STUNTING AND INFANT AND YOUNG CHILD FEEDING PRACTICES IN MADAGASCAR: ANALYSIS OF THE DEMOGRAPHIC AND HEALTH SURVEY

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Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
May, 2016

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ACKNOWLEDGEMENTS

I am grateful for God Almighty's love and blessing.

I am also grateful for the Fulbright Foreign Student Program sponsored by the US Department of State for giving me the great opportunity to pursue my education in the US.

I would like to gratefully acknowledge my Advisor, Dr. Barbara Stoecker, for her guidance and her mentorship. My gratitude also goes to Dr. Gail Gates and Dr. Deana Hildebrand who are part of my advisory committee.

I also appreciate all of the Nutritional Sciences Department faculty and staff for creating a welcoming environment for learning to all of the students and for their great help.

I am also grateful for my family back in Madagascar (Neny, Heritiana, Njiva, Harivola, Tsanta sy Hary) for their full support throughout my studies. I also would like to thank my friends back in Madagascar (Nirina, Mbola, Shek, Alexandra and Claudia) as well as friends here in the US (Marina, Miary, Blanchefort, Mark, Ojo, Christine and Josephus) for their support. I also thank all the colleagues in Dr. Stoecker's lab for their help and their guidance (Meron, Workneh and Tafere).

Last but not least, I acknowledge the DHS Program for allowing me access their data about Madagascar, without which this study could not have been done.

God bless you all!

Name: HASINA RAKOTOMANANA

Date of Degree: MAY, 2016

Title of Study: STUNTING AND INFANT AND YOUNG CHILD FEEDING PRACTICES IN MADAGASCAR: ANALYSIS OF THE DEMOGRAPHIC AND HEALTH SURVEY

Major Field: NUTRITIONAL SCIENCES

Abstract:

Madagascar is among the countries with a dramatically high prevalence of stunting in children under 5 years old. This study used the latest Demographic and Health Survey (2009) to investigate determinants of child stunting according to the United Nations Children's Fund (UNICEF) framework on the causes of malnutrition and to evaluate infant and young child feeding (IYCF) practices using the World Health Organization (WHO) indicators. Logistic regressions were performed to determine the variables associated with stunting and with inappropriate feeding practices. A cut-off at 24 months was used to separate the population into two groups. In 2009, 40.1% of the 1863 children aged 0-23 months and 53.9% of the 2911 children aged 24-59 months were stunted contributing to the 48.5% overall prevalence. In the younger group, boys (AOR=0.69 for girls), severely anemic children (AOR=3.50), children living in households that used non-iodized salt (AOR=0.76 for iodine content more than 15 ppm) and children living in rural areas (AOR=0.66 for urban) were more likely to be stunted. In the 24-59 months group, boys (AOR=0.84 for girls), moderately anemic children (AOR=1.79), children with incomplete immunization coverage (AOR=0.84 for full coverage), children whose mothers were breastfeeding (AOR=1.29), children who were perceived as small at birth (AOR=1.55) and children living in limited-resource households (AOR=3.13) were more likely to be stunted. Increased maternal height was associated with lower risks of stunting in both age groups (AORs=0.77 and 0.69). Region of residence was also a significant factor for stunting. The results also confirmed poor complementary feeding practices as only 17.4% of the children 6-23 months received the minimum diet diversity and 1.8% ate iron-rich food the day before the survey. No association was found between the IYCF indicators and stunting with logistic regression. Inappropriate feeding practices were associated with lower media exposure, lower family wealth and lower maternal education. This study contributes to the understanding of the determinants of child undernutrition and feeding practices in Madagascar.

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CHAPTER I

INTRODUCTION

Undernutrition, resulting from inadequate dietary intake, is a global health problem that affects almost all age groups but is more prevalent in developing countries. Using data from 2011, Black et al. (1) estimated that 45% of the deaths for children under 5 years in low and middle-income countries were directly attributable to undernutrition. When discussing undernutrition, three major terms are used, especially for children: stunted (too short-for-age), underweight (too light-for-age) and wasted (too light-for-height/length). These indicators are used not only to assess the nutritional status of children but also to have an insight about the nutrition situation across countries. Stunting is a sensitive indicator of undernutrition and stunting in under 5 year old children is associated with irreversible negative changes in health outcomes later in life.

Considerable efforts have been made in reducing the prevalence of stunting in children but the number of children affected is still high. Out of the 40 countries with the highest prevalence of stunting, 39 are located in Africa and Asia. Madagascar is one of the sub-Saharan African countries with a high burden of undernutrition. According to the State of the World's Children 2015 (2), 50% of the children were stunted, 36% were underweight and 15% were wasted. These statistics confirm the urgent need to implement successful nutrition interventions in order to address the problem.

An important amount of research has been conducted in investigating the determinants of undernutrition in various countries in order to design appropriate interventions. Translating research results into actions is challenging, as it requires political and social commitments so that interventions can be implemented easily. Madagascar is among the 20 countries with the highest burden of undernutrition that has a National Nutrition Plan. However, the lack of nutrition research and information to design better strategies to fight child undernutrition is an obstacle that the country is facing. In fact, research and data are invaluable tools to conduct, direct and monitor each of the interventions. Furthermore, acting at scale, reaching the part of the population in need and using indicators to follow up on the progress of the interventions are also vital for adequate nutrition actions. All of these suggest that a good knowledge about the target population and the context of the region of intervention is crucial. Unfortunately, to our knowledge, there is only limited literature and research about malnutrition in Madagascar despite the presence of agencies and Non Governmental Organizations (NGOs) operating in the field of nutrition. Inadequate interventions based on other countries are less likely to be effective without data-driven decision-making.

Therefore, the purpose of the study is to determine the key factors that influence child undernutrition in Madagascar. By knowing these factors, we will be able to assist in targeting more specific actions to overcome child undernutrition.

The overall research question to be answered is: "What are the determinants of child stunting in Madagascar?" The specific aims of the study are to:

- Determine the situation of child undernutrition in Madagascar according to the DHS data 2009
- Identify the factors that influence child stunting in Madagascar
- Assess the infant and young child feeding practices (IYCF) in Madagascar

- Determine if there is relationship between IYCF indicators and stunting
- Provide recommendations for future interventions.

CHAPTER II

LITERATURE REVIEW

Importance of nutrition in the first 1000 days

It is now well established that nutrition during the first 1000 days of life (starting from pregnancy until the second birthday is crucial for a child's survival and development). Several studies, done under the "Barker hypothesis" or the developmental origins of adult disease theories, demonstrated that unfavorable environments during fetal growth could cause permanent negative changes that increased the risk of various diseases later in adulthood (3). Specifically, deprived fetal development and low birthweight have been associated with increased risk of coronary heart diseases, diabetes, hypertension and stroke. Nutritional stress during intrauterine life is one of the factors that has been suggested to trigger such changes. Studies done in animals showed that both macronutrient imbalance and micronutrient intake during pregnancy affected birthweight, blood pressure and glucose tolerance. On the other hand, several nutrients have been shown to have multiple impacts on a child's neurodevelopment, and thus to influence the child's psychosocial abilities as well as academic performance. Specifically, deficits in protein, iron, zinc, copper or choline during pregnancy will affect the infant's brain size, as well as cognitive and motor development (4). Fetal nutrition is then critical for a child's development and will determine her abilities as an adult. Additionally, over the past decades the World Health Organization (WHO) has emphasized the importance of infant feeding during the first two years

of life, as it will have a direct influence on the nutritional status of the child, then on health and on survival (5).

Complementary feeding, i.e., feeding along with breast milk when the milk is no longer sufficient for the infant's nutritional needs, has a particular significance. At this time the infant is introduced to new foods that have to meet his specific nutritional requirements, otherwise he will most likely be malnourished. Inadequate complementary feeding practices are a cause of child malnutrition as well as some underlying infectious diseases in developing countries. Gibson et al. (6) showed that complementary feeding in developing countries often fails to meet the nutritional needs of the infants. Also, complementary foods are the main source of contamination in infants in places where access to improved drinking water is not frequent, which is the case in most developing countries. Consequently, complementary feeding practices, usually starting around 6 months of age, play an important role in child survival and in child nutritional status as well. Therefore, several of the interventions against child undernutrition are targeted on the improvement of complementary feeding practices, which have been shown to significantly reduce the prevalence of stunting at 36 months of age (7). Thus, the first 1000 days of the life of a child offers a critical period of time when the effects of nutrition on a child's development and survival as well as general health later in life are crucial. In developing countries where complementary feedings are inadequate, sanitation is a problem and food security is a huge concern, child undernutrition has reached alarming proportions (1). Undernutrition accounted for approximately 35% of the deaths and disease of children less than 5 years of age in low and middle-income countries in 2008 (8).

Short and long term consequences of child undernutrition

Several studies, mostly done in developing countries, have looked at the short and long term consequences of child undernutrition on health and economic development. Short term consequences of stunting include greater susceptibility to various infections and diseases due to a weaker immune system. Undernourished children are at an increased risk of having diarrhea and pneumonia, which can increase the risk of mortality (9). As an example, zinc deficiency is associated with an increased risk of pneumonia and diarrhea (8). Furthermore, nutritional deficiency has been shown to alter cognition, memory and locomotor skills later in life (4). As a result, children's brains do not achieve their full potential leading to poorer cognitive performance and educational achievement (9-11).

In the long term, stunting is negatively associated with increased years of school completed and ultimately with increased wage rate in adults (1). The INCAP Oriente study, a longitudinal study in Guatemala with a follow up of 40 years after the intervention, showed that better nutrition in early childhood resulted in increased wage rate in men, independently of schooling (12). A study done in Brazil confirmed these findings showing a positive dose-response association between height-for-age and lifetime earnings as well (8).

In addition, stunting affects at its greatest extent the nation because of its intergenerational effects. Apart from increased risk of having intrauterine growth restriction, undernourished and short stature mothers are most likely to have babies born with low birth weight who will have poor growth. These children from underweight mothers will, in their turn, be more likely to have low birthweight babies, thus creating an intergenerational effect of stunting (8). Some authors refer to this phenomenon as the stunting syndrome (9) contributing to the cyclical process of poverty. Stunted mothers will give birth to stunted children who will not be able to fully contribute to their country's development. In brief, child undernutrition is

affecting the individual, the family, the community and ultimately the nation because of its intergenerational effects and its role in poverty. Thereby, acting and intervening on the improvement of child nutrition can surely help in breaking the cycle of malnutrition and its intergenerational effects thus reducing, with appropriate measures, poverty in the long term.

Prevalence of stunting

The prevalence of stunting is significantly higher in developing countries, especially in Southeast Asia and sub-Saharan Africa (1, 13). A worldwide decrease in the proportion of stunted children from 47% in 1985 to 29.9% in 2011 has been observed over the past decades (13). In 2005, 32% of the children younger than 5 years living in developing countries had height-for-age z-scores (14) lower than -2, constituting 177.7 million children (8). The latest estimation in 2014 of the prevalence of stunting is the joint child malnutrition estimates done by the WHO, the United Nations Children's Fund (UNICEF) and the World Bank reporting a total number of 158.6 million stunted children globally bringing the global prevalence to 23.8% (15). Among these stunted children, 90% live in just 36 countries in the African and Southeast Asian regions (7), where the highest prevalence of undernutrition is observed. For the African continent, 56.3 million children were stunted in 2011 (1) constituting the highest prevalence of stunting (35.6%). Additionally, of the 40 countries with the highest stunting prevalence in the world, 23, including Madagascar, are located in the African continent. According to the State of the World's Children 2015 (2), 37% of the children in the sub-Saharan region were stunted and 21% were underweight. In 2015, 49.2% of the Malagasy children under 5 years were estimated to suffer from chronic malnutrition or stunting (2).

Determinants of child stunting and undernutrition

In an effort to better understand the underlying causes of undernutrition, several studies have been done in various countries, trying to define the determinants of child undernutrition.

In 1998, UNICEF issued a framework identifying the causes of malnutrition by categorizing all the factors in three: basic causes, underlying causes and immediate causes (16). Several authors have updated the framework but the three categories remained the same (1, 8).

The basic causes regroup all of the general contexts of the country or the community such as political, social, economic and environmental. The most obvious determinant of child undernutrition is poverty and the lack of capital. Moreover, the area of residence is a predictor of child undernutrition as well. Using DHS data from 36 developing countries, Smith et al. (17) showed that stunting prevalence was significantly higher in rural areas demonstrating that children living in urban areas had better nutritional status. Also, the region of residence is a strong predictor of malnutrition in a Burkina Faso study (18) and in a pooled data study in three Central Asian Republics (19).

The underlying causes encompass factors that are closer to the child such as household and maternal factors. Some authors argued that stunting starts before birth as low birthweight and preterm babies have higher chances to be stunted and an estimate of 20% of stunting has *in utero* origins (9). Therefore, maternal characteristics are important determinants of child undernutrition. A study done in Sri Lanka using DHS data showed that maternal stature is strongly correlated with height-for-age z-scores (14). For every 1 cm increase in maternal height, there was an increase of 0.03 - 0.06 HAZ in children. Also, both high and low maternal BMI had negative impacts on a child's HAZ (20). Similarly, results from a study in Kenya confirmed that short maternal stature had an impact on child HAZ; children born to short mothers had two times higher risk to be stunted (OR: 2.61 in infants 0-24 months and 2.94 in children 25-59 months).

Maternal BMI (low and high) was also a significant determinant of child undernutrition in the Kenyan study, having an effect on underweight and wasting but not on stunting (21). In a recent study in Tanzania, children whose mothers had BMIs less than 18.5 were more likely to be

stunted (OR: 1.54 in 0-23 months and 1.38 in 24-59 months) (22). Another important maternal characteristic is educational attainment. In Cameroon and in Senegal, HAZ improved as mothers had higher years of education (23). Likewise, in the Tanzanian study, children had higher risk of being stunted (OR: 2.51) when they were born to mothers with no education. The risks were lower when the mothers had primary education (OR: 2.08) (22). In some cases, the Sri Lankan study for instance, the mother's ethnicity was associated with the child's height-for-age, resulting in significant differences in the impact on stunting according to maternal origin (20). Lack of maternal access to health care as well as poor maternal health-seeking behaviors worsened children's nutritional status in Cameroon and in Ethiopia (24, 25). Finally, mother's age at child's birth was a significant predictor of stunting in Tanzania: infants aged 0-23 months whose mothers gave birth for the first time at an age younger than 20 were more likely to be stunted compared to those whose mothers gave birth the first time at 20-29 years (22). Thus, maternal age, stature, education and access to health care are important determinants of the child's health status.

Household factors are also considered as underlying factors as they can impact indirectly the child's health status. The most recognizable determinant of stunting and underweight in general is household wealth. A study investigating the socio-economic determinants of stunting in four regions of Senegal reported that an increase of 0.038 cm in HAZ for each unit increase of the family wealth index on a five point scale in children 6-35 months (23). Pongou et al. (24) confirmed these results showing that each increase of one unit in wealth index resulted in a rise of 0.176 cm in HAZ in Cameroon. Moreover, Gewa and Yandell (21) reported that children living in the richest households had lower odds of being stunted in Kenya compared to children living in the poorest families.

Also, evidence was found in studies in Asian countries such as Sri Lanka (20) and in some Central Asian Republics such as Uzbekistan, Kyrgyzstan and Kazakhstan (19), confirming the importance of household wealth in the child's nutritional status. Households with higher

income can have more resources dedicated to nutrition and health care than a low-income family, putting the latter at higher nutritional risk.

Another household factor that has been studied is sanitation. The Cameroonian study concluded that access to clean water and a high level of sanitation contributed to less stunting risks. Additionally, bigger household size (23) and a higher number of children younger than five years old (19, 20) were associated with lower HAZ in Senegal, in Sri Lanka and in the Central Asian Republics. Interestingly, Egata et al. (25) showed that the odds of being acutely undernourished increased if the decision-making process regarding the illness of the child was individually based compared to a common decision of both parents (OR=1.62). Some authors also found that maternal access to health care and services was associated with better HAZ in children (25, 26).

Immediate factors of malnutrition encompass the factors that are directly related to the child. In addition to feeding practices, sex, age and immunization and health status in general have been associated with stunting and underweight in children. Males were more likely to be stunted in most of the studies (21, 23, 24). In Kenya, infants with up-to-date immunization coverage had lower odds for being stunted (21). Also, children who had diarrhea or cough during the time of the survey were more likely to be stunted (21). In Cameroon (24) and Ghana (27), increased age was associated with decreased HAZ in children under 5 years.

Infant and Young Child Feeding (IYCF) practices indicators

Definitions of indicators

As previously mentioned, nutrition during the first two years of life offers a "window of opportunity" to optimize a child's growth and development. Aware of the importance of infant nutrition and to monitor the progress of each country following the recommendations on complementary feeding in 2002, the WHO released a set of indicators that could be used to assess

the situation of young child feeding practices. They included the early initiation of breastfeeding, exclusive breastfeeding under 6 months, continued breastfeeding at 1 year, introduction of solid, semi-solid or soft foods, minimum dietary diversity, minimum meal frequency, minimum acceptable diet, and consumption of iron-rich or iron-fortified foods as core indicators (5).

Indicators

Table 1 summarizes the core indicators of IYCF (5).

There are seven optional indicators including the proportion of children ever breastfed, continued breastfeeding at 2 years, age-appropriate breastfeeding, predominant breastfeeding under 6 months, duration of breastfeeding, proportion of bottle-fed children and milk frequency for non-breastfed children. If sufficient resources are allocated to the data collection during the survey, for instance advanced trainings of investigators or prolonged timeframe, data on the seven optional indicators on breastfeeding and complementary feeding practices can be produced.

IYCF in developing countries

The IYCF practices are often assessed in developing countries where undernutrition prevalence is the highest because of their importance in children's general health and nutritional status. The State of the World's Children 2015 reported poor progress in meeting the IYCF recommendations for the least developed countries for early initiation of breastfeeding (53%), exclusive breastfeeding under 6 months (46%) and introduction of complementary foods at 6-8 months (62%) (2). The statistics were even lower in the West and Central African regions and in East Asian countries.

Table 1: Core indicators of IYCF (5)

Indicator	Definition	Children included
Early initiation of breastfeeding	Proportion of the infants alive or deceased who were put to breast milk within one hour after birth.	Children born in the past 24 months
Exclusive breastfeeding under 6 months	Proportion of infants who were exclusively fed with breast milk for the first 5 months	Infants aged 0-5 months who received only breast milk the previous day
Continued breastfeeding at 1 year	Proportion of children aged 12-15 months who were fed breast milk	Infants aged 12-15 months who received only breast milk the previous day
Introduction of complementary foods	Proportion of children who received solid, semi-solid or soft foods	Infants aged 6-8 months who received solid, semi-solid or soft foods the previous day
Minimum dietary diversity	Proportion of children who received foods from 4 or more food groups	Children aged 6-23 months who received foods from 4 or more food groups the previous day
Minimum meal frequency	Proportion of children who received solid, semi-solid or soft foods the minimum number of times - 2 times for breastfed infants 6-8 months - 3 times for breastfed children 9-23 months - 4 times for non-breastfed children 6-23 months	Children aged 6-23 months (breastfed or not) who received solid, semi-solid or soft foods the minimum number of times the previous day
Minimum acceptable diet	Proportion of children aged 6-23 months, breastfed or not, who received a minimum acceptable diet (minimum meal frequency and minimum dietary diversity)	For non-breastfed children, those who received at least 2 milk feedings and had at least the minimum dietary diversity and the minimum meal frequency during the previous day
Consumption of iron-rich or iron-fortified foods	Proportion of children who received iron-rich or iron-fortified foods	Children aged 6-23 months who received iron-rich or iron-fortified foods the previous day

For Madagascar, from the 2004 Demographic and Health Survey (DHS) data (28), only 61% of infants were breastfed within one hour after birth, 67% were exclusively breastfed under 6 months and 78% were introduced to complementary foods between 6 and 8 months, showing better indicators than the average of the least developing and Sub-Saharan countries. Yet, complementary feeding practices such as meeting the minimum dietary diversity (31%) or minimum acceptable diet (25%) still need improvement because they were far below recommendations.

IYCF and stunting

A recent literature review collected studies that linked children's nutritional status and IYCF indicators in nine developing countries (29). They showed that not all of the indicators were associated with stunting in all of the countries. However, minimum meal frequency and consumption of iron-rich foods were the only indicators that were not associated with HAZ in any country. For instance, timely introduction of complementary foods was associated with lower odds of stunting in Bangladesh. Moreover, children who had the minimum acceptable diet had lower chances of being stunted in Zimbabwe. Although emphasizing the usefulness of the IYCF indicators, the authors suggested that additional information should be included when assessing IYCF. The association between stunting, wasting and underweight was also investigated by Disha et al. (30) in Zambia by using DHS data. Results showed that continued breastfeeding at 1 year, timely introduction of complementary foods and minimum acceptable diet were associated with improved HAZ in Zambia.

Determinants of IYCF practices

Few studies looked at the determinants of IYCF practices in developing countries. Most of the determinants are related to maternal characteristics such as maternal education or women's empowerment. For instance, mothers with no formal education were less likely to meet the

recommended complementary feeding practices including minimum meal frequency, dietary diversity, minimum acceptable diet and iron-rich food consumption in Uganda (31). Similar results were found in Bangladesh, as mothers with no education were more likely to have inappropriate complementary feeding practices compared to mothers who had at least primary education. Mothers with no formal education tended not to introduce complementary foods at 6-8 months and not to meet the minimum dietary diversity, the minimum meal frequency and the minimum acceptable diet (32). Additionally, a study using DHS data from 10 sub-Saharan African countries showed an association between some IYCF indicators and women's empowerment (33). For contextual reasons, results differed greatly among the countries. However, they demonstrated that higher economic empowerment or increased access to financial resources had positive associations with the minimum dietary diversity and the minimum acceptable diet criteria in nine of the countries. Interestingly, they found that socio-familial empowerment or a greater freedom of mobility and control of own health were associated with the likelihood of not meeting the IYCF recommendations in certain countries including Benin, Burkina Faso and Nigeria. They suggested that women with more social empowerment were more likely to be exposed to a broader and possibly erroneous knowledge of IYCF practices.

Household characteristics were also found to be associated with IYCF practices. For instance, children living in limited-resources households were more likely to have untimely introduction to complementary foods in India and Pakistan (14). Similar children were also more likely to meet the minimum acceptable diet in Nepal and India. These results confirmed the link between maternal, household and community characteristics and the breastfeeding and complementary feeding practices.

Child stunting is associated with short and long term negative consequences later in life. The first 1,000 days of life is critical for a child's development and offers a "window of opportunity" to address undernutrition. Also, child feeding practices, assessed by the IYCF

indicators play a major role in children's growth. The methods used for this study will be developed in the next chapter.

CHAPTER III

METHODS

The Demographic and Health Surveys datasets are an invaluable tool for the analysis of the nutrition situation in Madagascar because of their representativeness and the multitude of information they gathered. Used appropriately, the data analyses can be a great help for evidence-based decision-making processes in terms of nutrition interventions and policy.

Data source

Demographic and Health Surveys (DHS)

The DHS are a set of surveys established by the United States Agency for International Development (34) with the technical assistance of ICF International through the project called MEASURE DHS. This worldwide project is accountable for more than 300 household-based surveys in more than 90 countries across Africa, Asia, Latin America/Caribbean and Eastern Europe. The surveys are meant to be nationally representative to provide accurate data on the situation of the country. Information about fertility, family planning, maternal and child health, gender, HIV/AIDS, malaria and nutrition are collected at intervals of 5 years for many of the countries and the data are disseminated and are available for public use (34, 35).

The primary objective of the DHS is to provide the most representative and accurate information about the population in order help policy makers direct their analyses and choices.

Furthermore, governments but also donors, researchers and civil society widely use the DHS data for their investigations, for setting their funding priorities or simply to inform the population about health-related problems or up-to date situations (35). For instance, international organizations such as USAID, the World Bank or UNICEF use data from DHS to publish reports on various aspects of a country's health and demographic situation and then to prioritize their interventions.

Because the DHS is done at national and regional levels inside a country, one objective of the DHS is to improve the partnership and the collaboration between ICF International, USAID and the participating countries (34). In fact, ICF International only provides technical assistance before and during the survey and local institutions are responsible for conducting the actual surveys on-site.

Additionally, through the technical assistance of ICF International, another objective would be to develop in participating countries the skills necessary to conduct high-quality nation-wide demographic and health surveys (36). Through their 25 and more years of expertise in designing and monitoring nationwide representative surveys, the process of conducting a DHS can help participating countries by improving data collection methods, using efficient data analysis tools and enhancing methodology.

And the final objective for the DHS is to help disseminate the data as well as encourage their utilization (36). Data from the DHS can be accessed and utilized by students, researchers and other institutions for further analyses. In fact, DHS data have been widely analyzed and used as a reliable source of information especially in the field of maternal and infant nutrition in developing countries.

Sampling methods for DHS

For all of their surveys, MEASURE DHS always follows some general principles in order to have consistent and comparable data for different countries, and to have excellent quality results (34).

- Use of an existing sampling frame: since they are selecting a probability sample, MEASURE DHS uses an officially recognized sampling frame indicating the complete list of the statistical units covering the target population. The sample is then drawn from the sampling frame.

- Full coverage of the target population: DHS are nationally representative and cover all the territory of the participating country.

- Probability sampling: to avoid bias and to provide representative information, completely randomized and purposive sampling methods have been excluded.

- Using a suitable sample size: sample size is calculated according to the number of subgroups of the population of interest, the budget and the logistic organization.

- Using the most simple design possible: ICF International opted for the two-stage household-based sample design for all of the DHS because of its simplicity of implementation and the quality of the data obtained.

- Conducting a household listing and pre-selection of households: in order to work efficiently and to avoid bias during the fieldwork, interviewers only conduct the survey in a list of pre-selected households. They are not allowed to change or replace the pre-selected households.

- Providing good sample documentation: the sample documentation provides useful information about the sampling methodology including the sample size, the sample allocation and the stratification.

- Maintaining confidentiality of an individual's information: because a great amount of personal information is asked during the surveys and blood samples and bio-markers are also collected, DHS policy insures that files are kept confidential. No potential identification of the households in the data file/datasets is allowed during and after the survey.

- Implementing the sample exactly as designed: this is done by working with competent and trained staff before, during and after the survey.

For collecting the data, the DHS use a two-stage sampling method. It is a probability sampling method, which means that every single household has an equal chance to be selected. The target population is typically any women aged 15-49 years and children under 5 years old even though some surveys include men aged 15-49 years. DHS ordinarily use two-level stratification for the determination of the sample size. The survey population is divided into regions, which constitute the first strata. And for each region a second stratification by urban-rural separation is completed. According to the budget allowed for the survey, a certain number of enumeration areas (EA) are defined in advance and are distributed equally between regions covering the totality of the country. Then within each region, the EAs are divided according to the population living in urban or rural areas, ensuring the representativeness of the information to be collected. Finally after the distribution of the EAs, still according to the budget, the number of households to be surveyed for each enumeration area is allocated depending on the total sample size of the national survey (34).

Madagascar DHS

The Madagascar Demographic and Health Survey 2008–09 (EDSMD-IV), or *Enquête Démographique et de Santé de Madagascar 2008–09*, was conducted by the Institut National de la Statistique (35)/Direction de la Démographie et des Statistiques Sociales, the Vice Primature chargée de la Santé Publique, and the Institut Pasteur de Madagascar with technical assistance from ICF International. A total of 600 EAs were drawn and each of the 22 regions were assigned 25 EAs with the exception of the region Antananarivo which had 50 EAs due to the size and the complexity of the social and economic characteristics of the households within this area.

For each EA, DHS chose to interview 32 households bringing the total expected sample survey at 19,200 households with 4,768 in urban areas and 14,432 in rural areas, covering 118/119 Districts. The fieldwork took place from November 2008 to August 2009 (35). A total of 17,857 households participated in the survey, and complete interviews were conducted with 17,375 women aged 15−49 and 8,586 men aged 15–59.

Variables

Data presentation

The data for the Madagascar 2009 DHS are divided into seven separate datasets: couples, household, women, children, men, household members and birth datasets. The datasets are the responses to the three core questionnaires of DHS: the Household questionnaire, the Women's questionnaire and the Men's questionnaire. For consistency in all DHS surveys, variables are coded by the DHS standard codes and country-specific responses and/or variables are also given. Missing values and responses that are not within the acceptable range of the possibilities are handled the same way for all the DHS datasets. Each dataset then has several sections or specific topics such as respondent's basic data, maternity, fertility or malaria; and each section has its own

variables, which are basically a response to a question in the survey. The variables are presented as numbers and a recode file is available for transcription during analyses.

Data treatment

Given that the current project was conducted on children under 5 years old, the child dataset was the most relevant because it not only provided basic and detailed information about the mother and the household but it also covered topics about the child such as health, immunization and nutrition. The dataset contained a large number of variables and some of them were not related to our analyses (such as the fertility preference or the knowledge of tuberculosis by the parents). Because it would take considerable time to run a program on the statistical software if the dataset is huge, we removed unrelated variables and created a new dataset. Furthermore, for the descriptive analyses, new variables, especially for categorical variables, had to be created. These include nutritional status of children (stunted or not stunted), source of drinking water and toilet facilities.

Only 5,875 children under five from the 12,448 in the child dataset were included in the height measurement. Furthermore, weight data were intentionally omitted in the child dataset due to a reported lack of precision during the measurements. After removing the missing values and the values out of the plausible limits, the dataset contained 4,774 observations. The next figure summarizes the process in the creation of the definitive dataset.

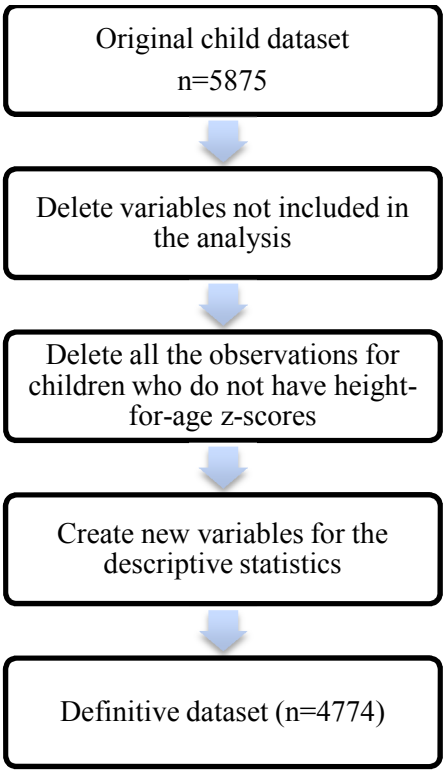


Figure 1:Data treatment

Variable choice

The UNICEF framework on the causes of malnutrition is now widely recognized (16). It identifies three levels of factors that predict malnutrition: immediate, underlying and basic causes.

- The immediate causes can also be considered as individual child causes such as sex, age or immunization coverage.

- The underlying causes identify the problems beyond the individual level. Factors such as household food security, sanitation or caring practices are considered as underlying causes.

- The basic causes encompass the factors at a regional or the national level such as political and legal situation.

According to previous studies and the UNICEF framework (1, 16) and considering the availability of the data, the next table presents the summary of variables that were tested for possible association with child stunting and the IYCF.

Table 2: Variables included in the study according to the UNICEF framework on the causes of malnutrition

Factors levels	Categories	Variables
Immediate causes	Child characteristics	Gender Age Breastfeeding status Immunization coverage Anemia level
Underlying causes	Maternal characteristics	Education Religion Marital status Media exposure Age at first birth Anthropometric measures Anemia level Work status Antenatal care and delivery
	Household characteristics	Household size Wealth index Sanitation (drinking water, toilet facility) Head of the household characteristics Partner/husband's education Partner/husband's work status Child's caregiver
Basic causes	Other characteristics	Region of residence Area of residence (urban vs. rural)

Statistical analyses

Descriptive statistics

Before checking for the association between variables, a brief descriptive statistical analysis was performed on the survey population. The frequency of the variables such as gender, wealth index distribution, place of residence, maternal education or sanitation was calculated in

order to have basic information about the population. Additionally, the national and regional prevalence of stunting in 2009 in Madagascar was also calculated for children under 5 years old. The 2006 WHO growth standards were used by the DHS group to assess the height/length-for-age of the children and the cut off of <-2 height/length-for-age z-score was used to define stunting (36).

For the IYCF, there are eight core indicators and seven optional indicators. These indicators not only assess the breast-feeding practices but also the early nutrition of infants and children. The core indicators include early initiation of breastfeeding; exclusive breastfeeding under 6 months; continued breastfeeding at 1 year; introduction of solid, semi-solid or soft foods; minimum dietary diversity; minimum meal frequency; minimum acceptable diet and consumption of iron-rich or iron-fortified foods. The WHO released in the report the formulas and provided guidance for the calculation of the indicators (5). Information about minimum meal frequency as well as minimum acceptable diet were not collected during the 2009 Madagascar DHS, so indicators six and seven could not be calculated. After calculations, the results were shown as the proportion of children for each indicator in specific age groups, as recommended by the WHO. These indicators constitute invaluable tools in evaluating the progress of Madagascar regarding child feeding practices.

Regression analyses

In order to identify the determinants of child stunting, logistic regression models have been used since the outcome variable is not normally distributed. As previous studies suggested, and based on the WHO recommendations for continued breastfeeding, analyses were done within specific age groups: infants of 0-23 months of age and young children between 24-59 months. Within each age group, each plausible explanatory variable was tested with bivariate logistic regression for an association with the binary variable created for the presence or absence of

stunting. In order to analyze categorical variables, dummy variables were created and the responses were compared with a reference. Variables that reached a significance level of $p < 0.1$ in bivariate analyses were included in the multiple regression models. Additive stepwise models were constructed for each of the three risk factor categories according to the UNICEF framework with all the significant variables. The adjusted odds ratio of each determinant of stunting will be identified.

To determine the relationship between stunting and IYCF practices, simple logistic regressions were also performed. IYCF practices as well as stunting variables were coded as binary variables. Binary logistic regressions were also used to define the determinants of inappropriate IYCF practices. All of the statistical analyses were computed on SAS 9.4 and a significance level of 5% was chosen.

CHAPTER IV

DETERMINANTS OF STUNTING IN CHILDREN UNDER FIVE IN MADAGASCAR

Introduction

With an estimated 158.6 million children affected in 2014 (15), stunting is a major public health issue especially for developing countries located in sub-Saharan Africa and Southeast Asia. The World Health Organization (WHO) predicted that a total of 49.2% of children were chronically malnourished in Madagascar in 2014 placing the country among those with the highest prevalence of stunting in the world (37).

Stunting resulting from chronic malnutrition leads to short and long term negative consequences if not addressed at a young age. Short-term negative outcomes include greater susceptibility to various infections such as diarrhea and pneumonia due to a weaker immune system (9). Stunted children do not achieve their full developmental potential leading to poorer cognitive performance and educational achievement compared to their well-nourished counterparts. Memory and locomotor skills can be altered as well (4). Negative associations have been found in Brazil and Guatemala between stunting, years of schooling and salary as adults (8, 10). Moreover, stunting promotes the continuation of the cycle of poverty because of its intergenerational effect: stunted mothers are more likely to give birth to stunted children who will contribute less to their country's development (9).

Based on the UNICEF framework, there are three main categories of determinants of childhood malnutrition: the basic causes, the underlying causes and the immediate causes (1, 2). Poverty and lack of capital as well as political instability are the basic causes of malnutrition. Area of residence is also a determinant of stunting as rural children are more affected (18). A growing body of literature confirms that household factors such as family wealth (18, 20, 21), sanitation (24) and household size (23) are some of the underlying causes of malnutrition. Furthermore, maternal characteristics such as education (23, 24), maternal stature (21) and BMI (20, 22), maternal access to health care (25, 26) and maternal age at first birth (22) are strong determinants of stunting. Immediate or biological risk factors include the sex (22-24), age (19, 22, 26) and birthweight of the child (24, 27).

Lately, a myriad of nutrition interventions targeting the improvement of children's nutrition have been implemented. The Maternal and Child Nutrition Group (MCNG) showed that the promotion of proper complementary feeding along with other supportive strategies including educational groups and food provision are the most effective interventions to reduce stunting in children before 36 months of age (7). They reported reductions in the prevalence of stunting of 19% in infants at 12 months and 17.2% at 24 months with 99% coverage with feeding interventions combined with supportive activities. However, for any intervention to be successful, it should be designed and tailored to fit the local context of the country so it can reach the most vulnerable segment of the population.

Despite being one of the 20 countries with the highest burden of malnutrition (8), there is to our knowledge, very limited research concerning nutrition in Madagascar. One of the few published studies about nutrition in Madagascar was carried out by Asgary et al. (38) in a commune in the Northern part of the country. They found a relatively high stunting prevalence (36.2%) and concluded that inadequate access to food as well as the lack of nutrition knowledge by the mothers were the barriers to adequate nutrition in children under 5 years. Our study is the

first to use nationwide data to analyze the key factors that influence stunting in Madagascar. Knowing these factors will be a valuable tool to help policy decision-making and to assist in more specific targeting of actions to overcome child undernutrition.

Methods

Data from the most recent Demographic and Health Survey (DHS) done for Madagascar from November 2008 to August 2009 (EDSMD-IV) were used. A total of 17,375 participating women aged 15 to 49 years old (35) were interviewed. From the total participants, data from 4,881 women who had children under 5 years old were collected to create the child database. After removing missing values, statistical analyses were conducted with a total of 4,774 children.

The 2006 WHO growth standards (39) were used by the DHS group to assess height-for-age of the children with a cut off of <-2 length/height-for-age z-score (LAZ/HAZ) used to define stunting (40). Variables for analysis from the larger survey were selected according to significant determinants of child undernutrition in developing countries found in the literature (21, 22) and according to their availability in the dataset. Plausible explanatory variables were analyzed by the three categories based on the UNICEF framework: basic, underlying and immediate determinants.

Analyses were done within two groups, dividing the study population into: 0 – 23 months and 24 – 59 months, as recommended by the WHO for continued breastfeeding (41) and as suggested by previous studies (20). Bivariate logistic regressions were performed individually on each variable to determine the association with the LAZ/HAZ. Variables that reached a p-value of < 0.1 were included in the final additive stepwise models. After the bivariate analyses, all of the variables having association at a level of $p < 0.1$ with HAZ were grouped into the three factors described by UNICEF (immediate, underlying and basic). Multivariate logistic regression models were run for each set of factors for all significant variables. All of the statistical analyses were

computed on SAS, v. 9.4 (SAS Institute, Cary, NC, USA) and a significance level of 5% was chosen for the final models.

Results

Socio-demographic characteristics of the study population

The characteristics of the population in the two age groups: 0-23 months and 24-59 months were very similar (Table 3). There were no significant differences in the percentage of boys and girls in either group. Almost half of the households were in the poorer and poorest categories (49.6% for the 0-23 months group and 49.9% for the 24-59 months group). The great majority of the households lived in the rural areas (82.2% for the younger group and 81.7% for the older group). Additionally, a total of 28.6% of the mothers in the younger group and 27.9% in the older group did not receive any formal education. Moreover, the majority of the mothers who had gone to school only attended primary school (49.7% for the 0-23 months group and 51.9% for the 24-59 months group). Nearly all of the mothers breastfed their children as evidenced by less than 1% of the mothers who never breastfeeding in either of the age groups.

A substantial proportion of the households were facing sanitation problems: only 3.4% and 3.1% in each group received their drinking water from protected and safe sources such as public taps or tube wells. Moreover, more than half of the households in each age group did not have toilet facilities (57.5% and 55.1% respectively).

According to the 2006 WHO growth charts, a total of 48.4% of the children under five in Madagascar were stunted in 2009. Stunting was more prevalent in the older group (53.8% vs. 40.1%) than among younger children (figure 2). In both age groups, an extremely high prevalence of stunting was observed in the regions Amoron'I Mania (66.3% for the younger group and 74.3% for older group) and Matsiatra Ambony (52.7% for the 0-23 months and 72.7% for the 24-59 months groups) (Figure 3). Lower prevalence was calculated for the regions Betsiboka (14.9%

for the younger group and 23.6% for the older group), Sava (34.6% for the 0-23 months) and Diana (40.5% for the 24-59 months) (Figure 3).

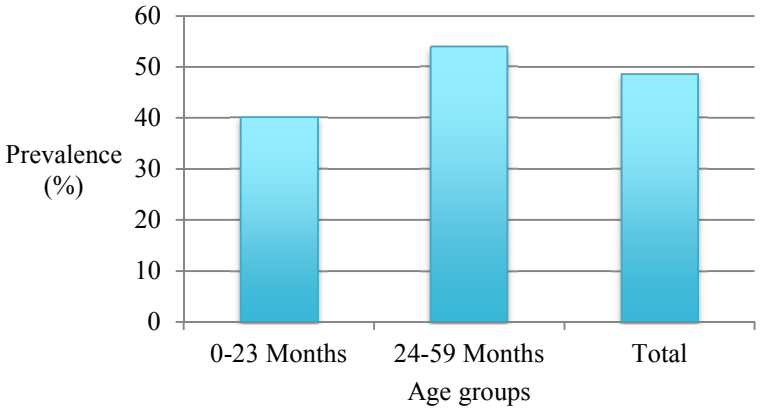


Figure 2: Prevalence of stunting in Madagascar by age groups

After the bivariate analyses, all of the variables having association at a level of $p < 0.1$ with HAZ were grouped into the three factors described by UNICEF (immediate, underlying and basic). Multivariate logistic regression models were run for each set of factors for all significant variables.

Multivariate analyses

Immediate factors of stunting

In the younger children, sex and anemia level as well as child age were associated with stunting in the younger children (Table 4). Girls younger than 24 months were less likely to be stunted (AOR=0.69) and the risk of stunting increased with the age. Severely (AOR=3.50) and moderately anemic (AOR=1.72) children were more likely to be stunted. Similar results were observed for sex in the older group with an AOR=0.84 for girls.

Children in the older group with moderate and mild anemia were at higher risk of being stunted (AOR=1.79 and 1.27) than those with normal hemoglobin concentrations. Severe anemia

was not significantly associated with stunting in the 24-59 months group but only 13 children were severely anemic. Also, full immunization coverage (BCG, DPT, hepatitis B and polio) was associated with a lower risk of stunting (AOR=0.84).

Underlying factors of stunting

The risk of stunting was lower as maternal HAZ increased in both age groups: AOR=0.77 and 0.69, respectively (Table 5). Children in the 0-23 months group who were still being breastfed had lower risk of stunting (AOR=0.63). Lower odds ratios were also observed in children whose mothers watched TV almost every day (AOR=0.55). Still in the younger group, children living in households using iodized salt (concentration > 15 ppm) were less likely to be stunted compared to those using salt with 0 – 7 ppm iodine (AOR=0.76).

In the older group, children were more likely to be stunted if their mothers were breastfeeding (AOR=1.29). Also, children whose mothers were working on extended family's land were more likely to be stunted (AOR=1.63) than children whose mothers were working on their own land. Children perceived by mothers as smaller than average at birth were also more likely to be stunted (AOR=1.55) compared to those seen as having an average birthweight. Additionally, the chances of being stunted increased with number of living children (AOR=1.09) in the 24-59 months group. Not sharing a toilet facility was associated with decreased odds of being stunted (AOR=0.62). Finally, still in the older group, decreased household wealth was associated with higher odds of stunting in some wealth categories (AOR=3.13 in the poorer and AOR=3.18 in the middle). But there was no significant difference between the richest and the poorest households regarding the odds of stunting.

Basic factors of stunting

Both region and area of residence were significant basic factors predicting under five stunting (Table 6). Children living in the urban areas were less likely to be stunted in both age

groups (AOR=0.67 and 0.73 respectively). Additionally, children living in the region Amoron'I Mania were more than twice as likely to be stunted compared to the children living in the the capitol city region Analamanga, regardless of the age group (AOR=2.45 for the younger group and AOR=2.34 for older children). In contrast, children living in the regions Betsiboka (AOR=0.22 for younger age group and 0.25 for older age group) and Melaky (AOR=0.28 for 0-23 months and 0.42 for 24-59 months) were less likely to be stunted compared to those living in Analamanga.

Discussion

Our results demonstrate that childhood stunting is a public health challenge in Madagascar as almost half of the children under five years old (48.5%) were affected in 2009. The situation has hardly changed for more than half a decade because the WHO reported a prevalence of 49% of childhood stunting in 2015.

Immediate factors

The key individual factors associated with stunting appeared to be age of the child and the anemia level for both age groups. Several studies done in sub-Saharan Africa confirmed the finding that risk of stunting increases with age (21, 22, 24). A study using data from 54 countries from the WHO Global Database on Child Growth and Malnutrition confirmed that growth faltering occurs as soon as 3 months after birth in developing countries. And, the mean LAZ of infants drops dramatically until 24 months, indicating that odds of being stunted are higher as the infant grows older during this timeframe (42).

Additionally, sex was a significant determinant as boys were more likely to be stunted compared to girls in both age groups, which is in accordance with findings from other sub-Saharan countries (22-24). A meta-analysis using DHS data from 16 African countries concluded that boys were consistently at higher risk of stunting than girls in 10 of the countries with an

OR=1.16 (43). Comparison of the normal height-for-age growth curves (50th percentiles) between boys and girls showed that boys have higher lengths than girls suggesting higher nutritional needs (44). Thus, given the same amount of food, boys will be more likely to be stunted than girls.

Tested in the older group only because some children in the younger group would not meet the recommended age, complete immunization coverage was an immediate factor which was associated with lower risk of stunting. A study in Indonesia concluded that complete immunization was associated with lower morbidity and lower prevalence of stunting in children aged 12-59 months (45). Given the sanitary conditions in Madagascar, where 46.6% of the households drank from unprotected water sources and only 3.6% had improved toilet facilities, having all required vaccines could be critical in the prevention of infectious diseases that affect not only nutritional status but also health in general. Additionally, Gewa and Yandell (21) suggested that the mothers of the children with complete immunization coverage may have access to health care and have contact with health professionals leading to better nutritional and health knowledge and thus better nutritional status in children.

Underlying factors

Maternal height was a significant underlying factors for stunting in both age groups. Maternal stature often has been shown as a strong determinant of child undernutrition in various studies (20-22). Additionally, Victora et al. confirmed the consistent association between maternal height and infants low HAZ by using pooled data from developing countries. They found significant association between birthweight of the children and their grandmother's height, suggesting that the intergenerational effects of undernutrition last at least for three generations (11).

Moreover, Black et al. (8) pointed out the association between maternal short stature and maternal BMI and child undernutrition. We also found that children whose mothers had low BMI (<18.5) were more likely to be stunted (data not shown) but the BMI variable was not included in the multivariate models because it is correlated with maternal height. Low BMI in mothers may be due to an overall food insecurity in the household. Gewa and Yandell (21) argued that an environment lacking in adequate nutritious food sources would affect the children and the parents in a similar way resulting in poor nutritional status in both. A study investigating seasonal food poverty reported that more than two thirds of the Malagasy population had an average calorie intake below 2133 calories. Dietary energy intakes can drop as low as 1794 calories per capita within the poor households during the lean season suggesting an overall food insecurity situation (46).

The lower risk of stunting with maternal breastfeeding status in the younger group if the mother is currently breastfeeding may be explained by the protective effects of breastfeeding on growth and development during the first two years of life following the WHO recommendations (41). In the older group, however, the risks are higher which may suggest poor dietary diversity, which has been linked to stunting (47). Also, this may be the result of cumulative inappropriate complementary feeding practices. Moreover, a study done in the Northern part of the country reported that most mothers share the same food with their children regardless of their age (38). And the Malagasy household diet consists mainly of carbohydrates including rice, consumed 6.2 times a week and cassava, consumed 3.9 times a week, and rarely contains animal protein (48), which is not ideal for children. Uauy et al. (49) confirmed the importance of dietary protein for children's growth because they have higher requirements per kg of body weight than adults. Additionally, the mother might breastfeed a younger sibling, which could also influence the growth of the index child because less time would be allocated for the care of the index child.

Not using iodized salt was significantly associated with stunting in the 0-23 months group as the odds ratio decreased with an increased concentration of iodine in domestic salt (OR=0.76 with a concentration more than 15 ppm of iodine compared to 0-7 ppm). In fact, iodine has been shown to play a role in growth and development through the thyroid hormones (50, 51). However, no information was collected during the survey about whether or not mothers/caregivers used iodized salt for the preparation of complementary foods.

Additionally, the results of the Comprehensive Food and Nutrition Security and Vulnerability Analysis conducted in the rural areas of Madagascar in 2010 showed that only 28.1% of the infants aged 6-12 months, 35.5% of infants 12-18 months and 36.5% of the infants aged 18-24 months were given flesh foods potentially rich in iodine such as fish and seafoods. And even lower proportions were given eggs, another potential source of dietary iodine (48). If we assume that the only source of iodine was from the diet after the first 6 months, most of the breastfed children would rely on the iodine content in breast milk because of the low consumption of iodine-rich foods, unless mothers added iodine to their complementary foods. Thus, the infants are at higher risk of stunting if the mothers do not have sufficient iodine intake. Additionally, using iodized salt may reflect better nutrition knowledge in mothers leading to better nutrition outcomes in children.

Mothers who work on extended family lands have children with higher risks of being stunted in the 24-59 months group compared to mothers who work on their own land. Maternal working status may be a determinant for child growth, especially if they work in agriculture, because of the lesser time allocated to childcare and nutrition as they spend all day away from their children. Households who have to work on family's land have to split the agricultural products reducing considerably the food supply.

Children perceived by the mothers as small during delivery were more likely to be stunted. They may in fact have been low birthweight, which will put them at a higher risk of stunting. Channon (52) reported that mothers' perception of infant size is a suitable proxy for birthweight regardless of the country.

Numerous studies have demonstrated the importance of household wealth in children's nutritional status (22-25). Higher family wealth usually means that more resources can be distributed to nutrition and health care in general suggesting lesser risks of undernutrition in children (17). However, the odds of stunting between the richest households and the poorest were not significantly different. The poorest household may have been eating other sources of food that were not being captured in the questions asked by the DHS that could influence children's nutritional status. For example, Ramaroson Rakotosamimanana et al. (53) reported that eating *Moringa oleifera* leaves is fairly common in children in the most Northern part of the country compared to children living in the capital. And *Moringa* is a good source of protein (54) and its consumption is likely to benefit the children's growth. These results confirm that household wealth alone does not explain stunting odds in the poorest households.

Association between toilet facilities and HAZ are consistent with the findings in the literature (24), as having shared toilets will favor the dissemination of infectious diseases.

Basic factors

The area and region of residence were strong predictors of child stunting for both age groups. Urban children were less likely to be stunted as confirmed by a study from 36 developing countries (17). The authors suggested that children living in urban areas have better socioeconomic conditions that promote better nutritional status than their rural counterparts. However, the positive effects of living in urban areas are cumulative and children presumably would be exposed to the advantages for their lifetime. For instance, they may be born to well-

nourished mothers, already reducing considerably the risk of stunting; they are also more likely to receive better complementary food and be provided better health care. For example, we found that the mean diet diversity score was higher in children living in urban areas (2.42) than in rural areas (1.36).

The differences in the odds of stunting in various regions of Madagascar may be explained by the availability of the resources for food as well as the work opportunities. The Analamanga region was chosen as a reference because it encloses the capital city. The Sofia, Melaky and Betsiboka regions are located on the coast and/or near fishing areas, suggesting that households can generate money and have healthier food sources. Additionally, these three regions have several tourist sites including various national parks and natural reserves providing another source of income for households working on these sites. Thus, these factors may explain why children living in these regions may have lower risks of being stunted compared to children living in the Analamanga region. On the other hand, children living in the Amoron'I Mania and Matsiatra Ambony regions were at increased risk of stunting compared to children living in the capitol region. One reason for the higher odds of stunting may be that those regions are landlocked and do not necessarily have access to diverse foods, especially during the lean season. Moreover, a substantial proportion of the households in these regions are below the second wealth index quintile (36.4% for Matsiatra Ambony and 50.7% for Amoron'I Mania, data not shown). However, household wealth alone does not explain the higher risk of stunting in these regions because other regions such as Atsimo Atsinanana have dramatically higher proportions of poor households (71.4%) yet the risk of stunting is not significantly different compared to Analamanga.

Implications for the Malagasy National Nutrition Plan

The *Plan National d'Action pour la Nutrition* (PNAN II 2012-2015), the most recent national nutrition plan of Madagascar, has five main focus points including preventing and managing malnutrition as well as reducing malnutrition risks in vulnerable groups in case of natural disasters (55). The interventions focused on the promotion of community programs, micronutrient supplementation and fortification; deworming as well as nutrition education among adolescents, school-aged children, pregnant women and children under 5 years of age. Several interventions mentioned in the PNAN II have successfully reduced stunting in other developing countries. Preliminary studies including a landscape nutrition analysis by international experts from UNICEF and WHO as well as an evaluation of the former National Nutrition Plan were done prior to the elaboration of the PNAN II. However, specific data on determinants of child undernutrition in Madagascar are scarce. Morris et al. (56) argued that the rarity of strong evidence-based data and the lack of relevant national program evaluations are one of the main reasons why nutrition interventions are having low success.

One of the main findings of this study is the disparity between the 22 regions of Madagascar in terms of stunting prevalence and the odds for children under five to be stunted. Having individual regional nutritional plans could be a more effective way to tackle the problem as argued by Bryce et al. (57). Goals and objectives are written at a national level in the PNAN II, however, some regions, for instance Amoron'I Mania, may require more interventions and more specific actions than others because of the very high prevalence of stunting. Plus, Ramaroson Rakotosamimanana and colleagues (58) showed that parental knowledge about nutrition in poor households was different in two regions of Madagascar and parental beliefs about nutritional values of foods lead to different food habits in different regions.

This present study highlights the importance of designing more specific and tailored interventions at a subnational level. Moreover, resources available and cultural context are different for each region, suggesting that various approaches may be needed.

Our results also showed that determinants in infants and young children (0-23 months) and children (24-59 months) are different. The nutritional status of the older group seems to depend more on household and community factors in addition to maternal variables. Thus, implementing different nutrition interventions for each age group could be more effective.

One main point to consider about the PNAN II is the sustainability of the results. Though designed to have results within three years of intervention, consideration should be made of the parameters that could affect stunting in the medium and long-term. Parameters that indirectly influence nutrition such as women's education and women's health care programs should be emphasized as they have shown protective effects on the household nutritional status as a whole. Particularly, interventions promoting the health of women of reproductive age (15-49 years) should be strengthened. Efforts should be made to avoid low birthweight because short stature mothers are more likely to have low birthweight babies who will be at increased risk of stunting.

The current interventions suggested in the PNAN II involve supplementation of micronutrients such as iron, folic acid, vitamin A and zinc for women aged 15-24 years and pregnant women through mass campaigns. The PNAN II also includes nutrition education programs for adolescents in community centers and nutrition education sessions in primary and secondary schools. No considerations were made about aspects of pregnant women's health such as antenatal visits or nutrition counseling during pregnancy. The Kenyan government placed the improvement of nutritional status of women of reproductive age as a priority for their National Nutrition Plan (59). One of the priority areas of the Kenyan nutrition plan is to promote regular weight monitoring and appropriate counseling of pregnant and lactating women, besides

promoting adequate micronutrient intake by improving nutrition knowledge among the population. Thus, in the Kenyan Nutrition Plan, multiple efforts are made to avoid low birthweight and complications during birth.

The PNAN II includes a wide variety of nutrition education programs targeted to mothers and women of reproductive age about healthy nutrition and complementary feeding. Bhutta et al. (7), however, pointed out that education strategies alone are less likely to be successful in reducing malnutrition in food insecure populations unless accompanied with food provision. Additionally, Liu and colleagues (60) predicted that Madagascar would remain one of the hotspots of food insecurity for the next decades. According to the population growth and the climate change, they reported that Madagascar would have less caloric intake per capita and a decrease in the capacity for importing food leading to additional undernutrition problems. Moreover, because more than 80% of the population make their living from agriculture, reinforcing this sector would not only give better food sources but also would improve household income. Minten and Barrett (61) suggested that ameliorating the yields of staple crops such as rice and cassava through the adoption of improved agricultural techniques were associated with better economic conditions for the poorest households in Madagascar. They also concluded that cash crop production such as vanilla and cloves were associated with improved welfare indicators.

Another point to be addressed in the fight against malnutrition in Madagascar is investment in capacity building and training of local human capital. As Morris et al. (56) reported, the lack of skilled personnel and nutrition specialists in developing countries is an obstacle for the success of nutrition actions. The results of the Landscape Analysis conducted in the 36 countries with the highest burden of undernutrition, including Madagascar, showed the inadequacy of the capacity of nutrition specialists in all of the countries. Postgraduate degrees in nutrition are limited and the existing ones tend to focus more on disease control (62). There is an

urgent need to design and implement nutrition curriculum throughout the teaching and research institutions in the country. Advanced training in nutrition should bring not only necessary knowledge and skills but also motivation and ability for malnutrition-related jobs and activities (56).

Overall, our results confirmed the multifactorial aspects of stunting, as several of the risks factors are not directly related to child nutrition. Promoting and implementing nutrition-sensitive interventions, essentially in agriculture, education and health should be seriously considered. One of the main strategic points of the PNAN II is to reduce food insecurity by diversifying agricultural activities. The PNAN II includes programs that promote the production of short cycle livestock and the culture of vegetables through dissemination of improved agricultural techniques, ensuring adequate access to micronutrients and animal products. Such nutrition-sensitive activities in different sectors would be helpful in the effort of reducing malnutrition. For instance, the Ethiopian Nutrition Plan aimed to strengthen nutrition related interventions in agriculture, education, sanitation and industry. Their initiatives in the education sector include promoting key nutrition actions in schools, such as gardening and nutrition clubs, as well as capacity building of teachers regarding nutrition and food security (63). The next National Nutrition Plan for Madagascar should be multi-sectorial as well and should be part of a broader action plan including agricultural, health and education-related considerations.

Our study is the first looking at the determinants of child stunting by using nationwide data according to the UNICEF framework on the causes of malnutrition. By doing so, this study explored the association between several explanatory variables and child stunting. The DHS sampling frame is widely known as representative and fairly captures the global situation within a country. However, there are some limitations in using survey data. For instance, recall bias can occur especially when asking about child nutrition and child feeding practices. Also, weight was omitted from the dataset because of the lack of precision during measurements. Thus, other

indicators of undernutrition and their determinants could not be calculated. Finally, not all the children included in the child dataset had their height measured resulting in a substantial amount of missing values. Despite all of these limitations, DHS data constitutes the primary source of quality data for nutrition and health status.

Conclusions

Our results confirmed that nearly half of the Malagasy children were stunted in 2009. Stunting prevalence and risks varied across different regions of Madagascar. The determinants of stunting were different in young children (0-23 months) and in children aged 24-59 months leading to the conclusion that nutrition interventions should be different for each age group. Because underlying and basic factors greatly affect children's nutritional status, consideration of these factors should be made when designing programs and nutrition actions targeting the reduction of stunting. Malnutrition is a multifactorial problem, so sustainable solutions should include different sectors mainly agriculture, education and public health as well as economy.

Table 3: Socio-demographic characteristics of the children under 5 years of age, Madagascar 2009 (n=4774).

Age groups	**0-23 months**		**24-59 months**	
Variables	**Frequency**	**Percentage (%)**	**Frequency**	**Percentage (%)**
Sex				
➢ Male	924	49.6	1480	50.8
➢ Female	939	50.4	1431	49.2
Wealth index quintile				
➢ Poorest	551	29.6	822	28.2
➢ Poorer	373	20.0	632	21.7
➢ Average	341	18.3	505	17.3
➢ Richer	300	16.1	488	16.8
➢ Richest	298	16.0	464	15.9
Area of residence				
➢ Urban	332	17.8	532	18.3
➢ Rural	1531	82.2	2379	81.7
Highest maternal education level				
➢ No education	553	28.6	813	27.9
➢ Primary	926	49.7	1512	51.9
➢ Secondary	371	19.9	558	19.2
➢ Higher	33	1.8	28	1.0
Breastfeeding				
➢ Never breastfed	10	0.5	24	0.8
➢ 0 - 6 months	531	29.0	46	1.6
➢ 7 - 12 months	557	30.5	350	12.2
➢ 13 - 23 months	729	39.9	1229	42.8
➢ 24 – 59 months	-	-	1221	42.5
➢ Missing	36		41	
Drinking water source				
➢ Unimproved[a]	851	46.6	1374	47.6
➢ Improved[b]	913	50.0	1420	49.2
➢ Piped water	62	3.4	90	3.1
➢ Missing	37		27	

Age groups	0-23 months		24-59 months	
Variables	**Frequency**	**Percentage (%)**	**Frequency**	**Percentage (%)**
Toilets facility				
➢ No toilet	1055	57.5	1598	55.1
➢ Latrines (bucket, hanging, pit)	705	38.0	1204	41.5
➢ Flush toilet	76	4.1	97	3.35
➢ Missing	27		12	

[a]Unimproved soure of water: surface water, spring water, river, rainwater

[b]Improved source of water: public tap, tube wells, dug wells.

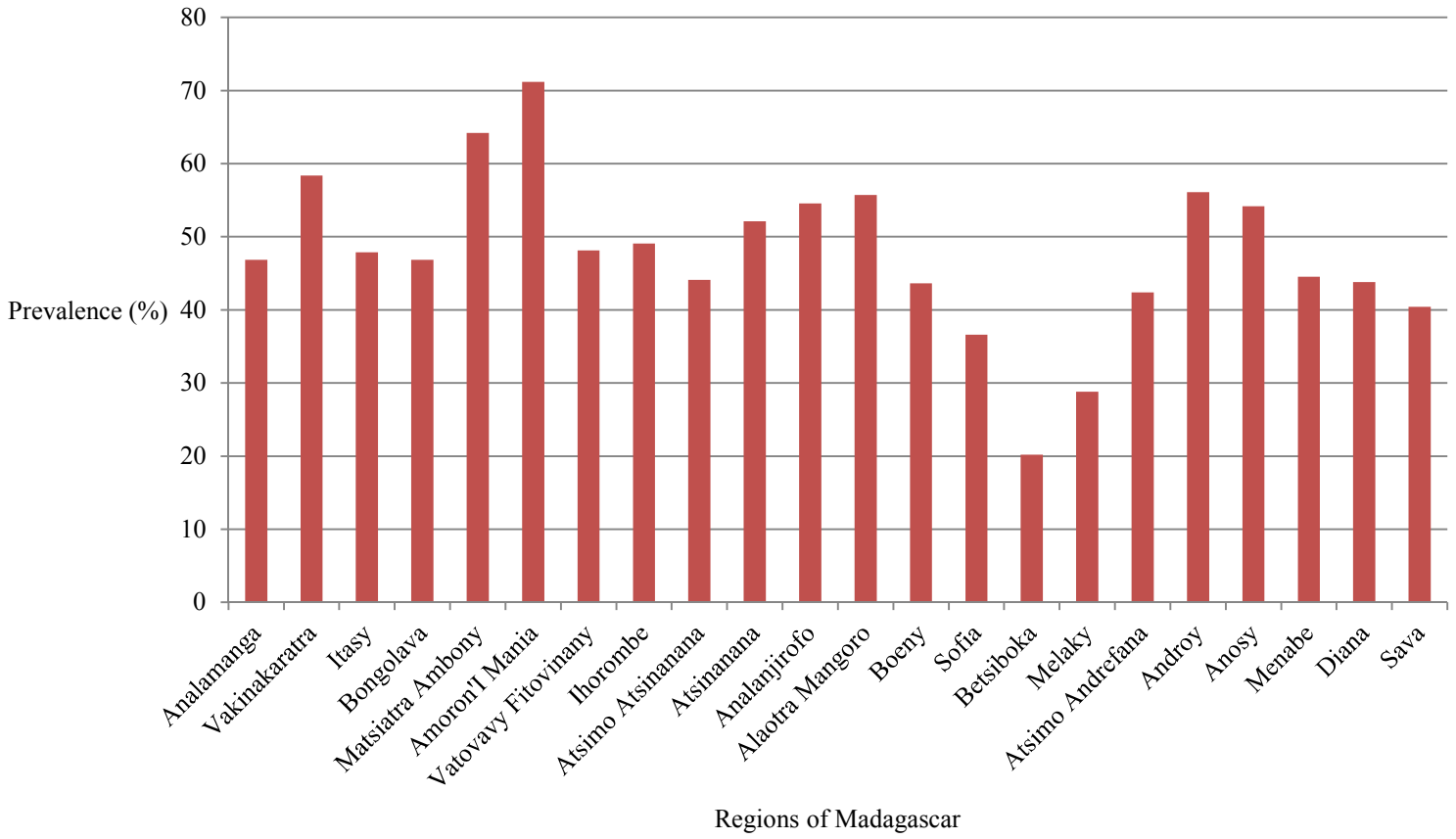


Figure 3: Prevalence of stunting in the regions of Madagascar

Table 4: Immediate factors of stunting in children under 5 years old, Madagascar 2009

Age group	**0-23 months (n=1171)**		**24-59 months (n=2749)**	
Variables	**COR (95% CI)**	**AOR (95% CI)**	**COR (95% CI)**	**AOR (95% CI)**
Sex of the child				
Male	1	1	1	1
Female	0.69 (0.58-0.83)***	0.69 (0.55 0.88)**	0.84 (0.72-0.97)*	0.84 (0.72-0.98)*
Age of child in months	1.08 (1.06-1.10)***	1.07 (1.04-1.09)***	1.01 (1.00-1.02)**	1.01 (1.00-1.02)**
Anemia level				
Not anemic	1	1	1	1
Mild	1.09 (0.84-1.42)	1.14 (0.85-1.53)	1.24 (1.05 -1.48)*	1.27 (1.06-1.50)**
Moderate	1.58 (1.21-2.07)**	1.72 (1.28-2.30)**	1.70 (1.37-2.22)***	1.80 (1.43-2.25)***
Severe	3.81 (1.47-9.92)**	3.50 (1.18-10.42)**	2.22 (0.68-7.26)	2.31 (0.70-7.57)
Immunization coverage[a]				
Incomplete	Not tested	Not tested	1	1
Complete			0.84 (0.72-0.97)*	0.84 (0.72-0.99)*
Time after birth for first breastfeeding				
Immediately	1	1	1	ns
At least after 1 hour	0.83 (0.68-1.01)	0.73 (0.57-0.94)*	0.99 (0.85-1.16)	
Calculated months of breastfeeding	1.09 (1.07-1.10)***	ns	1.01 (1.00-1.03)**	ns

OR: odds ratios; CI: confidence interval; COR: crude odds ratios; AOR: adjusted odds ratios

[a]Immunization coverage: complete if the child received BCG, DPT, hepatitis B and polio vaccines

*p-value < 0.05; **p-value < 0.01; ***p-value < 0.001

Table 5: Underlying factors (maternal and household) of stunting in children under 5 years old, Madagascar

Age group	**0 – 23 months**		**24 – 59 months**	
VARIABLES (maternal)	**COR (95% CI)**	**AOR (95% CI)**	**COR (95% CI)**	**AOR (95% CI)**
	n= 1731		**n= 1644**	
Maternal education No formal education Incomplete primary Complete primary Incomplete secondary Complete secondary Higher	ns	-	1 1.29 (1.08-1.53)** 1.08 (0.74-1.58) 0.87 (0.70-1.09) 0.26 (0.10-0.66)** 0.37 (0.16-0.85)*	-
Maternal HAZ	0.73 (0.66-0.81)***	0.77 (0.69-0.86)***	0.71 (0.66-0.77)***	0.69 (0.62-0.77)***
Currently breastfeeding No Yes	1 0.66 (0.50-0.87)**	1 0.63 (0.47-0.86)**	1 1.43 (1.24-1.66)***	1 1.29 (1.05-1.58)*
Tobacco use Yes No	ns	ns	1 1.40 (1.16-1.68)**	-
Land where mother works Own land Extended family's land Someone else's or rented	ns	ns	1 1.43 (1.14-1.79)** 0.79 (0.59-1.06)	1 1.63 (1.25-2.14)** 0.74 (0.53-1.03)
Employment status Working Not working	1 1.40 (1.03-1.89)*	-	ns	ns
Number of living children	ns	ns	1.08 (1.04-1.12)***	1.09 (1.04-1.15)***

Age group	0 – 23 months		24 – 59 months	
VARIABLES (maternal)	**COR (95% CI)**	**AOR (95% CI)**	**COR (95% CI)**	**AOR (95% CI)**
Frequency of watching TV	**n= 1731**	**n= 1644**		
Not at all			1	-
Less than once a week			0.88 (0.57-1.36)	
At least once a week			0.80 (0.47-1.38)	
Almost everyday			0.59 (0.46-0.75)***	
Maternal religion				
Traditional	1.41 (1.10-1.79)**	-	ns	ns
Christian/Muslim	1.26 (0.99-1.59)			
No religion	1			
VARIABLES (household)	**n=1739**		**n=1146**	
Wealth index				
Poorest	1.18 (0.88-1.60)	-	1.47 (1.17-1.86)	1.10 (0.29-4.07)
Poorer	1.41(1.03-1.93)*		1.72 (1.35-2.20)***	3.13 (1.94-5.95)***
Average	1.35 (0.98-1.87)		1.96 (1.52-2.53)***	3.18 (2.03-4.96)***
Richer	1.59 (1.14-2.21)**		1.69 (1.30-2.18)***	2.31 (1.59-3.36)***
Richest	1		1	1
Number of household members	ns	ns	1.03 (1.02-1.06)*	1.06 (1.00-1.13)**
Salt iodine test				
0 - 7 ppm	1	1	1	-
8 - 15 ppm	0.92 (0.70-1.20)	0.92 (0.71-1.20)	0.78 (0.63-0.96)*	
> 15 ppm	0.76 (0.61-0.94)*	0.76 (0.61-0.94)*	0.61 (0.52-0.73)***	
Toilets facility shared				
Yes	ns	ns	1	1
No			0.78 (0.58-0.91)**	0.63 (0.48-0.82)*

OR: odds ratios; CI: confidence interval; COR: crude odds ratios; AOR: adjusted odds ratios

ns: not significant; *p-value < 0.05; **p-value < 0.01; ***p-value < 0.

Table 6: Basic factors of stunting in children under 5 years old, Madagascar 2009

Age group	**0 – 23 months n= 1863**	**24 – 59 months n= 2911**
VARIABLES	**Adjusted OR (95% CI)**	**Adjusted OR (95% CI)**
Area of residence		
Rural	1	1
Urban	0.67 (0.51-0.88)**	0.73 (0.59-0.90)**
Region of residence		
Analamanga[a]	1	1
Alaotra Mangoro	1.06 (0.60-1.89)	1.38 (0.88-2.17)
Amoron'I Mania	2.45 (1.44-4.16)**	2.34 (1.51-3.64)**
Analanjirofo	0.89 (0.46-1.72)	1.26 (0.78-2.03)
Androy	1.07 (0.62-1.84)	1.30 (0.84-2.02)
Anosy	0.59 (0.32-1.09)	1.75 (1.10-2.79)*
Atsimo Andrefana	0.57 (0.32-0.99)*	0.91 (0.58-1.41)
Atsimo Atsinanana	0.67 (0.39-1.14)	0.85 (0.57-1.28)
Atsinanana	1.00 (0.54-1.86)	1.13 (0.74-1.34)
Betsiboka	0.22 (0.11-0.43)***	0.25 (0.16-0.41)***
Boeny	1.19 (0.69-2.07)	0.59 (0.37-0.94)*
Bongolava	0.69 (0.34-1.44)	0.93 (0.54-1.60)
Diana	1.21 (0.66-2.21)	0.57 (0.33-0.96)*
Ihorombe	0.84 (0.502-1.415)	1.04 (0.69-1.55)
Itasy	0.53 (0.29-0.96)*	1.08 (0.71-1.65)
Matsiatra Ambony	1.44 (0.88-2.36)	2.26 (1.48-3.45)**
Melaky	0.28 (0.13-0.60)**	0.42 (0.2-0.66)**
Menabe	0.97(0.53-1.77)	0.71 (0.43-1.15)
Sava	0.66 (0.33-1.32)	0.65 (0.39-1.06)
Sofia	0.41 (0.23-0.73)**	0.66 (0.43-1.00)
Vakinakaratra	1.54 (0.89-2.66)	1.25 (0.81-1.91)
Vatovavy Fitovinany	0.680 (0.39-1.19)	1.00 (0.66-1.52)

OR: odds ratios; CI: confidence interval

[a]Capitol city region

*p-value < 0.05; **p-value < 0.01; ***p-value < 0.001

CHAPTER V

INFANT AND YOUNG CHILD FEEDING (IYCF) INDICATORS IN MADAGASCAR: ANALYSIS OF THE DEMOGRAPHIC AND HEALTH SURVEY

Introduction

Childhood malnutrition remains a public health challenge, especially in low and middle-income countries, as more than one third of the disease burden is due to maternal and child undernutrition (8). Recent findings that growth faltering occurs sooner than expected in infants confirms the importance of nutrition during the first two years of life to ensure optimal growth and development for children (42). Aware that feeding practices directly impact nutritional status of infants and young children, the WHO validated a set of indicators to assess infant and child feeding practices across countries (23). The eight core indicators consider both breastfeeding and complementary feeding practices (Table 1).

Generally suboptimal IYCF indicators are observed in countries with the highest burden of malnutrition. The reported rates of exclusive breastfeeding under 6 months were relatively low in certain countries such as Ethiopia (43%), Zambia (51.4%), Bangladesh (36.1%) and India (42%) (29). Inappropriate complementary feeding practices were also reported in Ethiopia and Zambia where the proportion of children aged 6-23 months given more than four food groups in a day were respectively 7.1% and 37.1% (30).

For Madagascar, from the 2004 data, 61% of infants were breastfed within the first hour of birth, 67% were exclusively breastfed under 6 months and 78% were introduced to complementary foods between 6 and 8 months, showing better infant feeding practices than the average of the least developed and Sub-Saharan countries (28). Yet for the complementary feeding indicators such as dietary diversity (31%) or minimum acceptable diet (25%), practices still need improvement.

Few studies have looked at the determinants of IYCF practices in developing countries. Results showed that educated mothers were more likely to have appropriate complementary feeding practices regarding minimum meal frequency, dietary diversity, minimum acceptable diet and iron-rich food consumption in Uganda (31). Kabir et al. (32) found similar results in Bangladesh, as non-educated mothers were less likely to meet the recommendations for complementary feeding. Moreover, Na et al. (33) reported that increased maternal access to financial resources had positive association with the minimum dietary diversity and the minimum acceptable diet criteria in nine sub-Saharan African countries. Additionally, children living in the poorest households were more likely to have untimely introduction to complementary foods in India and Pakistan (14).

Area of residence has also been suggested to play a role in IYCF practices as Senarath et al. (64) found that children living in urban areas and in tea estates were less likely to be introduced to complementary food at 6-8 months. For Madagascar, the results of the Comprehensive Food and Nutrition Security and Vulnerability Analysis (CFSVA+N) showed that maternal education was associated with early initiation of breastfeeding, minimum dietary diversity and minimum acceptable diet. The report also stated that family wealth was associated with having greater diet diversity in complementary foods (48).

Study results are not consistent about the association of IYCF and child growth, especially when stunting is used as indicator. Marriott et al. (65) used pooled data from 14 developing countries to determine the relationship between IYCF indicators and stunting in children under 2 years old. Only timely introduction of solid and semi-solid foods, having a minimum acceptable diet and consumption of iron-fortified foods were associated with lower risk of stunting. Having minimum dietary diversity was also associated with better length-for age z-scores (LAZ) of the children in Bangladesh and Zambia (29). Continued breastfeeding at 1 year was inversely correlated with HAZ in Zimbabwe, Ethiopia and Zambia (29, 30). Additionally, in a study using the Cambodian DHS, only exclusive breastfeeding was associated with less stunting (66). Not all of the IYCF indicators are associated with child anthropometrics and findings tend to be different according to the country. Thus, there is a need to study the relationship between child undernutrition and the IYCF indicators at the country level.

Only a few studies have looked at the infant and young child feeding practices in relation to child nutrition in Madagascar. For instance, Moursi et al. (67) reported that infant complementary feeding indicators were correlated with total energy intake and minimum diet diversity adequacy in infants aged 6-23 months in urban areas. They also found that dietary diversity was positively associated with LAZ. Another study (68) looked at the pertinence of cross-sectional and longitudinal infant and children feeding indicators and their relationship with LAZ in infants 6-17 months. They elaborated cross sectional and longitudinal feeding indicator scores including breastfeeding status, bottle feeding, diet diversity score, food group frequency score and feeding frequency score. They noticed that the cross-sectional indicators were not significantly associated with LAZ in contrast to the longitudinal indicators in which the score is obtained from the sum of the cross sectional indicators. To our knowledge, our study is the first to look at the association of the WHO IYCF indicators and child stunting in Madagascar using

nation-wide data. We also aim to investigate the maternal and household factors associated with inappropriate IYCF practices.

Methods

Publicly available data from the latest Demographic and Health Survey (2009) in Madagascar were used. By using two-stage cluster sampling, information about fertility, family planning, maternal and child health, gender, HIV/AIDS, malaria and nutrition were collected at the national level (69). For the purpose of this study, we used the child dataset containing information about children born within the last 5 years. Specifically we analyzed data from infants and young children aged 0-23 months. The dataset included 1956 observations.

Binary variables corresponding to each of the definitions of IYCF indicators were created in compliance with the recommendations. The minimum diversity variable was created from the diet diversity score of each child and coded as 1 if the child had eaten at least from 4 or more food groups the day before the interview and 0 otherwise. The food groups were defined as 1) grains, roots and tubers, 2) legumes and nuts, 3) dairy products, 4) flesh foods, 5) eggs, 6) vitamin A-rich fruit and vegetables and 7) other fruit and vegetables (4). Information was not collected about the meal frequency thus we were not able to evaluate the indicators 6 and 7: minimum meal frequency and minimum acceptable diet. Because no data about the consumption of iron-fortified foods were collected, the indicator 8: consumption of iron-rich foods was estimated on the consumption of flesh foods (meat, fish, poultry and liver/organ meats).

Stunting was defined by the 2006 WHO growth standards: children with length/height-for-age z-scores (LAZ/HAZ) below -2 were considered stunted (39). Thus, a binary variable was also created for the LAZ/HAZ.

Logistic regressions were used to determine the association between the IYCF indicators and stunting. Chi-square tests and logistic regressions were performed to assess the relationship

between the maternal and household factors and IYCF indicators. All the statistical analyses were computed on SAS, v. 9.4 (SAS Institute, Cary, NC, USA) and a significance level of 5% was chosen.

Results

Characteristics of the infants and mothers

A total of 40.7% of the children aged 6-23 months in Madagascar were stunted. There was no difference between the proportions of boys and girls. More than half of the mothers (53.8%) were younger than 19 when they first gave birth (Table 7). A substantial proportion of the mothers had no formal education (28.8%) and almost half of them only attended primary school (49.5%). Exposure to media was very low because most mothers never read newspapers nor magazines (84.9%), listened to radio (46.5%) nor watched television (85.8%). The great majority of the households lived in rural areas (82.2%). Nearly half (49.6%) of the children lived in households with the two lowest quintiles of the wealth index. Additionally, more than half of the households (57.6%) did not have toilets and almost half (47%) drank from unimproved sources of water such as rainwater, spring or surface water.

Situation of IYCF indicators in Madagascar in 2009

A substantial number of infants were put to the breast within the first hour after birth (78.1%) and continued breastfeeding at one year was almost universal (99.6%) as seen in figure 4. However, exclusive breastfeeding was relatively low as less than half of the mothers (49%) exclusively breastfed their infants during the first 6 months. A total of 77.2% of the infants had timely introduction to complementary foods at 6-8 months. Only 17.4% of the infants aged 6-23 months ate from four or more food groups. And an extremely small proportion (1.8%) ate an iron-rich food the previous day.

IYCF and Stunting

No significant associations were found between any of the six IYCF indicators tested and stunting. Because children's weight was not reported in the 2009 DHS data for Madagascar, we could not test the association between IYCF practices and wasting (low height-for-weight) or underweight (low weight-for-age).

Determinants of Inappropriate IYCF in Madagascar

Because of the high compliance with continued breastfeeding at one year (only one observation did not comply), the indicator was not tested for regression models.

Sex of the child was not a determinant for any of the IYCF indicators. Infants whose mothers gave birth for the first time at an age younger than 19 years were more likely not to breastfed within the first hour (OR=1.29). Also, rich and richer households were less likely to have inappropriate early initiation breastfeeding practices (OR=0.62 and OR=0.55, respectively) compared to the poorest households (Table 8).

Maternal age at first birth was the only factor significantly associated with exclusive breastfeeding under six months. Infants of mothers who first gave birth at an age younger than 19 years had 60% higher risk of not being exclusively breastfed during the first 6 months (OR=1.60).

For the complementary feeding indicators, none of the factors tested were associated with the time of introduction of solid, semi-solid or soft foods. Infants whose mothers attended secondary school or higher had lower odds of having inadequate dietary diversity (OR=0.20 for secondary school and OR=0.05 for higher). Maternal exposure to media was also associated with adequate dietary diversity in infants. For instance, infants whose mothers did not listen to radio at all were more likely to have inadequate dietary diversity (OR=3.30) compared to those whose mothers listened to radio almost everyday. Likewise, infants were more likely to have inadequate

dietary diversity if their mothers did not read newspaper (OR=9.22) or did not watch TV (OR=2.30) at all. Additionally, infants born to younger mothers had higher risks of being fed with inappropriate dietary diversity (OR=1.61).

Infants of mothers who worked were at higher risks of having children with inadequate dietary diversity (OR=1.82). The odds of having inappropriate dietary diversity decreased with increased wealth of the family (OR=0.51 for the middle, OR=0.35 for the richer and OR=0.09 for the richest). Children whose mothers attended high school or higher education had lower chances of inadequate consumption of iron-rich foods. Finally, children living in rural areas had higher odds of having inadequate iron-rich food consumption.

Discussion

IYCF indicators for Madagascar

For the breastfeeding indicators, our results suggest that although the rate of exclusive breastfeeding under 6 months was low (49.0%), the two other breastfeeding practices indicators were high in Madagascar. A total of 78.1% of the children were put to breast within one hour after birth and continued breastfeeding at one year was almost universal (99.6%). Compared to the data published by WHO (28), all of the breastfeeding indicators were improved except for the exclusive breastfeeding rate, which was decreased from 67% to 49% (Figure 5). The decline in the rate of exclusive breastfeeding may be due to an increased number of working mothers because in 2009, a total of 88.6% of the mothers of infants aged 0-23 months were working. Thus, because of time constraints, they are more likely to have mixed feeding practices. The indicators are different from the State of the World's Children (SOWC) 2015 data (2) probably because they used both the 2009 DHS and the Multiple Indicators Cluster Surveys (MICS) as data sources. However, whether or not they used pooled data is not clear. Additionally, the results of the CFSVA+N in 2010 (48) showed that the rate of exclusive breastfeeding was higher

(74.5%) and the rate of early introduction of breastfeeding (58.5%) as well as the continued breastfeeding (96%) were lower in rural areas compared to Madagascar as a whole.

For the complementary feeding indicators, the rate of timely introduction of complementary foods from 2004 to 2009 hardly changed: 78% to 77.2% (Figure 6) based on DHS data. A considerable decrease was noticed in the percentage of infants who received the minimum dietary diversity from 31% to 14.4%. For the DHS 2009, data collection was conducted from November 2008 to August 2009, which coincided with a political crisis in the country. This may have contributed to the sizeable drop in the rate of minimum dietary diversity, as political instability is one of the basic causes of inadequate nutritional status in children. Additionally, there were even fewer infants in rural areas who had received the minimum dietary diversity according to the CFSVA+N analysis (14.1%) in 2010 (13).

Regarding IYCF indicators, compared to other countries with high burdens of undernutrition, only the rates of early introduction of breastfeeding and the continued breastfeeding at one year were higher in Madagascar with 99.6% (figure 7). The rate of timely introduction of complementary food was high (77.2%) but still lower than in Zambia (90%). The proportions of infants who received adequate dietary diversity were low for all of the countries investigated ranging from 7.1% in Ethiopia to 37.4% in Zambia. Similarly, the consumption of iron-rich/iron-fortified foods by children was low in all of the countries but it was dramatically worse for Madagascar (1.8%). The higher rate of consumption of iron-rich/iron-fortified foods in Zambia maybe the result of the iron fortification of commercialized milled maize. (70)

IYCF and stunting

None of the six core IYCF indicators tested showed a significant relationship with stunting. Jones et al. (29) found similar results in Cambodia, Haiti, Kenya and Uganda while using DHS data as well. They only found significant associations between stunting and the

introduction of solid, semi-solid or soft foods in Bangladesh; minimum dietary diversity in Cambodia and the minimum acceptable diet in Zimbabwe. The authors argued that the 24 h-recall nature of the study does not allow one single indicator to capture the whole situation of feeding practices. Because the questions are only considering the feeding practices the previous day (the last 24 hours), no matter how the infant had been fed in the past, as long as the caregivers had appropriate feeding practices the previous day, they will still be compliant with the indicator. For instance, infants who had been given liquids two days prior to the survey might be considered as exclusively breastfed if they were not given any other liquid than breast milk the day before the survey. They suggested that the lack of sensitivity of the indicators might explain the lack of association between some IYCF indicators and child anthropometric measurements.

Determinants of inappropriate IYCF practices

Sex of the child was not associated with any of the IYCF indicators tested suggesting that no differences were made by mothers or caregivers between boys and girls regarding feeding practices. Kabir et al. (32) found similar results while studying the determinants of inappropriate IYCF practices in Bangladesh.

Being born to a mother who gave birth at 19 or older or living in a family in the third and fourth quintile of wealth index was associated with an improved chance of initiating breastfeeding within the first hour after birth. A study using the Nigeria DHS reported that mothers with higher wealth were more likely to comply with the early initiation of breastfeeding (71). Richer households may have more access to health care and may have been in contact with health care professionals who encouraged better breastfeeding practices.

Lower odds of inadequate diet diversity in infants were associated with higher maternal education, greater maternal exposure to media and household wealth. Similar results were found in Bangladesh (32) and Uganda (31) as children of mothers with no formal education had higher

odds of not meeting the minimum dietary diversity criteria. Exposure to media may be used as a proxy for family wealth as owning a radio or a television or having access to a newspaper may reflect higher resources in the household. Additionally, studies across countries confirmed that increased family wealth was associated with better chances of meeting minimum dietary diversity (21, 31). Higher household wealth generally means having access to more diverse food and more resources can be allocated to childcare and nutrition.

Our results showed that infants of working mothers had higher odds of inadequate dietary diversity. There is no clear explanation about the association between the maternal working status and the dietary diversity score except that working mothers generally spend time away from their children, which may lead to poor complementary feeding practices. Additionally, caretakers might not be knowledgeable about infant and young children nutrition and good feeding practices.

The consumption of iron-rich foods was associated with secondary or higher maternal education. Additionally, children living in rural areas were less likely to eat flesh foods. The overall poor dietary diversity and poor consumption of iron-rich food may be linked to the access to food and to the general food insecurity in the country. Analyses from the CFSVA+N concluded that the seasonality of earnings due to a non-diversified income source in Malagasy households affects the access to food throughout the year (48). Thus, 84% of the households experienced a time in the year when they did not have sufficient food. Yet, when food was available, other factors may play a role in inappropriate complementary feeding such as maternal or caretaker nutrition knowledge or attitudes (58).

Implications for programs and nutrition interventions

Although we concluded that none of the IYCF indicators were associated with stunting in Madagascar, having appropriate feeding indicators has been associated with children's

anthropometric measurements in several countries (29). Thus, improvements in breastfeeding and complementary feeding practices are still needed.

The younger maternal age at first birth (less than 19) was associated with inappropriate breastfeeding and minimum diet diversity. Programs that promote avoidance of teen pregnancy and sexual education among youth may be needed as 53.3% of the Malagasy mothers were younger than 19 when they had their first child. Additionally, pregnant adolescents are more likely to give birth to low birthweight babies and are at risk of adverse birth outcomes (72).

Other maternal characteristics were also associated with inadequate complementary feeding such as low or no formal maternal education and low exposure to media. Improved maternal education has been linked to improved complementary feeding practices (31). Additionally, women's empowerment interventions may lead to better nutritional outcomes. For instance, a study done across sub-Sahara African countries demonstrated that women who made decisions on large purchases and who have control over the household income were more likely to have adequate complementary feeding practices (33).

Integrated nutrition interventions aiming to improve overall nutrition outcomes also have been shown to be efficient in ameliorating inadequate IYCF practices. A pilot study, implementing the Essential Nutrition Actions (ENA) framework, was done in two districts of Madagascar in 2000 and reported a significant increase in early breastfeeding, in exclusive breastfeeding under 6 months, and in meeting the minimum meal frequency for young children (73). Through technical support and various trainings, as well as micronutrient supplementation, the ENA promotes key messages about maternal and child nutrition including feeding practices. The authors reported that involving a wide array of partners and creating a favorable policy environment through policy analysis and development were the key factors for the success of the

pilot study. Thus, implementing of such programs on a larger scale would be helpful in an effort to improve IYCF practices.

Conclusions

The IYCF indicators for Madagascar were low, especially for the complementary feeding practices. Our results did not show any association between stunting and any of the IYCF indicators. Younger maternal age at first birth, low maternal education and low household wealth were associated with inappropriate feeding practices. Addressing food insecurity, increasing access to food and creating income generation opportunities may be needed in order to implement programs that improve complementary feeding practices in Madagascar.

Table 7: Characteristics of the infants aged 0-23 months and their mothers, Madagascar 2009 (n=1956).

Variables	Percentage (%)
Individual factors	
Sex	
- Male	49.7
- Female	50.3
Nutritional status	
- Not stunted	59.3
- Stunted	40.7
Maternal characteristics	
Age at first birth	
- Younger than 19	53.9
- 19 and older	46.1
Highest maternal education level	
- No education	28.9
- Primary	49.5
- Secondary	19.8
- Higher	1.7
Exposure to media	
Frequency of reading newspaper/magazine	
- Not at all	84.9
- Once a week	8.8
- At least once a week	3.9
- Almost every day	2.1
Frequency of listening to radio	
- Not at all	46.6
- Once a week	10.5
- At least once a week	11.2
- Almost every day	31.6
Frequency of watching TV	
- Not at all	85.9
- Once a week	2.7
- At least once a week	2.4
- Almost every day	8.9
Maternal current breastfeeding status	
- No	13.3
- Yes	86.7
Maternal working status	
- Working	88.6
- Not working	11.3
Household characteristics	

Wealth Index	
- Poorest	29.5
- Poor	20.1
- Middle	18.4
- Richer	16.0
- Richest	15.8
Area of residence	
- Rural	82.2
- Urban	17.7
Toilet facilities	
- No toilet	57.6
- Latrines (pit/hanging/bucket)	38.1
- Flush toilets	4.2
Drinking water source	
- Unimproved[a]	47
- Improved[b]	49.6
- Piped water	3.3

[a]Unimproved soure of water: surface water, spring water, river, rainwater.

[b]Improved source of water: public tap, tube wells, dug wells.

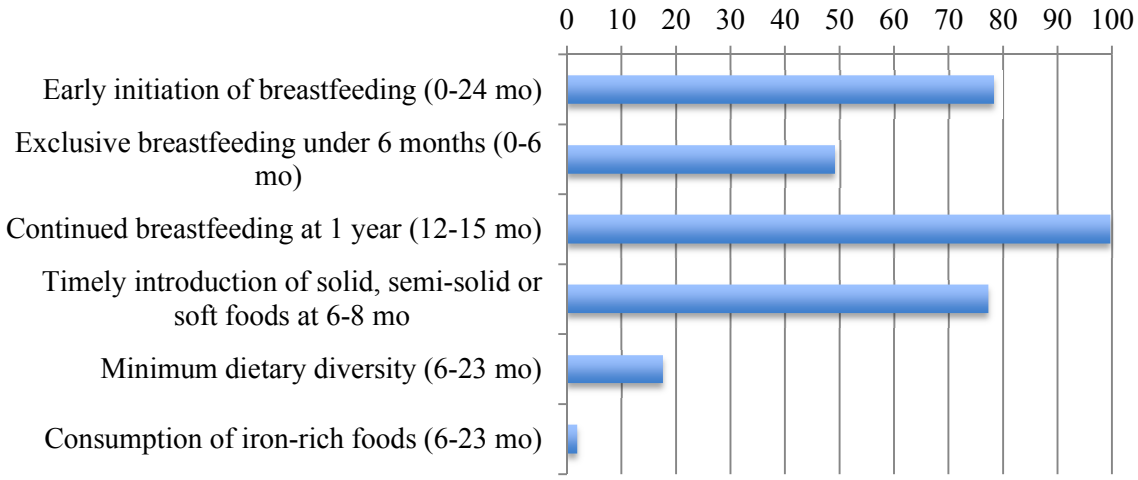


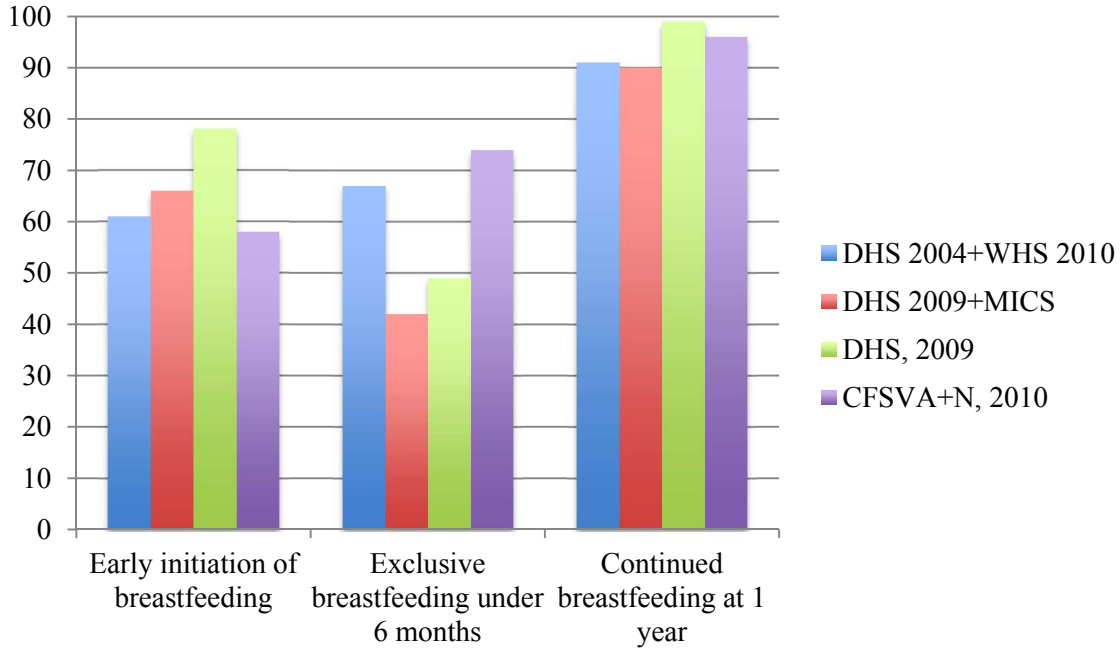
Figure 4: Infant and young child feeding (IYCF) indicators for Madagascar based on the DHS 2009.

Table 8: Determinants of inappropriate infant and young child feeding (IYCF) practices, Madagascar 2009.

Results expressed as crude odds ratios OR (95% CI).

Variables	Early introduction of breastfeeding	Exclusive breastfeeding under 6 months	Introduction of semi-solid, solid and soft foods	Minimum dietary diversity	Consumption of iron-rich/iron-fortified foods
	Individual factors				
Sex (ref. male)	1.10 (0.88-1.37)	0.71 (0.49-1.02)	1.50 (0.83-2.69)	1.06 (0.81-1.40)	1.70 (0.77-3.78)
	Maternal factors				
Age at first birth					
- 19 and older	1	1	1	1	1
- Less than 19	1.29 (1.03-1.61)*	1.60 (1.10-2.32)*	1.08 (0.60-1.94)	1.61 (1.22-2.12)***	0.85 (0.39-1.84)
Maternal education					
- No formal education	1	1	1	1	1
- Primary	0.82 (0.64-1.06)	0.87 (0.57-1.35)	0.57 (0.30-1.08)	0.76 (0.51-1.13)	0.39 (0.11-1.38)
- Secondary	0.71 (0.51-0.99)	0.67 (0.39-1.16)	0.55 (0.23-1.30)	0.20 (0.13-0.30)***	0.295 (0.07-1.15)
- Higher	1.33 (0.62-2.88)	1.68 (0.30-9.51)	0.79 (0.08-7.99)	0.05 (0.02-0.13)***	0.06 (0.01-0.30)***
Media exposure					
Reading newspaper					
- Not at all	1.28 (0.56-2.93)	1.02 (0.29-3.58)	0.79 (0.15-4.18)	9.22 (4.32-19.68)**	2.21 (0.28-17.12)
- At least once a week	1.32 (0.55-3.15)	1.06 (0.28-4.05)	0.37 (0.05-2.59)	2.17 (0.98-4.84)	1.000 (0.11-8.62)
- Almost every day	1	1	1	1	1
Listening to radio					
- Not at all	1.35 (1.05-1.75)*	1.24 (0.80-1.89)	1.96 (0.93-4.10)	3.30 (2.38-4.57)***	1.68 (0.76-3.71)
- At least once a week	1.05 (0.76-1.44)	0.79 (0.48-1.29)	2.33 (0.92-5.87)	1.59 (1.12-2.28)*	9.07 (1.18-89.65)*
- Almost every day	1	1	1	1	1
Watching TV					
- Not at all	1.16 (0.78-1.73)	1.026 (0.53-1.99)	2.30 (0.66-7.99)	7.62 (5.18-11.21)***	4.35 (1.75-10.77)**
- At least once a week	0.79 (0.40-1.52)	1.14 (0.434-2.98)	2.09 (0.29-15.19)	2.53 (1.36-4.72)**	1.26 (0.32-5.05)
- Almost every day	1	1	1	1	1

Variables	Early introduction of breastfeeding	Exclusive breastfeeding under 6 months	Introduction of semi-solid, solid and soft foods	Minimum dietary diversity	Consumption of iron-rich/iron-fortified foods
Work status					
- No	1	1	1	1	1
- Yes	1.22 (0.85-1.76)	0.96 (0.57-1.63)	1.15 (0.47-2.802)	1.82 (1.22-2.71)**	1.18 (0.54-2.56)
	Household factors				
Wealth Index					
- Poorest	1	1	1	1	1
- Poorer	0.79 (0.59-1.07)	0.80 (0.46-1.41)	0.43 (0.19-0.97)	0.76 (0.45-1.29)	1.41 (0.35-5.68)
- Middle	0.62 (0.45-0.87)**	0.63 (0.37-1.08)	0.70 (0.30-1.63)	0.51 (0.30-0.84)**	1.19 (0.29-4.82)
- Richer	0.55 (0.38-0.78)*	0.47 (0.22-0.84)	0.68 (0.27-1.72)	0.35 (0.21-0.57)***	0.80 (0.22-2.88)
- Richest	0.75 (0.54-1.05)	0.69 (0.39-1.22)	0.37 (0.14-0.99)	0.09 (0.059-0.15)***	0.31 (0.11-0.87)
Area of residence					
- Urban	1	1	1	1	1
- Rural	1.05 (0.79-1.41)	1.11 (0.71-1.81)	2.26 (0.91-5.62)	4.07 (2.95-5.47)	2.56 (1.13-5.82)*



Data sources:

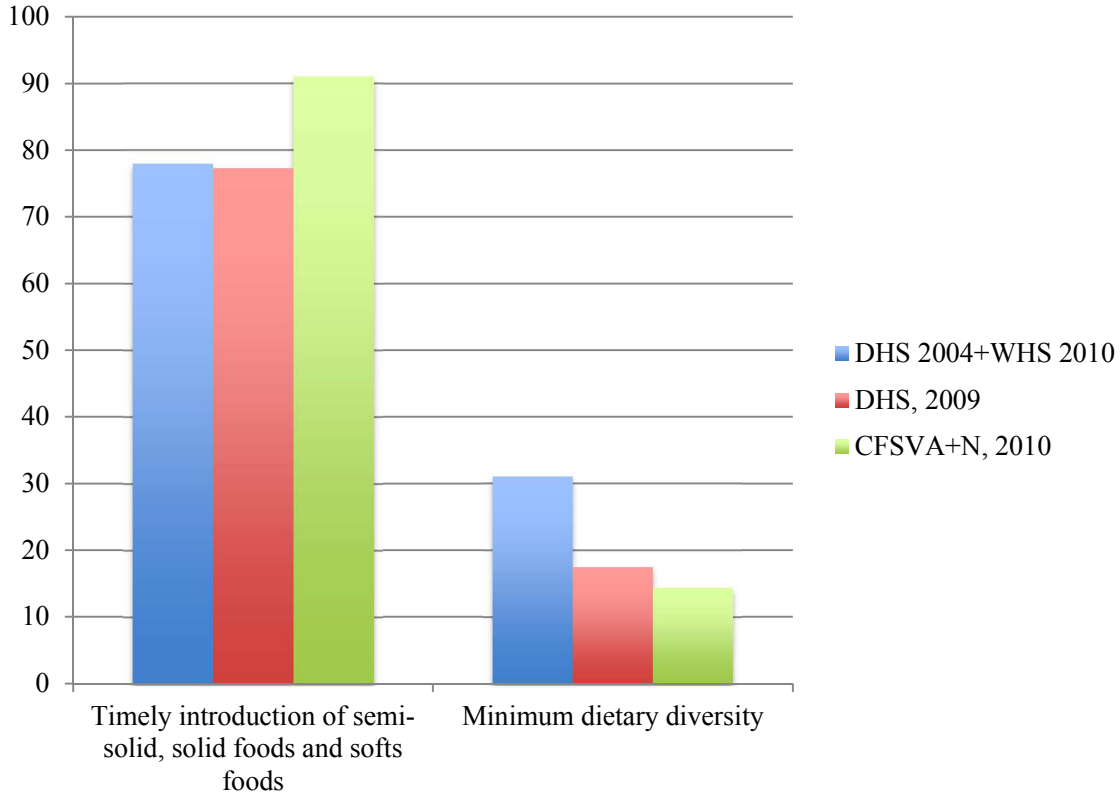
DHS: Demographic and Health Surveys

WHS: World Health Statistics

MICS: Multiple Indicators Cluster Surveys

CFSVA+N: Comprehensive Food and Nutrition Security and Vulnerability Analysis in rural areas

Figure 5: Comparisons between the breastfeeding indicators from different surveys in Madagascar. Results expressed as percentages (%)



Data sources:

DHS: Demographic and Health Surveys

WHS: World Health Statistics

CFSVA+N: Comprehensive Food and Nutrition Security and Vulnerability Analysis in rural area

Figure 6: Comparisons between selected complementary feeding indicators from different surveys in Madagascar. Results expressed by percentages (%).

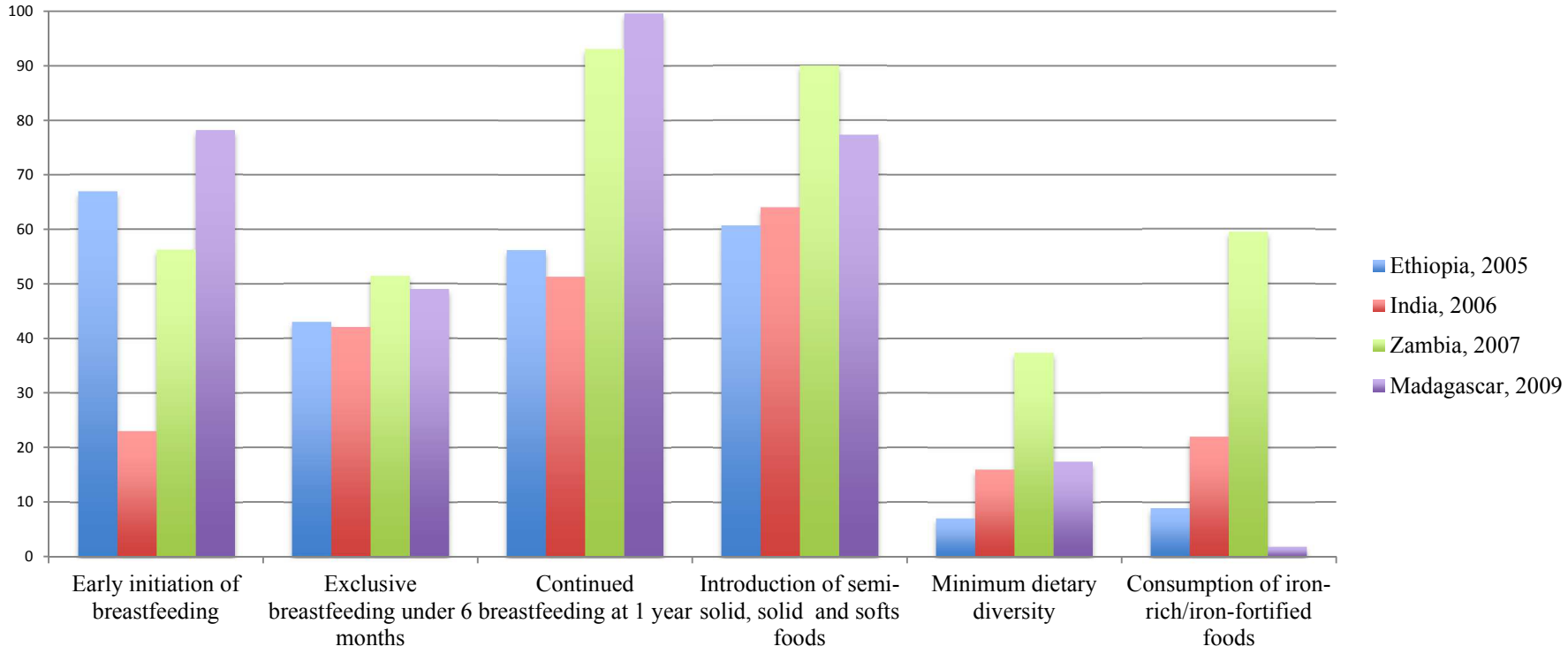


Figure 7:Comparison between countries of the infant and young child feeding (IYCF) indicators

CHAPTER VI

CONCLUSIONS

Our results confirmed the high prevalence of stunting in children under five years of age (48.5%) in Madagascar. The prevalence was higher in children older than 2 years (53.1%) than in the younger group (40.1%). A substantial proportion of the children lived in households with precarious conditions including unsafe sources of drinking water or non-existent toilet facilities. Sex and age of the child as well as anemia level and complete immunization coverage were identified as immediate factors affecting stunting. Maternal and household characteristics such as maternal HAZ, use of iodized salt and wealth were the main underlying factors affecting child stunting. Basic factors included areas and regions of residence.

Madagascar's National Nutrition Plan (2012) included a wide variety of interventions and strategies focused on reducing child and maternal undernutrition. Yet, our results suggest the need for regional nutrition plans and the need for separate interventions for infants aged 0-23 months and children aged 24-59 months. Moreover, investing in capacity building of local human resources and creation of nutrition curriculum may be the most sustainable way to build the needed capacity. Given the multifactorial aspects of stunting, the National Nutrition Plan should consider all sectors that could affect nutritional status such as agriculture, education, health and economic sectors.

Regarding feeding practices, the rates of early initiation of breastfeeding, of continued breastfeeding at 1 year and of timely introduction of complementary foods were reasonable in Madagascar. However, the exclusive breastfeeding rate, the proportion of children who received the minimum diet diversity and the consumption of iron-rich food were particularly low. No association was found between any of the IYCF indicators and stunting. The main determinants of inappropriate feeding practices included, but were not limited to, lack of maternal education, young maternal age at first birth, low maternal exposure to media and low household wealth.

Our findings constitute the first analysis of data on the determinants of child stunting in Madagascar, thus further research is needed in the field of undernutrition in the country. More focused or regional studies should be done in terms of the key factors affecting children's nutritional status, as social, economic and cultural contexts are different across the 22 regions. Additionally, results of interventions targeting the reduction of undernutrition should be reported and disseminated so lessons could be learned about what interventions are effective and efficient. Concerning IYCF indicators, more sensitive indicators could be created to assess feeding practices in children and their association with child undernutrition. The results of our study will be published in international journals.

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