (IQR)	22 (20–24)
Mother's education level,[a] No. (%)	
Illiterate/incomplete primary	219 (59)
Completed primary	88 (24)
Some secondary	62 (17)
No. of antenatal care visits attended, No. (%)	
1–3	248 (65)
≥4	131 (35)
Mother attended child growth monitoring site (past month), No. (%)	318 (84)
Household hunger score, median, (IQR)	1 (1–2)
Household size, median (IQR)	4 (3–6)
Wealth index terciles, No. (%)	
Lower	126 (33)
Middle	126 (33)
Upper	127 (34)

Abbreviations: IQR, interquartile range; MNP, multiple micronutrients powder.
[a] Owing to missing data, n=369.

TABLE 2. Proportion of Mothers Who Used/Did Not Use MNP to Feed Their Children (N=379), by Age Group, in Rutsiro District, Rwanda, September 2018–January 2019

Age Group, Months	No.	Used MNP in the Past 7 Days, No. (%)	Used MNP but Not in the Past 7 Days, No. (%)	Ever Used MNP,[a] No. (%)	Never Used MNP, No. (%)
6–8	57	10 (17)	2 (4)	12 (21)	45 (79)
9–11	63	22 (35)	13 (21)	35 (56)	28 (44)
12–23	259	113 (44)	83 (32)	196 (76)	63 (24)
Total	379	145 (38)	98 (26)	243 (64)	136 (36)

Abbreviation: MNP, multiple micronutrients powder.
[a] Sum of "used MNP in the past 7 days" and "used MNP but not in the past 7 days."

I don't have Ongera [MNP]. I have never fed him Ongera. Ongera are given to children who have bwaki (local term used to denote acute malnutrition). You don't know bwaki? It is when your child has golden hair and swollen tummy.

DISCUSSION

Limited information is available on the factors influencing access to and use of MNP in Rwanda. In the present study, we found that the proportion of mothers who added MNP to their children's foods in the previous 7 days was low (38%), especially those with younger children aged 6–11 months. This proportion increased to 64% when considering all mothers who reported ever having added MNP to their children's foods. In a small-scale survey of 186 caregivers recruited from 19 of Rwanda's 30 districts that implemented MNP program (n=10 caregivers in each district), McLean et al.[13] reported 87% coverage (defined as the proportion of caregivers receiving a box of MNP in the previous 3 months). It is worth mentioning that our study found that some mothers who received MNP still did not feed it to their children, so while receiving MNP is sometimes used as an indicator of program coverage, whether the child is consuming MNP according to the program recommended quantity and frequency, and not simply receiving it, may be a better indicator of program success.[21] No consensus exists on a cutoff value for satisfactory MNP program coverage; however, one suggestion is that effective MNP program performance should be appraised as satisfactory when >70% of target children are found (at the time of study) to be consuming MNP.[40] Although estimating actual coverage was beyond the scope of this study, our results suggest that the MNP program coverage in Rutsiro district is generally low. Further research to assess MNP coverage in Rwanda using appropriate frameworks is recommended. For example, Tanahashi's framework[41] has been widely used to assess health service or intervention coverage and to identify implementation bottlenecks. This framework defines different stages of coverage, including availability, accessibility, acceptability, contact, and effectiveness. Availability coverage refers to the availability of resources (e.g., drugs, health workers, health facilities) that determine the extent to which an intervention can be made available to the target population. Accessibility coverage is the proportion of the target population for whom an intervention is accessible. Acceptability coverage is the number of people who are willing to use an accessible intervention (they must find it acceptable in terms of, for example, cost, waiting time, beliefs). Contact coverage is the number of people who have been in contact with an intervention and have used it. Effectiveness coverage is the proportion of the target population in need of an intervention that receives an effective intervention.[41]

Limited availability of MNP supplies has been identified in this study, as well as others, as a major constraint to access to MNP.

In this study, a majority of mothers mentioned lack of MNP supplies as the major issue limiting their access to MNP. Limited availability of MNP supplies has been identified in this study, as in others, as a major constraint to access to MNP in many countries.[42,43] In Rwanda, lack of supplies and inadequate distribution of MNP were also reported as key obstacles limiting MNP program coverage.[13] These findings highlight the need to ensure uninterrupted MNP supply to increase coverage of the MNP program. However, even when MNP is available, there are factors related to MNP distribution arrangements that need to be considered. For example, while mothers were encouraged to pick up MNP sachets from their village CHWs, our data indicated that the mothers' expectation was to obtain MNP through routine

TABLE 3. Factors Associated With the Use of MNP in Rutsiro District, Rwanda, September 2018–January 2019[a]

Variables	COR (95% CI)	*P*-Value	aOR (95% CI)	*P*-Value
Child age group		<.001		<.001
6–11 months	1		1	
12–23 months	4.83 (3.04, 7.68)		3.63 (2.14, 6.16)	
Child sex		.52		.53
Female	1		1	
Male	0.87 (0.57, 1.33)		0.86 (0.53, 1.39)	
Maternal age at first birth	1.03 (0.96, 1.09)	.41	1.01 (0.94, 1.09)	.82
Maternal education level		.32		.44
None/incomplete primary education	1		1	
Complete primary education	1.12 (0.67, 1.88)		1.01 (0.56, 1.83)	
Some secondary education	1.62 (.87–3.01)		1.57 (0.77, 3.19)	
ANC visits		.82		.60
<4 visits	1		1	
≥4 visits	0.95 (0.61, 1.47)		0.87 (0.53, 1.45)	
Mother attended GM (past month)		.01		.43
No	1		1	
Yes	2.10 (1.21, 3.45)		1.31 (0.68, 2.53)	
Child ever participated in the supplementary food program		<.001		.001
No	1		1	
Yes	4.54 (2.78, 7.41)		2.84 (1.57, 5.13)	
Household hunger score	0.89 (0.76, 1.05)	.18	0.80 (0.65, 0.99)	.038
Household wealth index		.77		.26
Lowest tertile	1		1	
Middle tertile	1.20 (0.71, 2.00)		0.83 (0.45, 1.56)	
Upper tertile	1.01 (0.61, 1.69)		0.59 (0.31, 1.13)	

Abbreviations: ANC, antenatal care; aOR, adjusted odds ratio; CI, confidence interval; COR, crude odds ratio; GM, growth monitoring; MNP, multiple micronutrients powder.
[a] The multivariable model was adjusted for the presence of child diarrhea and respiratory infection in the previous 4 weeks.

distribution; however, some narratives suggested there may be opportunity costs associated with attending the distribution sites. This finding implies that the health system must ensure that mothers obtain MNP at no extra time cost. Also, instead of a monthly MNP supply, it may be useful to provide mothers with quantities that are sufficient for several months. If the aim is for mothers to actively seek out MNP, it is essential that they understand its health benefits.

Consistent with other studies,[17,42,44,45] qualitative results from the present study showed that perceived side effects (e.g., diarrhea, vomiting) and change in taste of foods mixed with MNP were among barriers to using MNP. It has been suggested that possible changes to foods due to addition of MNP and the potential negative side effects of MNP should be acknowledged and clearly communicated to caregivers before children start getting MNP.[23] Moreover, our results revealed that some mothers hold the belief that MNP is mainly for undernourished children. According to these mothers, giving MNP to their (perceived) healthy children was unnecessary. It is important to highlight that micronutrient deficiencies (also known as hidden hunger) such as

The belief among mothers that children do not need MNP because they lack overt symptoms of ill health or undernutrition requires further attention.

anemia often have no visible or immediate signs and can coexist with other forms of undernutrition such as stunting, which is also not easily recognized.[46,47] Therefore, the belief among mothers that children do not need MNP because they lack overt symptoms of ill health or undernutrition requires further attention because it presents important challenges for mothers, health professionals, as well as for MNP program implementers. On one hand, such beliefs may undermine the demand for and use of MNP among mothers. On the other hand, the beliefs may make it difficult for the health professionals and MNP program implementers to raise awareness among mothers about MNP. Research shows that belief is a key determinant of maternal health care seeking behavior.[48] For example, a study conducted in Kenya found that parents who considered MNP as a drug were reluctant to use it in the absence of explicit child illness.[49] These findings point to the need for appropriate health messages to ensure mothers understand the health benefits and need for MNP intervention. More specifically, clear and straightforward messages such as "children can still suffer from micronutrient deficiencies even when they are visually healthy" must be used. However, simple words that are adapted to the setting and mothers' level of education should be used to describe micronutrient deficiencies for a better understanding. It has been suggested that, unless there is some perceived need, individuals may not use an intervention, even if it is free.[50]

Our findings also showed that access to food is a predictor of using MNP.

MNP programs are designed such that children should start receiving MNP as soon as they are aged 6 months old. In the current study, we found that mothers of younger children were less likely to use MNP than mothers of older children. Similar findings have been reported in Nepal,[51] where MNP program coverage was lower among younger children (aged 6–11 months) than among older children (aged ≥12 months). In Mongolia, it was also reported that parents delayed feeding MNP to their children until an average age of 13 months.[52] The authors of these 2 studies did not elucidate the factors responsible for the delay in feeding MNP to young children. Qualitative results from the present study suggested that the delay in receiving MNP by younger children was due, in part, to the current complementary feeding practices. For example, our data indicated that half of the mothers with children aged 6–8 months reported that they had never used MNP, either because their child "was still adapting to complementary foods" or because the child "had not been introduced to complementary foods." Previous studies conducted in Rwanda showed that children were introduced to complementary foods later than recommended (i.e., aged 8 months),[13] and that dilute cereal porridges were the main food given to young children who were aged 2–8 months.[53] A recent study[33] conducted in the same population also found that thin porridges and stews/soups were the most common foods given to young children, and that the consistency of these foods hindered the use of MNP. In addition, MNP must be mixed with thick solid or semisolid complementary foods because it dissolves in liquids, which may change the taste or color of the foods, leading to less acceptance by children.[54] However, the recommendation to mix MNP with thick/solid or semisolid foods that are introduced to children at a later stage is likely to delay the introduction of MNP to younger children. Therefore, rather than discouraging mothers from using MNP with porridges or other soft foods, an alternative approach is to teach mothers how to improve the consistency of these foods by using local ingredients such as ground nut or bean flours. Once an improved porridge/stew is accepted and feasibility to use it as a vehicle for MNP explored, it could facilitate the mothers feeding MNP to children using a culturally accepted and age-appropriate food vehicle. A similar approach has been found to be successful in Mali.[55]

Our findings also showed that access to food is a predictor of using MNP. We found that the odds of using MNP reduced significantly with increasing household hunger score. Although not necessarily a direct cause, this may be a marker of other factors related to poverty that may play a causal role in access or use of MNP. Another study in Niger found that mothers were unable to give MNP to their children simply because they lacked foods to mix with MNP.[56] Results from the present study also showed that being a beneficiary of the supplementary food program (*Shisha Kibondo*) was associated with higher odds of using MNP. However, it is worth noting that the supplementary food program distributes a fortified cereal-based flour used to prepare porridge, which is not recommended for mixing with MNP. Thus, the influence of the supplementary food program on the use of MNP needs further exploration. Nevertheless, Rutsiro remains the most food insecure district in Rwanda, with 62% of households consuming an inadequate diet in 2018.[24] In the context of such a widespread food insecurity, mothers' ability to appropriately use MNP may be limited. Therefore, addressing anemia through the MNP program will require, in addition to ensuring availability of and appropriate use of MNP,

improvements in the household access to adequate foods.

Strengths and Limitations

The strength of the current study is the integration of both quantitative and qualitative approaches. Limitations of this study include a cross-sectional design, which only demonstrates association and not causal relationships. Another important limitation is that the study looked at a program performance in terms of ever-use and use within the past 7 days. In addition, the study focused on 1 district, and the sample was drawn from purposefully selected health centers. Thus, the findings may not be generalizable to the studied district or to other districts. Moreover, our qualitative findings are based on mothers' perspectives, but it would be important to understand the perspectives of other key informants such as CHWs and health center managers on how to improve uptake and use of MNP. This line of investigation could potentially provide additional insights into other context-specific factors that may also inform the MNP program implementation.

CONCLUSIONS

Findings from the current study point to several issues that need to be addressed to improve the MNP program implementation in Rwanda. The findings suggest the need for more robust supply-chain management to gauge the continuity of MNP supply and availability at the community level. However, even if MNP supply issues are addressed, it remains crucial to address gaps in complementary feeding practices, including inappropriate consistency of complementary foods and maternal perceptions about young children's developmental ability to consume a variety of foods, while enhancing mothers' access to foods. In order to increase the demand and use of MNP, the program implementers must also ensure that mothers have a clear understanding of the health benefits of MNP. Lastly, future research should examine the effect of other factors, including the quality of information and the frequency of interactions between CHWs and mothers on MNP program implementation.

Acknowledgments: The authors would also like to thank the study participants for sharing their experiences and the community health workers, as well as the research assistant, Mr. Jules Ihorere, for their assistance to the first author during the data collection.

Funding: This research was conducted as part of TD's doctoral research supported by the New Zealand Scholarships and Massey University, New Zealand.

Disclaimer: Content is solely the responsibility of the authors and does not represent the official views of the New Zealand Scholarships or Massey University.

Author contributions: TD, JLW, TR, POI, and LB designed the study. TD collected and analyzed and wrote the original draft. TD, LB, JLW, and TR contributed to data analysis. All authors critically reviewed, edited subsequent drafts of the manuscript, and interpreted the findings. All authors have read and approved the manuscript.

Competing interests: None declared.

REFERENCES

1. Black R. Micronutrient deficiency—an underlying cause of morbidity and mortality. *Bull World Health Organ.* 2003;81(2):79. Medline
2. World Health Organization (WHO). Nutrition topics: micronutrient deficiencies. WHO; 2021. Accessed March 17, 2021. https://apps.who.int/nutrition/topics/ida/en/
3. Lozoff B. Iron deficiency and child development. *Food Nutr Bull.* 2007;28(4_suppl4):S560–S571. CrossRef.
4. Soliman AT, Al Dabbagh MM, Habboub AH, Adel A, Humaidy NA, Abushahin A. Linear growth in children with iron deficiency anemia before and after treatment. *J Trop Pediatr.* 2009;55(5):324–327. CrossRef. Medline
5. National Institute of Statistics of Rwanda (NISR) [Rwanda], Ministry of Health (MOH) [Rwanda], ICF International. *Rwanda Demographic and Health Survey 2014–15.* NISR, MOH, and ICF International; 2015. Accessed March 10, 2021. https://dhsprogram.com/pubs/pdf/FR316/FR316.pdf
6. National Institute of Statistics of Rwanda (NISR) [Rwanda], Ministry of Health (MOH) [Rwanda], ICF International. *Rwanda Demographic and Health Survey 2019–20 Key Indicators Report.* NISR and ICF; 2020. Accessed March 10, 2021. https://dhsprogram.com/pubs/pdf/PR124/PR124.pdf
7. Ahmed F. Anaemia in Bangladesh: a review of prevalence and aetiology. *Public Health Nutr.* 2000;3(4):385–393. CrossRef. Medline
8. United Nations Children's Fund (UNICEF). *Nourishing a New Generation in Rwanda: Scaling-up the Point-of-Use Fortification Programme Nationwide.* UNICEF; 2019. Accessed March 10, 2021. https://www.unicef.org/media/94076/file/Field-Report-Nutrition-Rwanda-Final.pdf
9. Umugwaneza M. *The Development of Food Based Dietary Guidelines (FBDGs) for 6 to 23 Month Old Rwandan Children.* Thesis. North-West University; 2017. Accessed March 10, 2021. https://repository.nwu.ac.za/bitstream/handle/10394/26417/Umugwaneza_M_2017.pdf
10. Dewey KG. The challenge of meeting nutrient needs of infants and young children during the period of complementary feeding: an evolutionary perspective. *J Nutr.* 2013;143(12):2050–2054. CrossRef. Medline
11. Ministry of Health (MOH) [Rwanda]. *National Food and Nutrition Strategic Plan 2013–2018.* MOH; 2013. Accessed March 10, 2021. http://extwprlegs1.fao.org/docs/pdf/rwa151339.pdf
12. Iruhiriye E, Olney DK, Ramani GV, Heckert J, Niyongira E, Frongillo EA. *Stories of Change—Rwanda: Final Report.* International Food Policy Research Institute; 2019. Accessed March 10, 2021. https://www.ifpri.org/publication/stories-change-rwanda-final-report
13. McLean J, Northrup-Lyons M, Reid RJ, et al. From evidence to national scale: an implementation framework for micronutrient powders in Rwanda. *Matern Child Nutr.* 2019;15(3):e12752. CrossRef. Medline
14. World Health Organization (WHO). *WHO Guideline: Use of Multiple Micronutrient Powders for Point-of-Use Fortification of Foods*

Consumed by Infants and Young Children Aged 6–23 Months and Children Aged 2–12 Years. WHO; 2016. Accessed March 10, 2021. https://www.who.int/publications/i/item/9789241549943

15. De-Regil LM, Suchdev PS, Vist GE, Walleser S, Peña-Rosas JP. Home fortification of foods with multiple micronutrient powders for health and nutrition in children under two years of age (Review). *Evid Based Child Health*. 2013;8(1):112–201. CrossRef. Medline
16. Michaux K. *Assessing the Impacts of Home Fortification With Micronutrient Powders on Anemia, Growth, and Diarrhoea in Children Aged 6–24 Months Living in Rural Rwanda*. [master's thesis]. University of British Columbia; 2015. Accessed March 10, 2021. https://open.library.ubc.ca/cIRcle/collections/ubctheses/24/items/1.0166217
17. Locks LM, Dahal P, Pokharel R, et al. Predictors of micronutrient powder (MNP) knowledge, coverage, and consumption during the scale-up of an integrated infant and young child feeding (IYCF-MNP) programme in Nepal. *Matern Child Nutr*. 2019;15(S5):e12712. CrossRef. Medline
18. Andrew A, Attanasio O, Fitzsimons E, Rubio-Codina M. Why is multiple micronutrient powder ineffective at reducing anaemia among 12–24 month olds in Colombia? Evidence from a randomised controlled trial. *SSM Popul Health*. 2016;2:95–104. CrossRef. Medline
19. Ford ND, Ruth LJ, Ngalombi S, et al. An integrated infant and young child feeding and micronutrient powder intervention does not affect anemia, iron status, or vitamin A status among children aged 12–23 months in eastern Uganda. *J Nutr*. 2020;150(4):938–944. CrossRef. Medline
20. Menon P, Covic NM, Harrigan PB, et al. Strengthening implementation and utilization of nutrition interventions through research: a framework and research agenda. *Ann N Y Acad Sci*. 2014;1332(1):39–59. CrossRef. Medline
21. Leyvraz M, Aaron GJ, Poonawala A, et al. Coverage of nutrition interventions intended for infants and young children varies greatly across programs: results from coverage surveys in 5 countries. *J Nutr*. 2017;147(5):995S–1003S. CrossRef. Medline
22. de Pee S, Kraemer K, van den Briel T, et al.; World Food Programme; Sprinkles Global Health Initiative. Quality criteria for micronutrient powder products: report of a meeting organized by the World Food Programme and Sprinkles Global Health Initiative. *Food Nutr Bull*. 2008;29(3):232–241. CrossRef. Medline
23. Pelletier D, DePee S. Micronutrient powder programs: new findings and future directions for implementation science. *Matern Child Nutr*. 2019;15(S5):e12802. CrossRef. Medline
24. National Institute of Statistics of Rwanda (NISR). *Comprehensive Food Security and Vulnerability Analysis 2018*. NISR; 2018. Accessed March 10, 2021. https://microdata.statistics.gov.rw/index.php/catalog/91
25. National Institute of Statistics of Rwanda (NISR) [Rwanda], Ministry of Health (MOH) [Rwanda], ICF International. *Rwanda Demographic and Health Survey 2010*. NISR, MOH, and ICF International; 2012. Accessed March 10, 2021. https://dhsprogram.com/publications/publication-fr259-dhs-final-reports.cfm
26. Rutsiro District [Government of Rwanda]. *District Development Plan*. Rutsiro District; 2018. Accessed March 10, 2021. http://www.rutsiro.gov.rw/fileadmin/templates/document/Rutsiro_DDP_2013-2018.pdf
27. World Health Organization (WHO). *Primary Health Care Systems (PRIMASYS): Case Study From Rwanda*. WHO; 2017. Accessed March 10, 2021. https://www.who.int/alliance-hpsr/projects/primasys/en/
28. Fetters MD, Curry LA, Creswell JW. Achieving integration in mixed methods designs-principles and practices. *Health Serv Res*. 2013;48(6pt2):2134–2156. CrossRef. Medline
29. Dusingizimana T, Weber JL, Ramilan T, Iversen PO, Brough L. An empirical study of factors associated with height-for-age z -scores of children aged 6—23 months in northwest Rwanda: the role of care practices related to child feeding and health. *Br J Nutr*. 2020;1–12. CrossRef. Medline
30. Vyas S, Kumaranayake L. Constructing socio-economic status indices: how to use principal components analysis. *Health Policy Plan*. 2006;21(6):459–468. CrossRef. Medline
31. Ballard T, Coates J, Swindale A, Deitchler M. *Household Hunger Scale: Indicator Definition and Measurement Guide. Food and Nutrition Technical Assistance II Project*, FHI 360; 2011. Accessed March 10, 2021. https://www.fantaproject.org/sites/default/files/resources/HHS-Indicator-Guide-Aug2011.pdf
32. Hsieh HF, Shannon SE. Three approaches to qualitative content analysis. *Qual Health Res*. 2005;15(9):1277–1288. CrossRef. Medline
33. Dusingizimana T, Weber JL, Ramilan T, Iversen PO, Brough L. A qualitative analysis of infant and young child feeding practices in rural Rwanda. Public Health Nutr. 2020;1–10. CrossRef. Medline
34. Perneger TV. What's wrong with Bonferroni adjustments. *BMJ*. 1998;316(7139):1236–1238. CrossRef. Medline
35. Armstrong RA. When to use the Bonferroni correction. *Ophthalmic Physiol Opt*. 2014;34(5):502–508. CrossRef. Medline
36. Krippendorff K. *Content Analysis: An Introduction to its Methodology*. 3rd ed. Sage Publications, Inc; 2004.
37. Elo S, Kyngäs H. The qualitative content analysis process. *J Adv Nurs*. 2008;62(1):107–115. CrossRef. Medline
38. Patton MQ. *Qualitative Research and Evaluation Methods*. 3rd ed. Sage Publications, Inc; 2002.
39. Leech NL, Onwuegbuzie AJ. An array of qualitative data analysis tools: A call for data analysis triangulation. *Sch Psychol Q*. 2007;22(4):557–584. CrossRef
40. Reerink I, Namaste SM, Poonawala A, et al. Experiences and lessons learned for delivery of micronutrient powders interventions. *Matern Child Nutr*. 2017;13 Suppl 1(Suppl 1):e12495. CrossRef
41. Tanahashi T. Health service coverage and its evaluation. *Bull World Health Organ*. 1978;56(2):295–303. Medline
42. Tumilowicz A, Habicht JP, Mbuya MNN, et al. Bottlenecks and predictors of coverage and adherence outcomes for a micronutrient powder program in Ethiopia. *Matern Child Nutr*. 2019;15(S5):e12807. CrossRef. Medline
43. Mehta R, Martorell R, Chaudhuri I, et al. Use of monitoring data to improve implementation of a home fortification program in Bihar, India. *Matern Child Nutr*. 2019;15(3):e12753–e12753. CrossRef. Medline
44. Jefferds MED, Ogange L, Owuor M, et al. Formative research exploring acceptability, utilization, and promotion in order to develop a micronutrient powder (Sprinkles) intervention among Luo families in western Kenya. *Food Nutr Bull*. 2010;31(2 Suppl):S179–S185. CrossRef
45. de Barros SF, Cardoso MA. Adherence to and acceptability of home fortification with vitamins and minerals in children aged 6 to 23 months: a systematic review. *BMC Public Health*. 2016;16(1):299. CrossRef. Medline
46. Mohammed SH, Larijani B, Esmaillzadeh A. Concurrent anemia and stunting in young children: prevalence, dietary and non-dietary associated factors. *Nutr J*. 2019;18(1):10. CrossRef. Medline
47. de Onis M, Branca F. Childhood stunting: a global perspective. *Matern Child Nutr*. 2016;12(Suppl 1):12–26. CrossRef
48. Hill Z, Kendall C, Arthur P, Kirkwood B, Adjei E. Recognizing childhood illnesses and their traditional explanations: exploring options for care-seeking interventions in the context of the IMCI strategy in

rural Ghana. *Trop Med Int Health.* 2003;8(7):668–676. CrossRef. Medline

49. Kodish S, Rah JH, Kraemer K, de Pee S, Gittelsohn J. Understanding low usage of micronutrient powder in the Kakuma Refugee Camp, Kenya: findings from a qualitative study. *Food Nutr Bull.* 2011;32(3): 292–303. CrossRef. Medline
50. Shengelia B, Tandon A, Adams OB, Murray CJL. Access, utilization, quality, and effective coverage: an integrated conceptual framework and measurement strategy. *Soc Sci Med.* 2005;61(1):97–109. CrossRef. Medline
51. Jefferds MED, Mirkovic KR, Subedi GR, Mebrahtu S, Dahal P, Perrine CG. Predictors of micronutrient powder sachet coverage in Nepal. *Matern Child Nutr.* 2015;11(Suppl 4):77–89. CrossRef. Medline
52. World Vision Mongolia. *Effectiveness of Home-Based Fortification of Complementary Foods With Sprinkles in an Integrated Nutrition Program to Address Rickets and Anemia.* World Vision Mongolia; 2005. Accessed March 10, 2021. https://www.wvi.org/sites/default/files/Mongolia-Sprinkles-Evaluation-Report-2005.pdf
53. Michaux K, Anema A, Green T, et al. Home fortification with micronutrient powders: lessons learned from formative research across six countries. *Sight and Life.* 2014;28:26–32.
54. Siekmans K, Bégin F, Situma R, Kupka R. The potential role of micronutrient powders to improve complementary feeding practices. *Matern Child Nutr.* 2017;13(Suppl 2):e12464. CrossRef. Medline
55. Roschnik N, Diarra H, Dicko Y, et al. Adherence and acceptability of community-based distribution of micronutrient powders in Southern Mali. *Matern Child Nutr.* 2019;15(S5):e12831. CrossRef. Medline
56. Tripp K, Perrine CG, de Campos P, et al. Formative research for the development of a market-based home fortification programme for young children in Niger. *Matern Child Nutr.* 2011;7(Suppl 3):82–95. CrossRef. Medline

En français

Une étude par méthodes mixtes des facteurs qui influencent l'accès et l'utilisation des poudres de micronutriments au Rwanda.

MESSAGE CLÉ: Les lacunes dans les pratiques d'alimentation complémentaire entravent l'utilisation des poudres de micronutriments multiples (PMN) dans le district de Rutsiro au Rwanda. La réussite de la mise en œuvre du programme de PMN nécessite une disponibilité et une accessibilité ininterrompues du produit, ainsi qu'une meilleure compréhension des avantages du PMN pour la santé.

RÉSUMÉN

L'Organisation Mondiale de la Santé recommande l'enrichissement de l'alimentation à domicile (enrichissement sur le point d'utilisation) à l'aide des poudres de micronutriments multiples (PMN) pour les aliments consommés par les enfants âgés de 6 à 23 mois dans les populations où la prévalence de l'anémie chez les enfants de moins de 2 ans ou 5 ans est de 20% ou plus. Au Rwanda, l'anémie touche 37% des enfants de moins de 5 ans et le programme de PMN a été mis en œuvre pour lutter contre l'anémie. Cependant, la recherche sur les facteurs qui affectent la mise en œuvre du programme de PMN est limitée. Nous avons mené une étude par méthodes mixtes pour examiner les facteurs qui influencent l'accès des mères (n=379) à la PMN et son utilisation dans le district de Rutsiro, au nord-ouest du Rwanda. L'analyse du contenu inductif a été utilisée pour les données qualitatives. Pour déterminer les facteurs associés à l'utilisation des PMN, une régression logistique a été utilisée. Les résultats qualitatifs ont indiqué que l'indisponibilité des approvisionnements en PMN et les problèmes de distribution constituaient des obstacles majeurs à l'accès à la PMN. Les facteurs qui influencent l'utilisation des PMN comprenaient les perceptions, chez les mères, des effets secondaires et des avantages des PMN pour la santé, ainsi que des pratiques d'alimentation complémentaire inappropriées. Les mères d'enfants plus âgés (12 à 23 mois) étaient plus susceptibles d'utiliser la PMN que celles d'enfants plus jeunes (6 à 11 mois) (odds ratio ajusté [ORA]=3,63, $P<0,001$). Les mères des enfants qui avaient participé au programme d'alimentation complémentaire étaient près de 3 fois plus susceptibles d'utiliser la PMN que celles des enfants qui n'avaient jamais participé au programme (ORA=2,84, $P=0,001$). L'augmentation du score de faim dans les ménages était significativement associée à des chances plus faibles d'utiliser la PMN (ORA=0,80, $P=0,038$). Les mécanismes de suivi de l'approvisionnement en PMN et de la mise en œuvre du programme doivent être renforcés pour s'assurer que les mères ont accès au produit. Les responsables de la mise en œuvre du programme de PMN devraient combler les lacunes au niveau des pratiques d'alimentation complémentaire et veiller à ce que les mères aient accès à des aliments complémentaires adéquats.

Peer Reviewed

Received: July 20, 2020; **Accepted:** February 18, 2021; **First published online:** May 24, 2021.

Cite this article as: Dusingizimana T, Weber JL, Ramilan T, Iversen PO, Brough L. A mixed-methods study of factors influencing access to and use of micronutrient powders in Rwanda. *Glob Health Sci Pract.* 2021;9(2):274-285. https://doi.org/10.9745/GHSP-D-20-00422