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Applied formative research investigating the multi-level determinants of Multiple Micronutrient Supplementation among pregnant women in Bangladesh and Madagascar – a biocultural perspective

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ABSTRACT

Maternal malnutrition poses a significant global public health risk, especially in low- and middle-income countries such as Madagascar and Bangladesh. Nutrient deficiencies, commonly the result of inadequate dietary intake, can result in several adverse health outcomes for a pregnant woman and her developing child -- such as iron-deficiency anemia, hemorrhage during birth, childhood stunting, neural tube defects, and other birth complications. In order to help mitigate the effect of these complications, it is necessary to address the underlying nutrient deficiencies which contribute to them. When it is difficult to improve the nutritional status of a pregnant woman's dietary intake in certain settings, prenatal micronutrient supplementation or food fortification programs have been used to bolster her nutritional intake. Multiple Micronutrient Supplementation (MMS) is the supplement currently recommended by the World Health Organization for countries facing a significant burden of maternal malnutrition.

In this study, we use data collected from focus group discussions, community workshops, and semi-structured interviews to elucidate the multilevel determinants of a woman's potential compliance with MMS during pregnancy, comparing these determinants in Bangladesh and Madagascar. The findings suggest that, despite the geographical and cultural differences that exist between Madagascar and Bangladesh, the most salient determinants at each level—community, institutional, interpersonal, and individual—are very similar, yet still culturally bound within the cultural and social experience of those living within the communities. These findings thus highlight important factors to address in strategizing to ensure culturally appropriate and locally tailored MMS implementation programs.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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Chapter 1

Introduction

Global Burden of Malnutrition

The status of maternal nutrition throughout the pregnancy life stage is a vital determinant in many pregnancy and birth-related health outcomes, for both the pregnant woman and her developing baby. The nutritional status of a woman both prior to and during her pregnancy are directly linked to fetal growth and development, to the birth weight of the infant, to short- and long-term infant morbidity and mortality, and to the health of the pregnant woman during her pregnancy and during her birth (Christian et al., 2020; Hyde et al., 2016; Imdad et al., 2012). Maternal malnutrition both before and during pregnancy can thus have several adverse consequences on both maternal and fetal health (Dell et al., 2010). This includes low birth weight and poor fetal development of the child, as well as postpartum complications such as hemorrhage and postpartum infection (Morris et al., 2014; Todd et al., 2019). To improve birth and health outcomes of mothers and their developing babies in communities worldwide, it is necessary to find ways to address the nutritional deficiencies which contribute to the malnutrition epidemics that ultimately lead to these adverse health outcomes.

The global burden of maternal malnutrition is staggering and disparately high in several low- and middle-income countries, especially within Southeast Asia and sub-Saharan Africa (Christian et al., 2020). A recent study estimated that 20.5 million infants are born having a low birth weight every year, and that 48% of these births occur in South Asia and 24% in sub-Saharan Africa (Christian et al., 2020). These statistics are indicative of a similarly high prevalence of maternal malnutrition in these areas, seeing as a child's biological development depends entirely on the mother's nutritional status during pregnancy, and continues to be heavily influenced by her nutritional status within the first few months of

the infant's life (Ravaoarisoa et al., 2018). Two countries in these areas that report especially high rates of maternal malnutrition are Bangladesh and Madagascar (Ahmed et al., 2012; USAID, 2021). There are several reasons for the high burden of malnutrition within these countries, and it is important to understand not only the factors that ultimately lead to this high burden of malnutrition, but also the ways in which maternal malnutrition influences maternal and fetal health outcomes. If a person develops strong optimal health- and nutrition-seeking behaviors, it is possible to mitigate the effects of malnutrition and reduce the potential for developing certain adverse maternal and fetal health outcomes. One way for pregnant women specifically to accomplish this is by complying with a prescribed course of Multiple Micronutrient Supplementation (MMS) throughout the duration of pregnancy. There are several facilitators and barriers to achieving this optimal compliance behavior, however. Thus, to better understand how to create MMS implementation strategies to improve maternal compliance with MMS in the future, it is first necessary to understand the burden of maternal malnutrition within comparable communities in Madagascar and Bangladesh, and the factors that influence a pregnant woman's experience of malnutrition in these communities.

Burden of Malnutrition in Madagascar and Bangladesh

In both Bangladesh and Madagascar, the prevalence of maternal malnutrition among women of reproductive age poses a significant public health concern and risks to maternal and fetal health (Andrianantoandro et al., 2021; Nguyen et al., 2017; Rakotosamimanana et al., 2015). Despite governmental programs that aim to address these nutrient deficiencies, and thus improve maternal and fetal health outcomes and birth outcomes, malnutrition remains prevalent throughout the population of women of reproductive age throughout both these countries (Nguyen et al., 2017; Weber et al., 2019).

In Madagascar, as of 2019, the maternal mortality rate was 426 per 100,000 live births and twenty six percent of children under five were underweight (USAID, 2021). In Bangladesh, nearly one-third of

women are undernourished and 41% of the children aged less than five years are underweight (Ahmed et al., 2012). In both countries, the high prevalence of maternal malnutrition is concerning because of its association with maternal mortality and overall morbidities for both pregnant mothers and their children. In addition to the risks posed to maternal health due to maternal malnutrition, the association between maternal malnutrition and childhood malnourishment and stunting is a well-documented concern (Persson et al., 2012; Victoria et al., 2008). Identifying and addressing the factors that contribute to maternal malnutrition is an important step in being able to mitigate and lessen the global burden of disease contributed to maternal malnutrition.

In both Madagascar and Bangladesh, the ultimate drivers for maternal malnutrition are comparable and similar, making the comparison between these two countries in this specific scholarly project possible. In Bangladesh, the principal drivers of maternal malnutrition are poor-quality diets, poor-quality antenatal care practices, and low access to health care services (Choudhury and Ahmed, 2011; Rahman and Hossain, 2019). In Bangladesh, a recent social services assessment identified a potential driver of lack of good nutrition during pregnancy as being the fact that just over half of pregnant women increase their dietary intake during pregnancy (IMED et al., 2018). Additionally, less than half of this same population of pregnant women consume a balanced diet including foods from all five food groups, contributing to a lack of dietary diversity and subsequent lack of diversity of nutritional intake (IMED et al., 2018). The State of Food Security and Nutrition in Bangladesh Report published in 2016 identified 66% of pregnant women not consuming adequately diversified diets during pregnancy (State of Food Security and Nutrition in Bangladesh Report, 2016). In Madagascar, a woman's lack of increased dietary diversity during pregnancy and lack of increased dietary intake during pregnancy is a similar driver of malnutrition. Additionally, it is important to note that in Madagascar, the intergenerational transmission of chronic malnutrition is an important factor in the burden of malnutrition among women of reproductive age and children (McCuskee et al., 2017). In Madagascar, at least 37% of girls aged 15 to 19 have had at least one child or are currently pregnant and women living in Madagascar will, on average,

give birth to 5 children during their reproductive years (AFDB et al., 2021). This level of early and high fertility ultimately contributes to the transmission of malnutrition between generations and thus the burden of maternal malnutrition in Madagascar.

Together, this lack of increased consumption of food during pregnancy, as well as a distinct lack of dietary diversity during pregnancy, contribute in part to the high burden of maternal malnutrition in Bangladesh and Madagascar. In addition to this, the lack of access to antenatal care services and poor quality of antenatal care coverage also contribute to this burden, as will be discussed in future sections. As aforementioned, there are many consequences to both maternal and fetal health due to maternal malnutrition that must be taken into consideration when discussing the importance of successful MMS programs globally.

Consequences of Malnutrition

There are numerous adverse maternal and fetal health outcomes resulting from malnutrition during pregnancy, all of which contribute to the global burden of disease among women of reproductive age worldwide (Gernand et al., 2016). Pregnant women are often encouraged by public health officials to fortify their diets with iron and folic acid in order to prevent maternal and neonatal morbidities (Alam et al., 2015; Harding et al., 2016). Commonly children born to mothers who are malnourished end up facing certain challenging chronic illness and disease due to their low birthweight at birth or undernourishment during pregnancy and infancy (Victoria et al., 2008; Persson et al., 2012). It is specifically important to understand the relationship between micronutrient insufficiencies and deficiencies during pregnancy and these health consequences. In fact, one of the most common maternal health concerns resulting from a micronutrient deficiency during pregnancy is iron deficiency anemia (Gernand et al., 2016; van den Broek, 2003).

Iron deficiency anemia occurs when the body does not have enough functioning red blood cells to oxygenate all the body's tissues (Mayo Clinic, 2019). During pregnancy the risk of developing iron deficiency anemia is exacerbated because a pregnant woman's body needs twice the amount of iron that a nonpregnant woman's body needs in order to produce enough blood to supply oxygen to the baby's developing tissues (Mayo Clinic, 2019). If a pregnant woman does not consume enough iron during her pregnancy given her dietary intake, then it is likely possible that the resultant deficiency in iron in her body will result in several different complications for her and her developing baby (Gernand et al., 2016). These include an increased risk for premature birth, stillbirth, and low birth weight (Figueiredo et al., 2019). The consequences of low birth weight are many and include the child having an elevated risk for stunting and chronic disease development in adulthood (Christian et al., 2013). As previously mentioned, most women in Madagascar and Bangladesh do not adequately increase their dietary intake during pregnancy, nor do they consume enough of a diverse diet to receive the necessary nutrients and minerals, such as iron, needed to have a healthy pregnancy and birth. Thus, it is important for public health officials to encourage the use of food fortification programs and other prenatal supplementation programs to address these deficiencies and improve maternal and fetal birth and health outcomes.

One of the most common treatments for iron deficiency anemia in pregnant women is iron supplementation, via ferrous sulfate tablets, especially in countries facing disparately high burden of maternal malnutrition, such as in Madagascar and Bangladesh (Black et al., 2019). As will be discussed in the following sections, there exists a significant body of literature and research supporting the use of these iron and folic acid supplements (McDonagh et al., 2015). However, low coverage and compliance with prenatal supplementation programs intended to address the high prevalence of malnutrition and anemia in both Madagascar and Bangladesh ultimately result in no reduction of the overall burden of anemia among pregnant women, and thus do not provide the expected and desired result of reducing maternal and fetal morbidity and mortality due to maternal malnutrition. In order to accomplish this, it is necessary to

understand the factors that determine and affect the nutrition- and health-seeking behaviors contributing to the overall coverage of and compliance to these iron-folic acid supplementation programs.

History of Supplementation Used to Address Malnutrition

In order to address micronutrient deficiencies among pregnant and lactating women, food fortification programs are often used. These sorts of programs take many different forms, including flour fortification with iron and folate, micronutrient supplementation, and integrated programs that feature food supplementation programs with nutritional counseling (Black et al., 2019). In terms of micronutrient supplementation programs, providing pregnant women with iron-folic acid supplements (IFAS) has long been the standard practice in countries facing high prevalence of malnutrition and other nutritional deficiencies (Black et al., 2019; Sanghvi et al., 2010). Even though this sort of prenatal supplementation and fortification program has long been used, it has only found varying levels of success in the countries facing the highest burden of malnutrition worldwide (Alam et al., 2015; Harding et al., 2016).

Despite a variety of governmental actions to attempt to reduce the prevalence of malnutrition among pregnant women by implementing different fortification programs such as iron-folic acid supplementation, overall compliance with Multiple Micronutrient Supplementation (MMS) programming remains low among target audiences. In Madagascar, for example, 55% of pregnant women receive and take IFAS, but only 7.1% have used the supplement for longer than one trimester of their pregnancy (INSTAT, 2016). This lack of coverage likely has many contributors, but low coverage of antenatal care services is a main contributing factor. 87% of women have accessed antenatal care at least once in Madagascar, but only 51% have had four or more visits (INSTAT, 2016). Since antenatal care services are the most used means to distribute prenatal supplementation to mothers, it is important to note that increasing the coverage of antenatal care would likely similarly increase a pregnant woman’s likelihood of receiving MMS and complying with a prescribed course of the supplement. In Bangladesh, as well,

only 29% of pregnant women attend four or more antenatal care visits during pregnancy and only 18% consume at least 100 IFAS tablets throughout their pregnancy (James et al, 2016). Again, a similar trend persists in which low coverage of antenatal care services similarly results in low adherence to and compliance with prenatal supplementation programs.

While there are both governmental and non-governmental programs in place in both countries to improve the nutritional status of women and children by targeting antenatal nutrient supplementation practices, implementing effective interventions within these countries is challenging for a number of reasons (Nguyen et al., 2017; Weber et al., 2019). One reason being that it is vital to understand the social and cultural drivers of nutrition-related behaviors within a community to implement a program that is most aligned with these perceptions about nutrition, as well as subsequent nutrition-related behaviors (Nguyen et al., 2017; Weber et al., 2019). Although IFAS has, until recently, been the standard of fortification programs aimed at reducing the prevalence of maternal malnutrition, Multiple Micronutrient Supplementation (MMS) programs is another option to accomplish the same goal. In recent years, with its use being encouraged by the World Health Organization, MMS programs have become an increasingly interesting and promising option for dietary and nutrient supplementation and fortification in communities such as those studied in Madagascar and Bangladesh in this project.

Introduction to Multiple Micronutrient Supplementation

As aforementioned, while Iron Folic Acid Supplementation (IFAS) has been used to varying degrees of success in the past, Multiple Micronutrient Supplementation (MMS) is another more recently introduced and encouraged form of prenatal supplementation. The World Health Organization recently recommended that MMS should be chosen over IFAS for prenatal supplementation practices in countries with a high prevalence of nutritional deficiencies, such as Bangladesh and Madagascar (Black et al., 2019). There are several reasons why MMS has been encouraged over IFAS, including cost

effectiveness and positive maternal/fetal health and birth outcomes. Additionally, MMS provides additional micronutrients that IFAS does not. In addition to iron and folic acid, most MMS also provides zinc, calcium, and vitamins A, C, and D (Keats, 2019). In fact, MMS has been shown to reduce the risk of small-for-gestational age births, low birth weight, and stillbirths among pregnant women who consume MMS throughout their pregnancy (Keats, 2019). This is a promising outlook for the future of implementation of MMS in highly burdened countries if properly implemented in such a way that encourages and allows for optimal compliance among pregnant women in these communities.

In Madagascar, specifically, the Madagascar Ministry of Public Health participated in a pilot project that introduced MMS for pregnant women as an alternative supplementation to IFAS. This pilot aims to enhance antenatal care coverage with provision of MMS among pregnant women in Itasy and Vatovavy Fitovinany. The program aims to introduce MMS within these two districts between 2018-2022, and thus an improved understanding of the multi-level determinants of a woman's compliance with MMS in these communities is needed for the most successful program.

While MMS has shown promising opportunity for improving maternal nutritional deficiencies during pregnancy, the ultimate success of introducing the supplement in communities facing high prevalence of nutrient deficiencies relies upon the context within which the supplement is introduced. Globally, programs that introduce vitamin and mineral supplements face challenges with their intended audiences, in many cases being women of reproductive age, not complying with the prescribed course of supplementation (Bhutta et al., 2013). In order to ensure that communities with high prevalence of nutrient deficiency can reap the benefits of prenatal supplementation, understanding the factors that impact a woman's compliance with supplementation programs is necessary and important work.

Chapter 2

Methodology

Study Setting

This study took place in two districts of Madagascar and two districts of Bangladesh (Figure 1 and Figure 2).

Madagascar

Madagascar is an island nation off the eastern coast of Africa. In 2020, Madagascar was home to 27 million people, 70% of whom lived in rural areas at the time and more than 90% of whom identified as being culturally Malagasy (INSTAT, 2016). Madagascar is divided into 22 regions and 119 districts (INSTAT, 2016). This study was conducted in two districts in Madagascar: Ifanadiana and Soavinandriana (Figure 1). Ifanadiana is located within Vatovavy Fitovinany, along the southeastern coast of the country, and Soavinandriana is located within Itsay, in the central highlands region of the country. The Vatovavy Fitovinany district has a population of approximately 215,000 people and the Itsay district has a population of about 264,000 people (INSTAT, 2016). Both districts are rural and primarily support agrarian livelihoods.

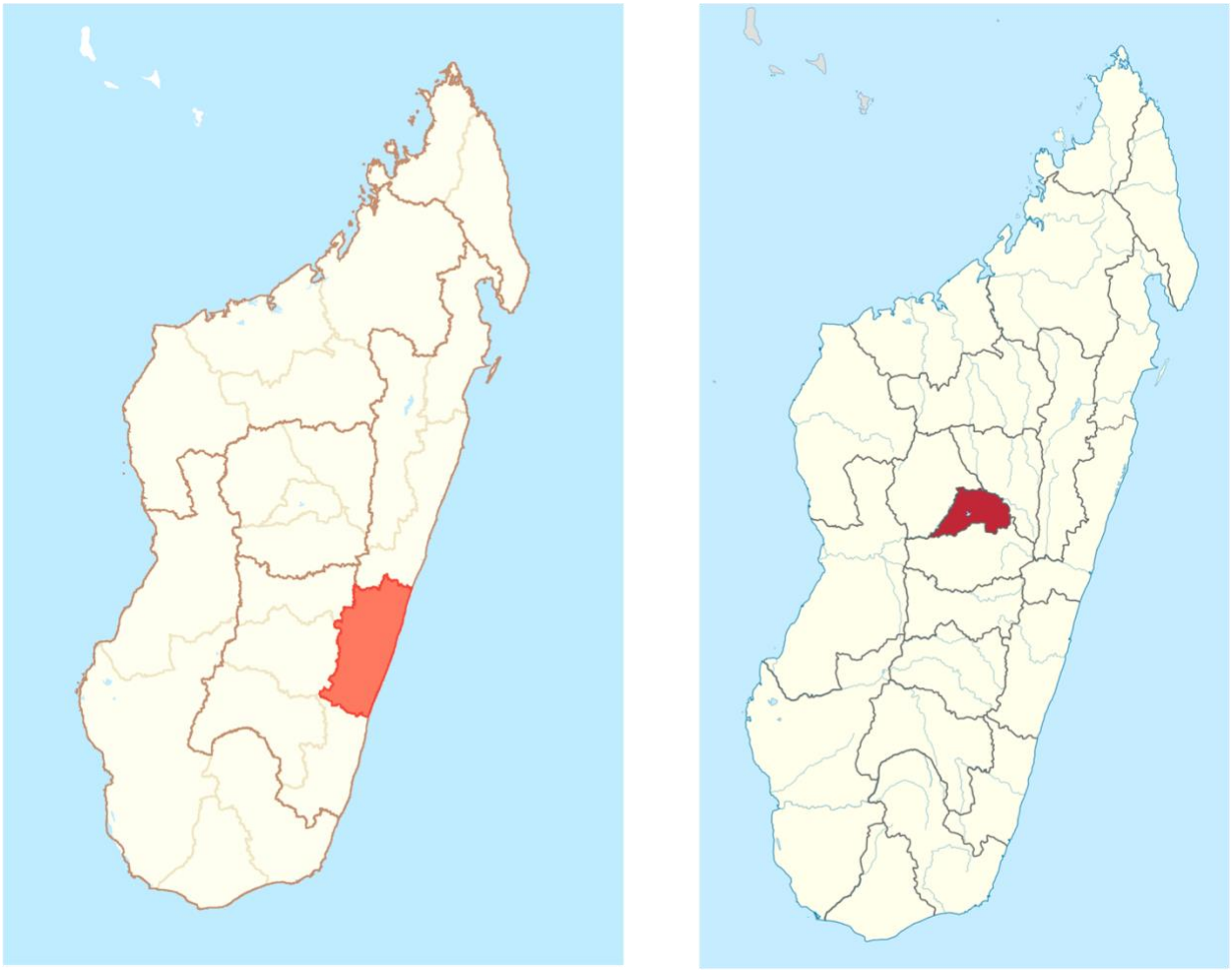

Figure 1. Vatovavy Fitovinany district (left) and Itasy district (right) in Madagascar

Bangladesh

Bangladesh is a South Asian nation sharing land borders with India to the north, east, and west, as well as having its southernmost coast along the Bay of Bengal. In 2020, Bangladesh was home to 165 million people, 62% of whom lived in rural areas at the time and 98% of whom identified as being culturally Bengali (World Bank, 2020). Bangladesh is divided into 64 districts, and this study was conducted in the Kurigram and Bhola districts (Figure 2). Kurigram is in north-central Bangladesh and Bhola is in south-central Bangladesh, bordered by the Shahbazpur Channel. The Bhola district has a

population of 1.7 million people and the Kurigram district has a population of approximately 2 million people. Both the Kurigram and Bhola districts are rural and support primarily agrarian livelihoods.

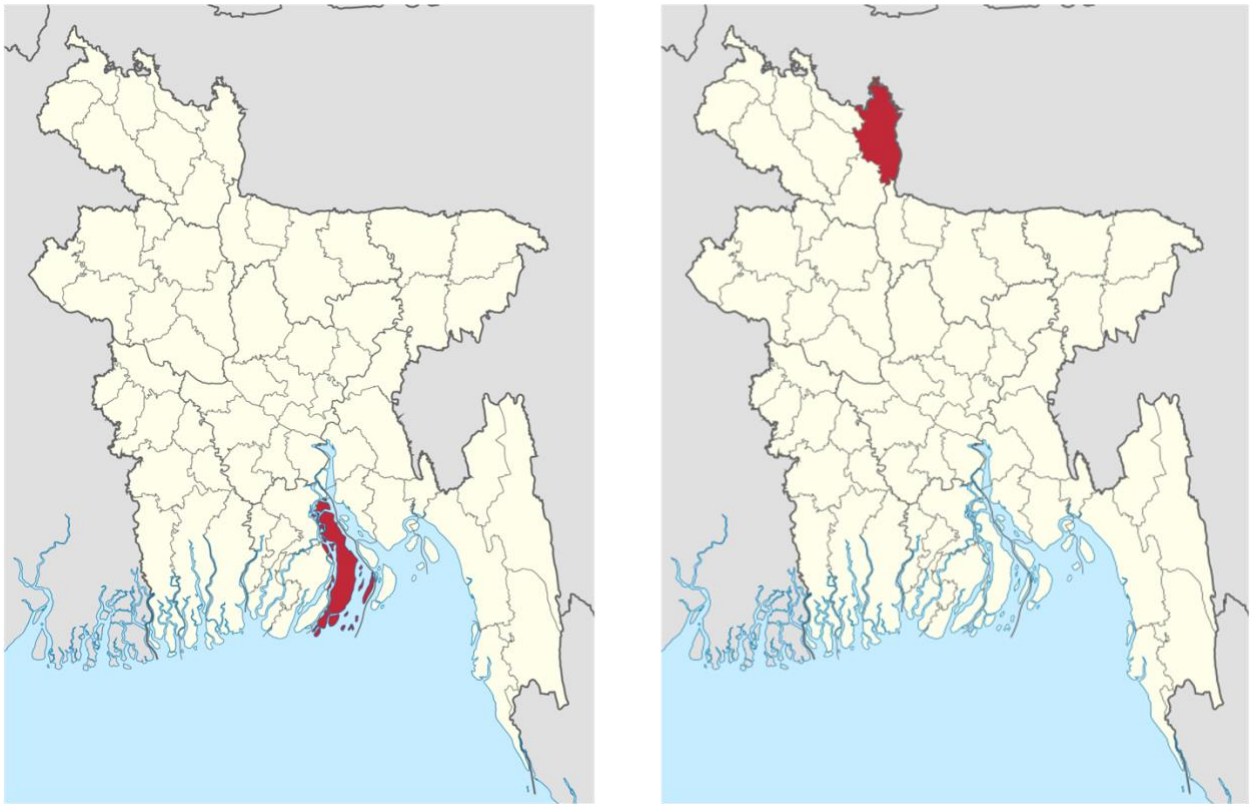

Figure 2. Bhola district (left) and Kurigram district (right) in Bangladesh

Data Collection and Procedures

This work was accomplished using data from a previous formative study about the introduction of Multiple Micronutrient Supplementation (MMS) in Madagascar and Bangladesh.

Focus Group Discussions

In Madagascar, 6 focus group discussions were conducted among pregnant and lactating women living in both Vatovavy Fitovinany and Itsay. In each focus group discussion, 8-14 women were sampled

with the help of local health workers and community members who were already familiar with the populations in each district. In Bangladesh, 6 focus group discussions were conducted among 57 pregnant and lactating women living in both districts.

In both study settings, age, social status, and cultural group were all considered during sampling in order to create a fairly homogeneous group that would allow for open and honest discussion in which every participant had an equal voice. In Madagascar, all discussions were moderated in Malagasy and digitally recorded with the assistance of a moderator and note-taker. All discussions in Bangladesh were moderated in Bangla and digitally recorded, as well.

Community Workshops

In Madagascar, 6 participatory community workshops were conducted among pregnant and lactating women living in both Vatovavy Fitovinany and Itsay. In each workshop, 15 participants, on average, were sampled. In Bangladesh, 6 participatory community workshops including 97 community members were conducted. The community members present for community workshops in Bangladesh included pregnant and lactating women, grandmothers, in-laws, and husbands.

Each workshop in both study settings focused on brainstorming, voting, and consensus building on topics pertinent to MMS intervention design. Each workshop was facilitated in Malagasy or Bangla (in Madagascar and Bangladesh, respectively) with the assistance of a moderator, note-taker, an observer who recorded field notes reflective of important discussion points.

Semi-structured interviews

In Madagascar, qualitative semi-structured interviews were conducted among 24 pregnant women and 17 healthcare providers covering topics related to antenatal healthcare-seeking behavior, diet during pregnancy, and factors influencing optimal maternal nutrition. In Bangladesh, qualitative semi-structured interviews were conducted among 24 pregnant women and 12 healthcare providers.

In Madagascar, the health workers who were included in the interviews included facility staff, midwives, and community health workers. In Bangladesh, healthcare providers included community health care providers working for community clinics and family welfare visitors working for union-based health facilities and Family Welfare Centers. All interviews were conducted in Malagasy in Madagascar and Bangla in Bangladesh and then digitally recorded. In both study settings, the interviews were conducted in private in a woman's home or in a health center, depending on each participant's preference.

Data Analysis

Textual data from focus group discussions and semi-structured interviews were first translated from Malagasy into French verbatim using Microsoft Word for data from Madagascar, and Bangla into English for data from Bangladesh. The French and English transcripts were then uploaded into Dedoose software for thematic analysis. All transcripts were coded using a structured codebook based upon thematic areas of analysis. Excerpts were then extracted and stratified by data collection site, participant type, and research question using Dedoose. Findings were then able to be presented according to study aim using quotations, tables, and figures to elucidate important themes. Numerical data from the community workshops were analyzed using simple descriptive statistics. Field notes from the workshops in both study settings were also reviewed and included during textual analyses for incorporation into the findings of this study.

Ethical Considerations

The participants in this study in all study settings in Madagascar and Bangladesh provided verbal informed consent before participating in the focus group discussions, community workshops, and/or semi-structured interviews.

Thesis Purpose

This work builds upon previous studies by seeking to understand the multilevel determinants of maternal compliance with Multiple Micronutrient Supplementation (MMS) at four different levels – the community level, institutional level, interpersonal level, and individual level – according to the Socioecological Model (SEM). This work also compares the findings across two different study settings to better understand the ways in which a pregnant woman's behavior is influenced by several different levels of factors. The settings are comparable due to the same methodology being used in both settings. Ultimately this work seeks to answer the following aim and research questions:

Aim 1. To elucidate the multi-level factors that may influence maternal compliance with MMS prenatal supplementation during pregnancy by comparing Madagascar and Bangladesh.

RQ 1. What are the community level factors that may influence MMS compliance?

RQ 2. What are the institution level factors that may influence MMS compliance?

RQ 3. What are the interpersonal level factors that may influence MMS compliance?

RQ 4. What are the individual level factors that may influence MMS compliance?

Chapter 3

Findings

In the Bhola and Kurigram districts of Bangladesh, several factors at the community, institutional, interpersonal, and individual levels were identified through focus groups and interviews as factors that affect a pregnant woman's compliance with Multiple Micronutrient Supplementation (MMS) throughout the duration of her pregnancy (Figure 3). At each of these levels, both facilitators of and barriers to optimal MMS compliance were identified in order to address the primary aim of this work: *To elucidate the multi-level factors that may influence maternal compliance with MMS prenatal supplementation during pregnancy by comparing Madagascar and Bangladesh.*

Bangladesh

There are several multilevel determinants that affect the status of health-seeking behaviors among pregnant women in Bangladesh, at the community, institutional, interpersonal, and individual levels.

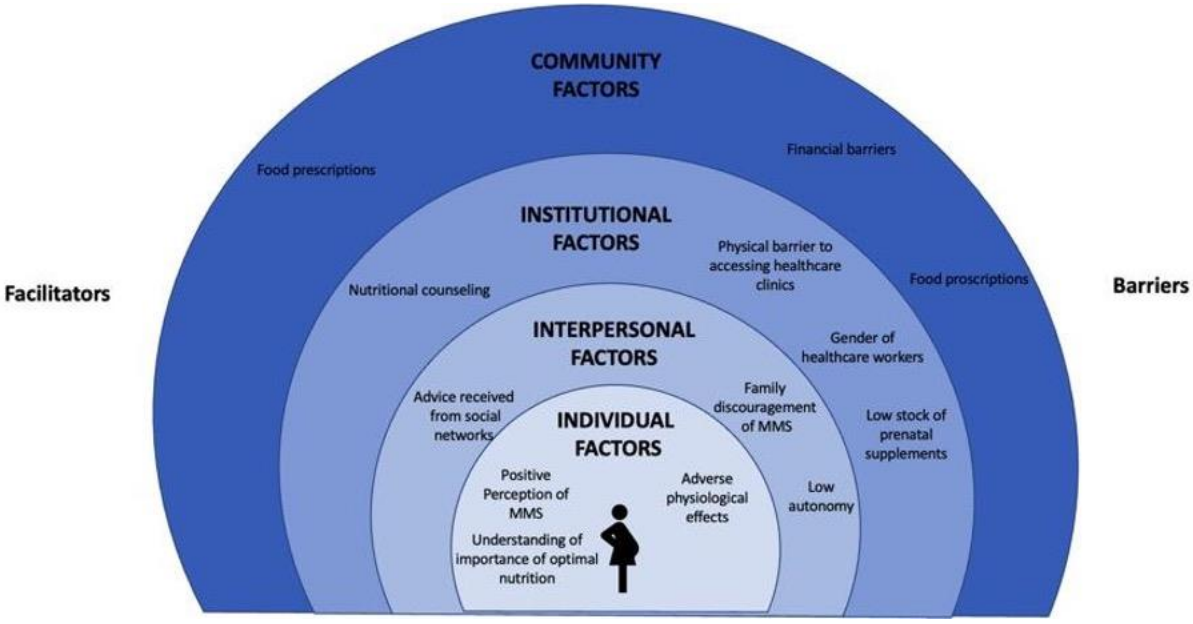

Figure 3. Multilevel determinants of optimal MMS compliance in Bangladesh

Community Level Factors

There are several factors that influence the ability of mothers to comply with MMS programs throughout pregnancy. At the community level, cultural food rules exist which affect how mothers perceive the importance of eating certain foods during pregnancy, as well as the impact that consuming these foods may have on their personal health or that of their developing baby. The findings suggest that some of these cultural food rules may also affect how mothers perceive the importance of supplementing their diet during pregnancy with MMS due to the perceived effects of supplemental nutrients consumed during pregnancy. Thus, food proscriptions, describing foods that a cultural group preferentially avoids, and food prescriptions, describing foods that a cultural group preferentially consumes, act as both facilitators of and barriers to optimal MMS compliance in Bangladesh (Table 1).

Table 1. Overview of community level facilitators and barriers in Bangladesh

Facilitators	• Food prescriptions encouraging the consumption of vitamin-dense foods
Barriers	• Food proscriptions discouraging the consumption of too much food for fear of rapid fetal growth

Facilitators of optimal MMS compliance

Certain cultural food prescriptions may increase the likelihood that a mother complies with MMS throughout the duration of her pregnancy. The findings suggest that a majority of pregnant mothers ascribe several food prescriptions to the nutritional benefit that comes from consuming that food. The positive effects that mothers cite as coming from consuming these foods include both benefits to maternal health and fetal health. For example, during both interviews and focus group discussions in both Bhola and Kurigram districts, many mothers described the importance of consuming foods that contain large amounts of iron in order to avoid iron deficiency during pregnancy. Plantains, red spinach, and taro leaves were noted to be specifically important for "producing blood in the mother's body" to mitigate the negative effects of iron deficiency anemia during pregnancy. Many mothers also described the importance of consuming fruits and vegetables during pregnancy due to their nutritional value and the perceived health benefits of consuming certain vitamins during pregnancy for both the mother's health and that of her developing baby in utero.

"*I was saying that maybe the baby is built from calcium. We need to eat vegetables, vitamins, and these types of other things [during pregnancy].*"

-Kurigram, focus group, pregnant woman

This indicates the common understanding among women in Bangladesh that achieving an optimal nutritional status is important during pregnancy, in order to maintain good health during pregnancy, avoid pregnancy complications, and ensure the health of the developing baby.

"*My mother says, my mother-in-law says, and my sister-in-law says that you should eat more vegetables… need to eat more vitamins.*"

-Bhola, interview, pregnant or lactating woman

While these positive associations stemming from cultural food prescriptions might encourage a mother to seek out opportunities to improve her nutrition during pregnancy, either through her diet choices or supplementation practices, there are also food proscriptions which act as a barrier to this goal.

Barriers to optimal MMS compliance

At the community level, some foods are actively discouraged from being consumed during pregnancy due to the belief that these foods may cause pregnancy and birth complications. While these food proscriptions are not directly ascribed to the nutritional value of the food item, a common fear among pregnant mothers is that increasing dietary or nutritional intake will cause the fetus to grow too large. If this were the case, many mothers worried that the size of the fetus would require a cesarean delivery.

"*I have heard that if a pregnant mother eats extra food during pregnancy, the baby gets bigger. Women suggest eating less… otherwise you will need a Cesarean delivery."*

-Bhola, focus group, pregnant woman

Not only do mothers generally avoid an increase in food consumption during pregnancy due to these cultural food rules, but they also avoid iron supplementation for the same reasons.

"*Vitamin supplements make the baby large, for which the baby cannot be delivered normally and will require a C-section.*"

-Kurigram, focus group, pregnant woman

Even if mothers recognize the importance of achieving optimal nutritional status during pregnancy in order to ensure the health of themselves and their developing babies, this common belief about those practices resulting in cesarean section ultimately poses a significant barrier to mothers doing so.

Institutional Level Factors

There are several different health services that are often accessed in the Bhola and Kurigram districts of Bangladesh, including community clinics, the Upazila Health Complex (UHC), the Union Health and Family Welfare Center (UH&FWC), the Building Resources Across Communities (BRAC) community health workers, private clinics and hospitals, and local pharmacy doctors. The services that these healthcare services provide, such as antenatal counseling, can positively influence a pregnant mother's nutrition and healthcare-seeking behaviors during pregnancy, including her compliance with MMS (Table 2). That being said, mothers must also compete against several barriers that limit their access to receiving these services, thus potentially inhibiting their compliance with MMS.

Table 2. Overview of institutional level facilitators and barriers in Bangladesh

Facilitators	• Nutritional counseling during antenatal care services at community clinics
Barriers	• Physical barriers to receiving antenatal care services, such as long distances to travel to clinics • Financial constraints • Gender of healthcare workers • Low supply of supplement at clinics

Facilitators of optimal MMS compliance

Community clinics were often described during interviews and focus group discussions as being helpful for pregnant women to receive many different antenatal care services -- including weight measurements, educational sessions, and check-ups to receive supplements. Several women interviewed during the study were actively taking iron and calcium tablets supplied by these community clinics.

"*We have a community clinic here… I go to the community clinic once a month… iron and calcium tablets are given, weight is measured, blood pressure is checked…*"

-Kurigram, interview, pregnant woman

Many women highlighted the importance of the community clinics offering nutrition counseling sessions during pregnancy, thus improving their overall nutrition-seeking behaviors.

"*When mothers come here at first, we provide nutrition advice to them. We counsel the mother to eat nutritious food and get enough rest during pregnancy.*"

-Bhola, interview, healthcare worker

These same counseling sessions may also be effective in improving MMS compliance if information about the importance of the nutritional value of MMS, as well as its positive effects on maternal and fetal health, is communicated during these sessions. Thus, the ability to be counseled by healthcare providers at a health clinic about MMS and prenatal supplementation may increase a woman's likelihood of complying with MMS programming throughout the duration of her pregnancy.

Barriers to optimal MMS compliance

Even though the services rendered at these healthcare facilities are useful in facilitating optimal maternal health practices during pregnancy, including MMS compliance, there are several barriers to mothers receiving this care. These include physical barriers, financial barriers, and barriers associated

with the gender of the healthcare worker, themselves. Physical barriers such as the specific geographic location of these clinics can cause difficulties for mothers seeking MMS at healthcare locations providing antenatal care services. Many times, they cannot easily access a healthcare provider that might be able to give them MMS due to the travel required to reach each healthcare facility and other impediments, such as weather conditions, incurred along the way.

"*The road to the community clinic is not good and gets flooded during high tides.*"

-Kurigram, interview, pregnant woman

In addition to these physical barriers, financial constraints were also cited as factors that might lead to decreased compliance with MMS throughout a woman's pregnancy. Even if a woman understands the importance of MMS during pregnancy, if she cannot afford to directly purchase MMS, or if she encounters financial strain when trying to seek out the antenatal care services needed to obtain MMS, then her compliance may decrease.

"*Mothers don't buy medicine when they are healthy and only buy it when they are sick. It is difficult to run a family of 4 to 5 people with one person's income, so most of the time they do not even get to finish the full course of medicine. They only buy medicines for 10 to 25 days.*"

-Bhola, focus group, pregnant or lactating woman

The price of MMS, itself, may act as a barrier to the woman's compliance, but the cost of receiving antenatal care counseling at a healthcare clinic that is not free to use and the cost of travel to and from the clinic that the mother must go to get MMS may also act as barriers to their ultimate compliance.

"*When a pregnant woman faces complications, then they go to doctors or big hospitals mostly. Only those who can afford [the services] will get medical care.*"

-Kurigram, interview, pregnant woman

In addition to these financial concerns, not all healthcare workers are female, and oftentimes pregnant mothers prefer to be treated by female-only healthcare workers and teams during pregnancy. If these

teams are not available, this could again decrease how likely a pregnant mother is to receive antenatal care, counseling about MMS, or obtain the supplement, itself.

"*As there is no female officer (i.e., female health worker) here, that's why we just check [the pregnant woman's] height and blood pressure [during antenatal check-ups].*"

-Kurigram, interview, male health worker

If a pregnant woman can overcome these barriers to access antenatal healthcare services that can provide her with MMS, oftentimes there is low stock of the supplements available, further complicating the mother's ability to comply with the prescribed course of supplement.

"*Most of the time the clinics cannot provide the supplements and ask us to come back the next day or [they just] give half of what is prescribed. Sometimes the clinics are closed as well*."

-Bhola, focus group, pregnant or lactating woman

It is important to recognize that, even if mothers understand the importance of MMS and desire to seek out MMS and other antenatal care services during their pregnancy, there are several institutional factors that can adversely affect their ability to do so.

Interpersonal Factors

In the Bhola and Kurigram districts of Bangladesh, the social networks surrounding pregnant mothers can greatly impact a mother's choices relating to her health and nutrition during pregnancy, including her use of and compliance with MMS throughout her pregnancy (Table 3). Generally, people within these social networks with direct access to the pregnant mother, including spouses, family members, in-laws, close friends, and community members offer advice and support about best practices concerning diet and supplementation during pregnancy. Pregnant mothers are generally greatly influenced by this advice, which can ultimately affect their ability to meet their nutritional needs during pregnancy through compliance with MMS.

Table 3. Overview of interpersonal level factors in Bangladesh

Facilitators	• Positive advice received from close social contacts
Barriers	• Active discouragement of prenatal supplements by older generations • Potential for disapproval if women disobey advice • Low female autonomy over health decisions

Facilitators of optimal MMS compliance

Close family members, especially female family members and in-laws, can encourage optimal nutrition-seeking behaviors by sharing their pregnancy experiences and their personal beliefs in the importance of achieving optimal nutrition during pregnancy. In addition to receiving advice from close friends and family members, community health workers also provide a similar level of trusted advice and care to mothers during pregnancy.

"*Health workers from BRAC visit mothers house to house for check-ups. They give advice related to nutritious foods and give medicines. BRAC also provides nutrition plates to mothers.*"

-Kurigram, focus group, pregnant or lactating woman

These positive interactions with family and community members can help facilitate a mother meeting her nutritional needs during pregnancy through the optimization of her diet or her inclusion of prenatal supplementation into her antenatal care routine.

Barriers to optimal MMS compliance

Although these connections can be beneficial in encouraging optimal nutrition-related behaviors during pregnancy, including the possibility of encouraging optimal MMS compliance, many members of older generations actively discourage the use of prenatal supplementation during pregnancy, resulting in a strong barrier to the mother's MMS compliance.

"*Iron supplements will make the babies fat and will need to be delivered through Caesarean section. That is why we are advised not to take vitamin supplements [by in-laws].*"

-Bhola, focus group, pregnant or lactating woman

Given the importance of these family members, mainly grandmothers and in-laws of the pregnant women, and the social roles they occupy, pregnant mothers would face disapproval from family if they did not follow the advice given to them.

"*Visiting the clinic makes my mother-in-law angry and she does not allow me to get the checkups. And she says, 'whatever is God's will happens', so I have to obey my mother-in-law.*"

-Bhola, focus group, pregnant or lactating woman

There is a strong incentive for the pregnant mother to not only listen to advice from people within her social networks, but also to follow it. If family members thus discourage her supplementation use, there is a strong likelihood the pregnant mother will not comply with MMS guidelines. Additionally, in Bangladesh, husbands hold most of the decision-making power when it comes to health and nutrition. Therefore, a mother's personal behaviors are heavily influenced by her husband's perceptions of nutrition and decisions regarding certain nutrition and healthcare-seeking behaviors. As mentioned previously in Section II, most pregnant women prefer to be seen by female healthcare workers, which can prove difficult if few healthcare clinics are staffed by female healthcare workers. The husbands of pregnant women further push for the treatment of their wives by female healthcare workers.

"*Most husbands do not like the idea of ultrasonography and do not like male doctors seeing their wives.*"

-Bhola, focus group, pregnant or lactating woman

All these factors combined make it difficult for pregnant women to ultimately achieve optimal MMS compliance, especially if the lack considerable power to make their own informed decisions about their use of supplementation without input from close contacts within their social circles.

Individual Factors

There are several factors that may impact a pregnant woman's level of compliance with MMS programming, reflecting their own individual perceptions of nutrition and the importance of MMS, as well as the influences of community, institutional, and interpersonal factors upstream of these individual perceptions and individual health behaviors which shape them (Table 4).

Table 4. Overview of individual level factors in Bangladesh

Facilitators	● Positive perception of fulfilling nutrient needs during pregnancy ● Positive perception of supplementation ● Perceived benefits of supplementation
Barriers	● Food aversions ● Negative perception of supplementation ● Belief that there is a more effective mode of improving nutritional status during pregnancy

Facilitators of optimal MMS compliance

A woman's perception of the importance of optimal nutrition during pregnancy and its effect on her own health and that of her baby may ultimately increase her likelihood to seek out and comply with MMS programming. Our findings suggest that many pregnant women associate pregnancy with certain illnesses, especially physiological side effects of pregnancy such as vomiting, lower abdominal pain, back pain, and acidity. Health workers, however, have a more biomedical perspective of how nutrition, and specifically a lack of important vitamins and micronutrients during pregnancy, impact the physiological experience of a pregnant mother. For example, many health workers describe their concern about anemia during pregnancy, discussing how nutritional inadequacies during pregnancy pose great risk of mothers developing iron deficiency anemia during pregnancy.

"*People in this area are not eating food properly…that's why most mothers are suffering from anemia.*"

-Bhola, interview, healthcare worker

Some mothers also described this phenomenon but focused primarily on the impact of the physical illnesses associated with pregnancy rather than micronutrient deficiencies.

"*Anemia is very harmful for both mother and baby. If a pregnant mother is anemic, then her baby will be anemic, too… and anemia during pregnancy can kill both mother and baby*."

-Kurigram, interview, pregnant woman

In addition to their positive perception of the importance of fulfilling nutrient needs during pregnancy, a woman's individual positive perception of prenatal supplementation, itself, can increase her likelihood of seeking out that supplementation as an antenatal healthcare-seeking behavior. The greater the degree to which a woman perceives benefits from prenatal supplementation, the more likely she is to choose prenatal supplementation during her pregnancy. Throughout the focus groups and interviews, the most commonly associated benefits of prenatal supplementation were its importance in increasing blood

volume and addressing iron-deficiency anemia, improving the mother's immunity, supporting the baby's bone strength and development, and helping address the mother's body pain and weakness.

If MMS is perceived as an opportunity for not only improving maternal nutrition, but also decreasing the incidence of pregnancy-related disease, thus improving birth outcomes and maternal and fetal health during pregnancy, then this could improve compliance with MMS programs.

Barriers to optimal MMS compliance

While many women describe having positive perceptions of prenatal supplementation, many women also reported barriers to accessing supplementation and complying with its prescribed course. For example, a woman's experiences with adverse physiological reactions to certain foods during pregnancy can decrease her likelihood of consuming that food again. Many women describe having food aversions during pregnancy and experiencing nausea, vomiting, and aversions to certain tastes throughout the duration of their pregnancies. It is important to note that these food aversions also impact a pregnant woman's likelihood to consume a MMS product depending on the taste or odor of that product.

"*Many people do not like the vitamins that are available in the clinic; the medicine has a mild odor, which is why many people do not want to eat [them].*"

-Bhola, interview, pregnant woman

Additionally, a woman's individual perception of supplementation can be influenced by the ways in which they believe they can achieve the goal of addressing micronutrient deficiency without taking a supplement to avoid its side effects. Some women describe their perception of MMS as simply one of many options to achieving optimal nutritional status during pregnancy. In this case, mothers may not wish to pursue MMS if they believe they can achieve optimal nutritional status by instead eating an optimal diet, and thus avoiding any of the barriers that exist to complying with MMS. There are, however, several

barriers to achieving this optimal diet, as well, leaving a vast majority of pregnant women malnourished: thus, necessitating the push for MMS in these districts in the first place.

Madagascar

There are several multilevel determinants that affect the status of health-seeking behaviors among pregnant women in Bangladesh, at the community, institutional, interpersonal, and individual levels (Figure 4).

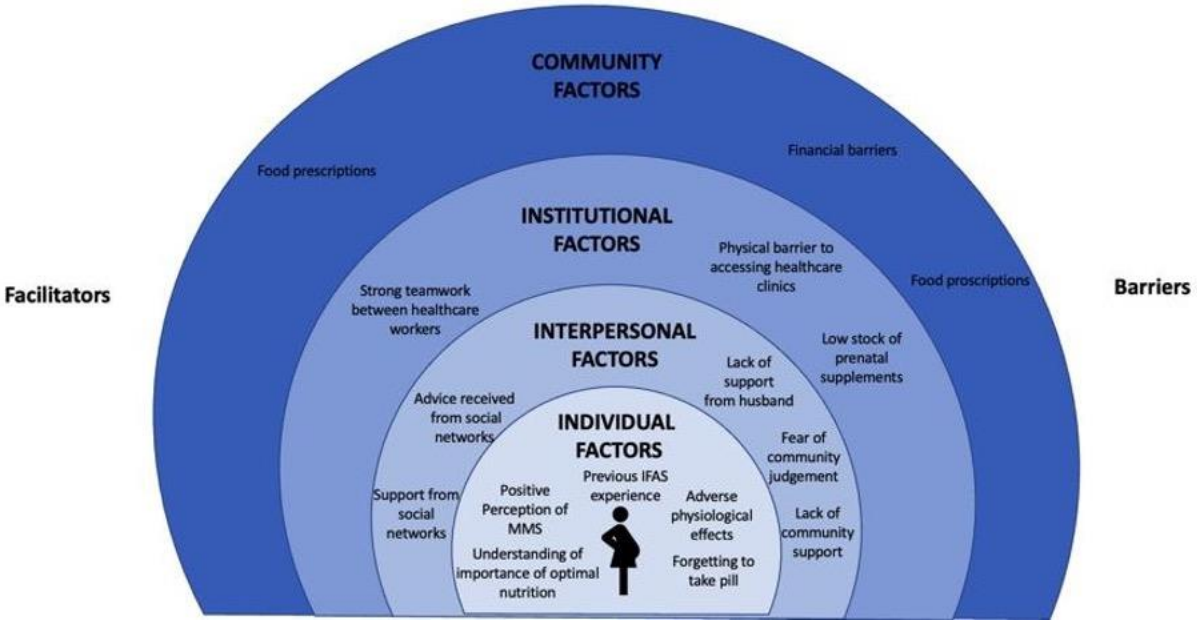

Figure 4. Multilevel determinants of optimal MMS compliance in Madagascar

Community Level Factors

Cultural food rules, including food proscriptions and food prescriptions are important determinants of common diets among pregnant women in Madagascar. These food rules not only impact the common diet of the Malagasy, but also how pregnant women view the importance of micronutrient supplementation during pregnancy and likely their compliance with a prescribed supplementation course. Additionally, financial impacts were cited by a majority of the pregnant women participating in the

interviews and focus groups as one of the most salient barriers to compliance with MMS programs (Figure 5).

Table 5. Overview of community level factors in Madagascar

Facilitators	• Food prescriptions
Barriers	• Food proscriptions • Financial barriers • Negative perception of cost of micronutrient supplement

Facilitators of optimal MMS compliance

Cultural food prescriptions strongly influence the foods that pregnant women perceive to be nutritious and important to consume during pregnancy. Among most women, a variety of fruits and vegetables were identified as leading to positive health outcomes for both the pregnant mother and her developing baby, encouraging their consumption during pregnancy. For example, bananas were identified as having important vitamins that promote the health of the pregnant mother.

"*A banana a day brings vitamins and health if consumed in moderation*."

-Itasy, free list field note, pregnant woman

Protein sources such as fish were identified as being another important source of vitamins important to the health of the pregnant mother and her developing baby.

"*Fresh fish bought at the market. This food provides vitamins for the pregnant woman and for the fetus.*"

-Itasy, free list field note, pregnant woman

Vegetables such as carrots were identified as being an important source of vitamins for both women and developing babies during pregnancy.

"*Eaten raw or cooked, it is a good food for pregnant women. They eat it because it is rich in vitamin A which is good for the eyes*."

-Itasy, field list field note, pregnant woman

"*This food (carrots) gives the fetus vitamins and nutrients.*"

-Itasy, free list field note, pregnant woman

In general, these food prescriptions suggest that many pregnant women have a positive association between the consumption of vitamins and nutrients during pregnancy and health benefits for both the pregnant woman and developing baby. These prescriptions may thus act as important facilitators to women complying with supplementation programs, which provide these same nutrients and vitamins cited as being important to consume during pregnancy, to the pregnant mother.

Barriers to optimal MMS compliance

Culturally bound food proscriptions may negatively impact a woman's compliance with MMS due to the belief that certain foods lack vitamins and may cause rapid and excessive fetal growth, ultimately leading to pregnancy and birth complications. A few women in Itasy described how cassava, a staple of the Malagasy diet, lacks nutrients and therefore, should be avoided during pregnancy. While this belief was not commonly expressed among all women in both districts during interviews and focus group discussions, it is important to note that a food's perceived lack of vitamins results in some women choosing to avoid consuming that food.

By far, the most salient barrier to optimal MMS compliance at this level in both Itasy and Vitovavy Fitovinany is the negative perception of the cost of micronutrient supplementation. Financial barriers are the most commonly cited barrier to achieving an optimal diet during pregnancy, and these

same financial barriers also decrease a woman's opportunity to seek out supplementation from a healthcare provider or comply with a prescribed course of supplementation.

"*They are all motivating [healthy eating], but the one and only problem is the purchasing power, problem of financial means*."

-Vitovavy Fitovinany, interview, healthcare worker

Even if both a pregnant mother and her spouse work, these same financial challenges persist.

"*The real problem is money; it means lack of money. I have seen that here, there are many people who have financial problems. Even if her husband works. I talk to the mother of the family, and she says that her family has money problems, and they don't have the time or even the strength to bring their children here sometimes*."

-Itasy, interview, pregnant woman

In order to encourage optimal MMS compliance, the breadth of these financial concerns must be considered to mitigate the barriers they impose on women seeking MMS.

Institutional Level Factors

There are several different health clinics/services available to pregnant mothers in Madagascar, each with their own distinct group of healthcare workers who are in close contact with women throughout their pregnancies and births. The positive ways in which pregnant women interact with these healthcare institutions in their communities, as well as the healthcare workers and services they provide acts as a strong facilitator of potential MMS compliance, while difficulty accessing the supplement due to physical barriers and low supply of supplement act as strong barriers (Table 6).

Table 6. Overview of institutional level factors in Madagascar

Facilitators	● Nutritional counseling during antenatal care services ● Effective collaboration between different types of healthcare workers
Barriers	● Low supply of supplement available ● High cost of supplement ● Physical barriers to getting to the healthcare clinic

Facilitators of optimal MMS compliance

As discussed in Section III, the supportive social network surrounding pregnant women is important and helpful in encouraging their optimal health and nutrition-seeking behaviors during pregnancy. Of particular importance is strong teamwork and collaboration between midwives and medical doctors at different healthcare service locations, including at large hospital centers and more local community healthcare centers. Many women receive advice about their health and nutrition while visiting these different healthcare centers to receive antenatal care.

"*Every time I go to the AC to weigh myself, she gives me advice. If, for example, your child has a height or weight problem, [she gives] advice on what food to eat…"*

-Itasy, interview, pregnant woman

Additionally, strong teamwork and collaboration between midwives and medical doctors at different healthcare service locations improves a pregnant woman's antenatal healthcare seeking behaviors and nutrition during pregnancy.

"*We collaborate with the midwives to convince pregnant women to give birth at the centre de santé (health center), because people pay attention to what midwives say, because they live in the same society… so the midwives tell [the pregnant women] that they will join them at the CSB II, you have a fever or illness so you should go to the hospital. It's also the midwives who bring the pregnant women back to do the fourth CPN (prenatal consultation)*."

-Vatovavy Fitovinany, interview, health worker

This important relationship between healthcare providers may also extend to improving a woman's compliance with MMS during pregnancy, given the trusted and respected role midwives occupy in the lives of pregnant women. The barriers at this level are still plentiful and difficult to get around, even with a positive working relationship between community health workers and medical doctors.

Barriers to optimal MMS compliance

Oftentimes prenatal supplements are not available at clinics providing antenatal care due to low supply. If MMS is not available to mothers, they cannot use it, thus not only inherently decreasing their compliance with MMS, but disrupting their ability to even obtain MMS in the first place. If there are low shortages of the supplement or it is not available at the community health centers where pregnant mothers most often go for antenatal care in Madagascar, then they are directed to the pharmacy to obtain MMS. Even at these pharmacies, however, stockouts are common and the supplement, if available, is expensive. At antenatal healthcare visits, if a pregnant woman is forced to buy supplements she cannot afford, then it is significantly more difficult for women to attend these antenatal healthcare visits, receive support from healthcare workers who forced them to buy a product they could not afford, or comply with the entire MMS course out of financial concerns.

"*For people who don't have financial problems, the price is not expensive at all. People who have money can buy it directly, but there are some people that I have to force her to buy, and*

she buys in small details. And when we force her like that, afterwards she doesn't come back to the prenatal consultation because she is afraid that I will force her to buy other things."

-Itasy, interview, healthcare worker

Additionally, the specific geographic location of these clinics can also pose a barrier to mothers seeking MMS, as many times they cannot easily access a healthcare provider that might be able to give them MMS due to the travel required to reach each healthcare facility and other impediments along the way.

"*To my understanding, the main obstacle is the issue of money. There is also the distance to the health center or the traditional birth attendants for massages. Because there are women who wanted to be treated but who have no money, they ended up having to stay.*"

-Itasy, interview, healthcare worker

All these factors can make it difficult for mothers to access MMS during antenatal care visits, thus potentially decreasing compliance with MMS programs throughout the duration of a woman's pregnancy.

Interpersonal Level Factors

The social network surrounding pregnant women is incredibly impactful in her life. Many pregnant women receive advice from their close contacts, whether their family members, spouses, local community members, or trusted healthcare providers. These supportive relationships and the positive advice gleaned from them can ultimately help encourage a pregnant woman to utilize MMS, while a lack of support from these relationships can act as barriers to a woman's compliance with using MMS (Table 7).

Table 7. Overview of interpersonal level factors in Madagascar

Facilitators	• Positive relationship between pregnant woman and midwives • Positive perception of the role of supplementation in supporting maternal health by healthcare workers • Advice provided by close social contacts
Barriers	• Lack of community support • Lack of spousal support • Fear of medical practice or healthcare workers • Fear of community judgement about health decisions

Facilitators of optimal MMS compliance

The positive relationship existing between a pregnant woman and her closest community healthcare providers, especially midwives, is a crucial facilitator to a woman receiving advice about the importance of her practicing good nutrition behaviors during pregnancy. A majority of pregnant women report that they follow health advice from these healthcare workers in order to have a healthy pregnancy and mitigate the effects of pregnancy and birth complications.

"*The reason that women follow health advice is that they want to be healthy and that they fear complications during birth. It is also a matter of thinking about the future of their baby, that the baby will be healthy at birth.*"

-Itasy, interview, pregnant woman

Midwives, especially, play an important role in advising women on optimal nutrition during pregnancy and the importance of prenatal supplementation during pregnancy. They hold a very well regarded and trusted position in the lives of pregnant women.

"*We know the diet of pregnant and breastfeeding women. We give advice on healthy food such as: hot food, food must be clean, food that gives strength to the fetus, and I also encourage the mother to take iron folic acid and go to the hospital*."

-Itasy, interview, healthcare worker

Women who have been advised by midwives and other community healthcare workers have a generally more positive view of prenatal supplementation and thus are likely more inclined to seek out MMS and comply with a supplementation program. Healthcare workers also encourage taking MMS in order to mitigate the effects of potential pregnancy complications.

"*For the headache, we know that it is because of anemia. And we encourage her to eat foods rich in iron, or to take iron folic acid. And when she takes it afterwards, she is relieved for a while*."

-Itasy, interview, healthcare worker

Additionally, healthcare workers advise women to comply with supplementation programs to address complications that arise during birth, such as hemorrhage.

"*A pregnant woman has just given birth with a huge hemorrhage, that's why all pregnant women must take the iron battery to fight against this hemorrhage, to give energy to the mother during her pregnancy, and not to lose a lot of blood during the delivery.*"

-Vatovavy Fitovinany, interview, pregnant woman

There are several different healthcare centers in Madagascar, each with its own unique set of healthcare workers who can advise women and care for women during pregnancy.

Adequate support offered by healthcare workers and community members generally improves the nutrition-seeking behaviors of pregnant women. Close family members, as well as community members (e.g., neighbors and friends), also provide support and personal advice to pregnant mothers, increasing their ability to and likelihood of seeking optimal nutrition during pregnancy and antenatal healthcare services.

> "*Sometimes I go to the doctor, but when I need advice, I talk to people a little older than me, and they give me advice… and I ask the same question to another person and then I decide what to do.*"
>
> -Itasy, interview, pregnant woman

Altogether, these several varied relationships that pregnant mothers have are useful in not only facilitating positive antenatal care and nutritional behaviors during pregnancy, but also increasing compliance with MMS programs.

Barriers to optimal MMS compliance

While many mothers have positive relationships with family members, community members, and healthcare workers that facilitate optimal health during pregnancy, a lack of family or community support acts as a barrier to this same goal. A general lack of community or family support hinders a woman's ability to receive the antenatal care counseling that is necessary to receive MMS and ensure a pregnant woman's compliance with the MMS program.

> "*The family does not support me. Once I was afraid… [and] nobody brought me, and nobody followed me to the hospital. As the hospital is close by, and I had to go there because I was sick.*" -Itasy, interview, pregnant women

Specifically, a lack of spousal support was cited as a barrier to women receiving antenatal care and counseling, similarly decreasing her likelihood of receiving counseling regarding the importance of MMS during pregnancy.

"*For example, if the wife wants to go to counseling, her spouse won't let her. You don't have the right to go, and she can't go either because of financial worries. But [antenatal counseling] is free!*" -Itasy, interview, pregnant women

A lack of financial support from husbands also decreases the financial resources a woman has available to purchase food, increase the diversity of her diet during pregnancy, or eat enough to achieve an optimal nutritional status during pregnancy.

"*For those who have no money, they wait for their husbands to sell bananas, when they come to sell the bananas, they waste the money, so they have no food*."

-Vatovavy Fitovinany, interview, healthcare worker

This may also extend to decreasing the woman's ability to purchase MMS if the supplement is not free to pregnant mothers at healthcare locations or pharmacies. Additionally, a lack of advice regarding prenatal supplementation from healthcare workers decreases a woman's compliance with taking the supplement.

"*When the midwife explains to me the iron-folic acid tablet, she only explains that it must be taken, there is no other improvement.*"

-Itasy, interview, pregnant woman

Some medical doctors were specifically cited as only encouraging the pregnant woman to consume the supplement, rather than explaining its importance or how to comply with its prescribed course.

"*No..... the doctor.... if you go to the doctor, he does not give advice*."

-Itasy, interview, pregnant woman

Psychosocial barriers such as fear of a medical practice or healthcare professional also exist, mediating the relationship between a pregnant woman and their healthcare providers. For example, some pregnant

women are fearful of formalized medical offices, such as they might find in a hospital setting with medical doctors present.

"*One of the obstacles too; some of them have never been in an office. So, they are afraid to go to the office, that's one of the obstacles too*."

-Vatovavy Fitovinany, interview, healthcare worker

Some women recounted instances in which they were warned that the midwife or other healthcare worker they were meeting with would be very strict or that they might have to pay extra for antenatal counseling with the healthcare worker.

"*For the care of pregnant women… there were people who tell women that the midwife is very strict, or she is afraid also that he needed money to come here, but now for pregnant women everything is almost free*."

-Itasy, interview, healthcare worker

Additionally, some pregnant women fear being judged by the community for their choices during pregnancy relating to their own health and that of their baby.

"*Sometimes, someone thinks or judges that all women who go to the CSB on Tuesday and Wednesday are pregnant. And they are stressed because of that*."

-Vatovavy Fitovinany, focus group, PLW

The perception of community members is very important to a pregnant woman and so the fear of being judged by that community seems to be strong enough to discourage or encourage certain behaviors in the pregnant mother. It is possible that this could also impact how pregnant women are to receive and comply with MMS.

Individual Level Factors

There are several factors that may impact a pregnant woman's level of compliance with MMS programming, reflecting their own individual perceptions of nutrition and the importance of MMS, as well as the influences of community, institutional, and interpersonal factors upstream of these individual perceptions and individual health behaviors which shape them. It is important to note that previous experiences with IFAS may impact a pregnant woman's perceptions of MMS, both positively and negatively – thus acting as both a booster and a barrier to optimal MMS compliance (Table 8).

Table 8. Overview of individual level factors in Madagascar

Facilitators	● Positive perception of prenatal supplementation ● Positive association between prenatal supplementation and maternal health
Barriers	● Food aversions ● Negative perception of supplementation

Facilitators to optimal MMS compliance

Pregnant women inherently have a certain level of knowledge about the role nutrition plays in their own health and the health of their developing babies, as well as the role of prenatal supplementation and importance of compliance with a prenatal supplementation program. A woman's positive association between optimal nutrition during pregnancy and benefit to her and her child's health increase the likelihood of her seeking out optimal nutrition and antenatal healthcare services.

"*Nutritional advice is to have a healthy diet. The goal is to have a healthy baby and a healthy mother who gives birth normally and that the baby can breastfeed at birth. That is the question of nutrition*."

-Itasy, interview, pregnant woman

"*A friend of mine tells me that I must eat properly so that I can have energy at the time of the delivery and also there is [positive] impact to the baby*."

-Itasy, interview, pregnant woman

Many women follow the advice they receive from their social networks regarding optimal health and nutrition practices during pregnancy, because they personally desire to have a healthy pregnancy, safe birth, and healthy baby.

"*The reason that women follow health advice is that they want to be healthy and that they fear complications during birth. It is also a matter of thinking about the future of their baby, that the baby will be healthy at birth.*"

-Itasy, interview, pregnant woman

Similarly, if pregnant women receive advice and counseling about prenatal supplementation that discusses supplementation as a means to achieving these goals -- having a healthy pregnancy, safe birth, and delivering a healthy baby -- then mothers are likely to desire to heed this advice.

"*What motivates them is what the midwife said they have to take [the supplement], she said it prevents bleeding, that's why they took it.*"

-Itasy, interview, pregnant woman

Many pregnant women also reported having their own individual positive perceptions of prenatal supplementation due to its positive impact on both maternal and fetal health during pregnancy. In community workshops in Itasy, pregnant women discussed their positive perceptions of prenatal supplements and the benefits they personally perceive coming from taking the supplement. Prenatal supplementation was most positively associated with preventing hemorrhage, giving strength to the

developing baby, encouraging the mother to stay hydrated, encouraging the growth of the fetus, and encouraging the growth of the pregnant woman herself. These positive perceptions will aid in mothers ultimately complying with prescribed MMS courses.

Barriers to optimal MMS compliance

While a positive personal perception of prenatal supplementation is helpful in encouraging optimal MMS compliance, there are still several barriers that women must overcome to achieve this goal. Many pregnant women develop food aversions during pregnancy which impact their perceptions of these foods, regardless of the food's nutritional status.

> *"...sometimes there are also pregnant women who don't like rice when they are pregnant, I experienced this when I was pregnant, every time I smelled the smell of rice I threw up*."
>
> -Vatovavy Fitovinany, focus group, pregnant or lactating woman

This means that if the supplement too closely resembles a food that triggers this aversion to a certain taste and results in undesirable side effects like nausea or vomiting, then the pregnant woman will be less likely to comply with taking that supplement throughout her pregnancy.

> "*Some people have an upset stomach when they take the iron pill, but for others, when the red color dissolves, the white color is very bad, and that's why they don't take it all*."
>
> -Vatovavy Fitovinany, interview, pregnant woman

A prior negative experience with supplementation may also decrease a woman's likelihood to seek out or comply with MMS programming. Previous experience with adverse physiological symptoms of taking supplementation, namely nausea and vomiting, may decrease her likelihood of complying with MMS programs. In community workshops in Itasy, many women explained that disadvantages of supplementation include its bad smell, how it causes malaise and vomiting, and its bad taste. Some

women also report simply forgetting to finish their MMS prescription throughout the course of pregnancy.

"*No, we didn't take all [IFA] all, there are always those [that] we forget*."

-Vatovavy Fitovinany, focus group, pregnant or lactating woman

All these factors influence the ability and likelihood of a pregnant woman to comply with prescribed MMS courses and must be taken into consideration when designing MMS implementation programs in Madagascar.

Chapter 4

Discussion

Comparison of Findings in Madagascar and Bangladesh

Community Level

In both Madagascar and Bangladesh, cultural food rules govern a woman's dietary choices during pregnancy and may also influence her likelihood to comply with Multiple Micronutrient Supplementation (MMS) regimes during pregnancy, acting as both facilitators of and barriers to this compliance. While food prescriptions and proscriptions were mentioned during interviews, focus group discussions, and community workshops in both settings, these factors were most salient in Madagascar and to a lesser extent in Bangladesh.

It is important to note that the cultural food rules that may become facilitators to a woman's optimal compliance with MMS are more biomedical in nature, drawing a link between food choices, the importance of the nutrients found in those foods, and ultimately how those nutrients may improve maternal health during pregnancy, fetal health during pregnancy, and birth outcomes. In both Madagascar and Bangladesh, women often discussed the importance of eating certain fruits or vegetables during pregnancy because of the iron, calcium, or other nutrients belonging to the food and their perceived link to maternal and fetal health benefits. This finding points to the broad understanding that women in these settings have about the ways in which good nutrition influences their overall health and birth outcomes. These findings are corroborated by previous studies that elucidated how many pregnant women in Madagascar have a strong understanding of the link between poor dietary consumption, malnutrition, and the potential birth complications that may result from poor nutrition (Dell et al., 2010; Pourette et al.,

2018; Rakotomanana et al., 2020; Rakotosamimanana et al., 2015). In rural parts of northwest Bangladesh, the same finding is corroborated among many pregnant and lactating women (Nguyen et al., 2017).

It is important to note that these findings also point to the fact that many women in these settings understand nutrition and its health impacts in a way that reflects guidelines prescribed within a biomedical framework. In previous studies conducted in Madagascar, the perceived health benefits of consuming certain foods are linked to knowledge about the roles of vitamins and nutrients in creating positive health outcomes, reflecting this idea that pregnant Malagasy women have some biomedical understanding of the role of nutrition in affecting maternal and fetal health outcomes (Rakotomanana et al., 2020). Similarly, in Bangladesh, many pregnant women ascribe the maternal and fetal health benefits of certain foods, and even that of Iron and Folic Acid Supplementation (IFAS), to the nutrients found within those foods (Harding et al., 2016; Nguyen et al., 2017). The findings suggest that many of these commonly held beliefs about the role of nutrition during pregnancy that reflect biomedical knowledge are more salient than ones reflecting traditional knowledge (Morris et al., 2014; Randrianarivony et al., 2017). This suggests the successful dissemination of this knowledge throughout communities, such that a majority of pregnant women in the communities in Madagascar and Bangladesh from this study, as well as many previous studies, abide by food rules that reflect biomedical knowledge more so than food rules reflecting traditional knowledge.

Rote knowledge of the importance of consuming certain foods during pregnancy, however, does not always lead to a systematic increase in the consumption of those foods (Rakotosamimanana et al., 2015). Understanding the factors that impede the translation of this knowledge to a positive nutrition-seeking behavior can help health officials better tailor interventions to increasing the actual desired optimal nutritional behavior; in this case being a pregnant woman’s consumption of the foods known to promote optimal maternal and fetal health during pregnancy, as well as adherence to MMS regime that similarly helps her achieve optimal maternal and fetal health during pregnancy. In both settings, food

rules were not only viewed as positive potential facilitators to a woman's MMS compliance, but also as barriers to this compliance. While many of the food rules that promoted optimal nutritional behaviors were mainly founded in biomedical knowledge, the food rules discussed that inhibit that same behavior might be more so founded in traditional knowledge (Andrianantoandro et al., 2021; Pourette et al., 2017; Morris et al., 2014). Specifically, women in both settings discussed the commonly held belief that consuming too much food or too many nutrients during pregnancy would cause excessive and rapid fetal growth, resulting in birth complications such as cesarean delivery or hemorrhage.

This belief is not limited to the communities participating in this study, as it is a well-documented belief among pregnant and lactating women in districts throughout both Madagascar and Bangladesh (Andrianantoandro et al., 2021; Bogren et al., 2018; Doraiswamy et al., 2021). In Madagascar, the avoidance of consuming certain foods or supplement during pregnancy so as to avoid having too large a baby may stem from local belief systems that promote the idea that birth complications are curses (Andrianantoandro et al., 2021; Morris et al., 2014). In Bangladesh, the belief that a pregnant woman should not consume too much food during pregnancy is often referred to as a common "superstition" within rural communities (Sultana et al., 2019). These findings ultimately suggest that these food rules rooted in more traditional knowledge might be stronger barriers to a woman's optimal nutrition-seeking behaviors during pregnancy than the food rules rooted in more biomedical knowledge are facilitators of the same behavior.

It is also important to note that while women in both settings mentioned this common fear within the community as a reason for consuming a lesser amount of food during pregnancy, mothers in Bangladesh acknowledged that their families often actively discouraged them from consuming prenatal supplementation for the same reasons. In moving forward towards implementing MMS within these countries, it will be important to address this common fear within the community that currently prevents mothers from consuming enough food during pregnancy and, in many cases, any prenatal supplement during pregnancy, as well. If this common fear is not addressed in the marketing of the product or not

appropriately communicated to the social networks surrounding pregnant women, as well as the pregnant women themselves, then the supplement will likely continue to face difficulties gaining compliance across the board.

These community-level findings provide important insight into potential implementation strategies of MMS within Madagascar and Bangladesh. In order to promote the MMS product, it is important to use promotional materials that align with the food rules abided by most of the community, which might mean finding avenues to increase biomedical understanding of the relationship between optimal nutrition during pregnancy and optimal maternal and fetal health outcomes, while mitigating the effects of a woman's fears surrounding the behaviors associated with achieving proper nutritional status during pregnancy (i.e. consuming nutrient-rich foods or taking MMS) leading to birth complications. Since MMS is ultimately intended to provide pregnant women with the same vitamins and nutrients they identify as being important to consume during pregnancy, making sure that the community understands the goal of MMS as augmenting a pregnant woman's ability to consume these nutrients in addition to her daily diet is key. Furthermore, identifying the community resources and people at the institutional and interpersonal levels who can help accomplish this is imperative.

Institutional Level

The institutional level concerns understanding the impact of the healthcare system and network of healthcare clinics and healthcare workers on the potential compliance of pregnant women to Multiple Micronutrient Supplementation (MMS) regimes in both Madagascar and Bangladesh. Like at the community level, at the institutional level, the potential facilitators of and barriers to optimal MMS compliance in the two settings are similar. In both Madagascar and Bangladesh, the study findings suggest that support gleaned from the healthcare system within the community is an important factor impacting a woman's ultimate compliance with MMS, though the individual experiences that pregnant

women identify as being facilitators to this compliance differ. Findings from both settings, however, indicate that a common barrier to a pregnant woman's supplementation compliance is having physical or geographical barriers to the access of the supplement, as well as there being a low supply of the supplement to distribute among women needing it. Additionally, the most salient barrier to a woman's compliance with MMS regimes in both settings was the impact of financial constraints. In Bangladesh only, however, the gender of the healthcare workers was indicated as also impacting the likelihood of a pregnant woman to adhere to MMS regimes.

In both Madagascar and Bangladesh, most women reported that they received counseling from healthcare workers when they attended antenatal care services. These counseling sessions provided pregnant women an opportunity to receive advice from healthcare workers about behaviors that maintain a healthy pregnancy and result in optimal maternal and fetal health outcomes. In both settings, this advice ranges from counseling specifically about nutrition, to counseling about a woman's vital signs (i.e., weight or blood pressure) during pregnancy, to counseling specifically about prenatal supplementation (Fernald et al., 2016; Hoddinott et al., 2017; Huda et al., 2018). The findings indicate that in Bangladesh and Madagascar, the nutritional counseling that women receive at these antenatal care visits is an important factor in their dietary choices made during pregnancy, as well as potential compliance with MMS regimes. Previous studies elucidated the importance of these nutritional counseling sessions in conjunction with antenatal counseling sessions in both Madagascar and Bangladesh. They suggest that the nutritional counseling aids in improving dietary intake during pregnancy, as well as potential MMS compliance, by educating women about the importance of optimal diet and nutrition during pregnancy (Hoddinott et al., 2017; Huda et al., 2018). Additionally, families that receive nutritional counseling often act on the advice received from the health workers running the sessions (Fernald et al., 2016; Stewart et al., 2020). These sessions, often provided by community health workers, not only facilitate a woman's optimal dietary intake during pregnancy, but also increase the likelihood she complies with a prescribed regime of prenatal supplement such as MMS.

While most women discussed the importance of the nutritional counseling sessions during the focus group discussions, community workshops, and semi-structured interviews in both Madagascar and Bangladesh, some women also mentioned that healthcare workers specifically instructed them to abide by recommended prenatal supplementation programs. This suggests that even if healthcare workers are not currently discussing prenatal supplementation with every woman who receives nutritional counseling, the framework for and spaces to have discussions about supplementation already exist in both study settings. To further advance the coverage of and overall compliance with MMS in both Madagascar and Bangladesh, implementing more purposeful counseling about prenatal supplementation, in combination with preexisting nutritional counseling, could be useful.

It is important to note, however, that counseling about prenatal supplementation, in conjunction with nutritional counseling during pregnancy, would only be useful to pregnant women who already receive this nutritional counseling by attending regularly scheduled antenatal care (ANC) visits throughout their pregnancies. In both Madagascar and Bangladesh, many pregnant women do not attend all recommended ANC visits, if any, with healthcare workers for several reasons (Ezran et al., 2019; Islam and Masud, 2018; Salem et al., 2018; Shahjahan et al., 2012, Siddique et al., 2018). In both settings, many pregnant women discussed the immense difficulty they face in gaining access to the ANC visits they need to have the healthiest pregnancy possible, which similarly decreases their level of access to prenatal supplementation such as MMS. Most women face physical and geographical barriers to accessing antenatal care services at healthcare locations within their communities (Islam and Masud, 2018; Morris et al., 2014). In both countries, women discussed the issue of having to travel to healthcare clinics for ANC visits via routes without easily accessible roads (Keya et al, 2014). Certain weather conditions washing out or flooding the roads leading to these clinics were also often cited as physical barriers to accessing antenatal care services.

In addition to the physical barriers a pregnant woman faces even accessing antenatal care, many pregnant women in both Madagascar and Bangladesh also discussed the barriers they face in receiving

supplementation; that is if they can physically access a dispensary point of the supplement through antenatal care services or otherwise through a pharmacy. In both countries, there is often low supply and stockouts of the prenatal supplement, which means it is not available for pregnant women to purchase. Low stock of prenatal supplementation or complete stock outages is a common problem in low- and middle-income countries, such as Madagascar and Bangladesh (Kavle and Landry, 2017; Regil and Stoltzfus, 2016). Additionally, in both countries, women cited financial concerns as one of the most salient barriers to receiving and complying with supplement regimes. If the MMS is not free of charge to pregnant women, many women cannot afford an entire pregnancy's worth of supplement (Engle-Stone et al., 2019; Fernald et al., 2016; Garchitorena at al., 2017; Svefors et al., 2018). To be most effective, it is necessary for a pregnant woman to take an entire course of MMS throughout her entire pregnancy and reducing the potential cost of MMS would likely result in this occurring most often.

One important difference between the two countries is that in Bangladesh, women also reported the importance of being able to have a female healthcare worker advise her on her nutrition, health, and supplementation during her ANC visits. In Bangladesh, some male health care workers mentioned how many pregnant women prefer to be seen by female healthcare workers rather than male healthcare workers. This was cited as being due to both the mothers' own preference, as well as her husbands' preference, too. In Bangladesh and surrounding South Asian countries, a patriarchal society dominates in which most healthcare decisions, even those surrounding a woman's reproductive health, are made by the male head of household, oftentimes a woman's husband (Bishwajit et al., 2017; Story et al., 2012). If a pregnant woman's husband does not wish for her to be seen by a male healthcare worker, then it is likely she will not, which decreases her ability to attend all recommended ANC visits, as well as receive MMS at those visits.

Understanding the compounded effect of these barriers is of particular importance in tailoring strategies to optimize compliance with MMS regimes among pregnant women. When looking forward to the ultimate implementation of MMS within communities in Madagascar and Bangladesh, it will be

necessary to address these institutional barriers that prevent women from having access to prenatal supplementation in the first place. Even though the strength of the healthcare network and advice provided by healthcare providers during antenatal care visits can be a powerful facilitator of MMS compliance, the barriers to accessing ANC services, and by proxy, prenatal supplementation, must first be addressed.

Interpersonal Level

One of the most influential factors in both Madagascar and Bangladesh in a woman's choosing to utilize Multiple Micronutrient Supplementation (MMS) is the extent to which prenatal supplementation is encouraged by her social networks. This advice was reported by participants in the study in both Madagascar and Bangladesh as often being contextualized alongside other nutritional or health advice received from these social contacts. On the contrary, a lack of social support, lack of advice received, or negative advice received from social contacts all act as barriers to a pregnant woman complying with a prenatal supplementation regime throughout pregnancy.

In both Madagascar and Bangladesh, one of the most important factors in facilitating optimal compliance with prenatal supplementation is the pregnant woman receiving positive advice from those in her immediate social network. This includes her immediate family, in-laws, extended family, close friends, trusted community members, and trusted healthcare professionals (Morris et al., 2014; Story et al., 2012). In both countries, the importance of the family unit, as well as the trust that one has in other members of their neighborhood and community, are important underlying social factors that contribute to the importance of this social network during a life stage such as pregnancy – one that forces a pregnant woman into an especially vulnerable position, both socially and medically (Edmonds et al., 2011; Morris et al., 2014; Jahan et al., 2022). Thus, it is imperative that a pregnant woman not only surrounds herself with a strong social support system, but also relies on that system for trusted advice when it comes to her

personal health and wellbeing during pregnancy (Morris et al., 2014). This was reflected in the study's focus group discussions, community workshops, and semi-structured interviews, in which women in both study settings described how important it was that they received advice from these trusted social contacts and how they often strictly followed this advice, as well.

In fact, previous studies have elucidated the importance of creating a more integrated healthcare system within these countries by incorporating those trusted social contacts in a pregnant woman's life into her healthcare via antenatal care (ANC) visits, nutritional counseling, and delivery support (Garchitorena et al., 2018; Morris et al., 2014). Of particular importance in Madagascar, for example, is the trusted relationship a pregnant woman has with her midwife, as was discussed by many participants during this study and previously in other studies, as well (Pourette et al., 2018; Quashie et al., 2014). The comfort a pregnant woman feels in being cared for by a trusted social contact, as well as the trust she has in that social contact thanks to their shared background and values, increases her likelihood to follow any advice received from the contact. In the case of improving maternal compliance with MMS in the future, these deeply valued connections within the family unit and community will be vital for encouraging adherence to MMS regimes throughout pregnancy.

As mentioned previously, most women trust the advice given to them by their social contacts, so much so that even when the advice received from a social contact discouraged a pregnant woman from pursuing positive health- and nutrition-seeking behaviors during pregnancy, many women described feeling like they still needed to follow that advice. In Bangladesh, for example, many women described how their own mothers or mothers-in-law actively discouraged them from using prenatal supplements during their pregnancy. This ultimately restricted the woman's ability to then pursue completing the recommended course of supplementation, especially because many women in Bangladesh also described having low autonomy when it comes to making decisions about healthcare – a finding that is corroborated by previous studies (Jahan and Islam, 2022; Story et al., 2012). As previously mentioned, a woman's husband also makes decisions for her and their family about their health and nutrition, which includes

decisions about prenatal supplementation (Story et al., 2012). Additionally, many women in Madagascar described how a lack of social support from their husbands, community members, or family members discouraged their perusal of certain behaviors related to health and nutrition (Andrianantoandro et al., 2021; Morris et al., 2014). These findings suggest that the ways in which discouraging advice affect a pregnant woman's health- and nutrition-seeking behaviors during pregnancy may also extend to a woman avoiding the use of MMS throughout her pregnancy if not advised by close social contacts, as well.

Altogether, receiving advice and support from trusted social contacts acts in many ways as both a facilitator of optimal behavior during pregnancy, as well as a barrier to practicing optimal behaviors during pregnancy. As aforementioned, if the advice is positive and supportive of optimal behaviors, such as complying with prenatal supplementation regimes, then it likely serves as a strong facilitator of pregnant women heeding this advice about optimal behaviors during pregnancy. If, however, the advice is negative and advises against certain behaviors during pregnancy, then it likely serves as a barrier to pregnant women complying with optimal behaviors during pregnancy. It is important to understand the extent to which pregnant women are influenced by these contacts and their support, or lack thereof, in order to most effectively implement MMS within these communities.

Individual Level

In both Madagascar and Bangladesh, women reported that having a positive perception of MMS is one of the most important factors in their personal compliance with prenatal supplementation programs. For many women in these countries, they explained that this positive perception can be shaped by the advice they receive from their social contacts specifically regarding prenatal supplementation. Additionally, having a more generally positive association of good nutrition and its maternal and fetal health benefits can help bolster this positive perception of prenatal supplementation among pregnant women. In both Madagascar and Bangladesh, the main individual barriers that women face in complying

with MMS throughout pregnancy include the adverse physiological side effects of pregnancy, including aversions to certain tastes and smells.

In both countries, women reported that having a positive perception of prenatal supplementation, likely bound by a similarly positive perception of the importance of optimal diet and nutrition during pregnancy, is an important facilitator of their compliance with a prenatal supplementation regime. This positive perception is shaped by a majority of the aforementioned determinants of a person's compliance with MMS, but it is also influenced by a person's own understanding of the importance of nutrition during pregnancy (Alam et al., 2015; Harding et al., 2016). Many women have a generally positive view of the importance of having good nutrition during pregnancy, largely due to the health benefits reaped from consuming a diet high in vitamins and nutrients (Andrianantoandro et al., 2021; Harding et al., 2016; Nguyen et al., 2017). This individual perception held by each pregnant woman can be a very important and strong facilitator of her ultimate compliance with an MMS program.

Many women in both countries experience negative side effects of pregnancy, including nausea, vomiting, and aversions to certain tastes and smells. Women reported that an association between or previously bad experience with a prenatal supplement and subsequent worsening of these pregnancy symptoms was a strong deterrent for most pregnant women from taking the supplement as often as it is prescribed, a finding that was also corroborated by previous studies (Baxter et al., 2014; Harding et al., 2016). In order to ensure that women feel comfortable taking the supplement and do not worry that it will exacerbate their pregnancy symptoms, it is important to understand which smells and tastes are most triggering to most pregnant women, and to avoid creating a supplement that has these smells and tastes. This would be largely important when implementing MMS within these communities.

In Madagascar, many women described the difficulty they face in complying with MMS regimes due to simply forgetting to take the supplement when they are supposed to. This indicates a need for better understanding the type of support supplement users, especially pregnant women, need in order to comply with the program throughout the duration of their pregnancy. Additionally, in Bangladesh, some

women reported having the perception that there is an alternate, more effective mode of improving nutritional status during pregnancy than by consuming prenatal supplementation. If this belief is commonly held among pregnant women, then they might believe that they can achieve optimal nutritional status by changing their diet without any of the added barriers that accompany prenatal supplementations. There remain, however, several barriers to achieving this optimal diet, regardless. If those barriers are not addressed and pregnant women are thus unable to achieve optimal nutritional status during pregnancy, then the epidemic of malnourishment among pregnant and lactating women and women of reproductive age continues, thereby further necessitating the need for proper MMS implementation into communities in Madagascar and Bangladesh.

Strengths and Limitations of the Study

Strengths

There were multiple strengths inherent to this study, including the utilization of the Socioecological Model (SEM) as the guiding organizational tool for the analysis of study findings, the mixed-methods approach that allowed for findings to be corroborated across multiple methods, and the participatory nature of the study that allowed for direct responses to be recorded from members of the affected population.

Structuring this study in accordance with the SEM provided the opportunity to better understand the complex interplay between the community, institutional, interpersonal, and individual factors affecting a woman's potential compliance with Multiple Micronutrient Supplementation (MMS) in Madagascar and Bangladesh. The SEM is commonly used in various health promotion endeavors to elucidate how the interactions between factors at the community, institution, interpersonal, and individual levels affect a person's health and health-seeking behaviors (Kilanowski, 2017). The model can be

especially helpful when investigating the factors that influence certain nutritional outcomes that are strongly affected by the social determinants of health at multiple levels, such as disparately high rates of malnutrition in low- and middle-income countries (DeLorme et al., 2018; Gregson et al., 2001; Mahmudiono et al., 2019; Perez-Escamilla et al., 2018; Pradeilles et al., 2018). Not only does the model provide a framework to understand the factors affecting these nutritional outcomes, but it also provides a structure for subsequently creating culturally appropriate and locally tailored recommendations for strategies to address the adverse nutritional outcome of interest (DeLorme et al., 2018; Tesfay et al., 2021; Zive and Rhee, 2014). The SEM is utilized broadly to address nutritional outcomes, but it has also been used in the past to specifically understand the factors that influence a woman's adherence to prenatal multivitamin/mineral supplementation during pregnancy, further supporting its use as the analytic framework in this study (Jasti et al., 2005; M'Cormack and Drolet, 2013; Rosen et al., 2018; Zive and Rhee, 2014). The overlapping nature of the various factors at these levels allows for the consideration of the complex interplay between these levels and thus a better understanding of how they build upon each other and impact each other to affect a woman's potential compliance with MMS. As mentioned previously, the model also provides insight into areas where tailored recommendations specific to these study settings might improve maternal compliance with MMS.

Another strength of this study comes from its mixed-methods approach, through which the study findings from each individual method – the focus group discussions, community workshops, and semi-structured interviews – were able to be triangulated and corroborated across method, further strengthening the conclusions drawn from the findings. Methodological triangulation is commonly used within social and behavioral sciences in order to establish validity of qualitative research work and improve understanding of how a particular social or behavioral health manifests (Carey, 1993; Guion et al., 2011; Mitchell and Sommer, 2016). This study design, as well as the subsequent analysis of the methods in this manner, thus allowed for a more comprehensive story to emerge about pregnant women's potential compliance with MMS throughout the duration of their pregnancies than if only study method had been

used and analyzed. Ultimately, the use of the three different methods, and the subsequent analysis of those methods, lent itself to increasing the validity of the study, providing confirmation of findings, and enhancing understanding of the manifestation of maternal MMS compliance in the study settings.

One of the most important strengths of this study is the participatory nature of the study and the direct utilization of members of the affected populations in the focus group discussions, community workshops, and semi-structured interviews in both study settings. The study methodology allowed for hundreds of pregnant women, health care workers, and community members to be involved in the study in both Madagascar and Bangladesh. This purposeful inclusion of study participants, as well as the detailed verbatim record of their responses, allows for a more nuanced analysis and understanding of the determinants affecting a woman's potential compliance with MMS. The ability of the participants to be interviewed in their own communities amongst a group of their peers might have aided in the level of comfort each participant had in the process, allowing for more honest and specific responses from participants in the group discussion, interviews, and workshops.

Limitations

Even though this is a strong study due to its methodology and supporting framework via the SEM, the study was limited by its completion during the COVID-19 pandemic, by the translation of data through multiple languages, and by the seasons during which the study was conducted in Madagascar and Bangladesh.

Due to the completion of the study during the COVID-19 pandemic throughout 2020-2021, much of the study's data collection and management was outsourced to local partners working within the Itasy and Vatovavy Fitovinany districts in Madagascar and the Bhola and Kurigram districts in Bangladesh. Due to international travel restrictions caused by the COVID-19 pandemic, the United States-based research team was unable to participate in the fieldwork data collection in person within the study

settings. If this had been possible, it might have resulted in a more iterative process as daily feedback from study participants and facilitators could have been included in the real-time adaptation of data collection throughout the duration of the study. In the future, as international travel policies allow, having the research team directly involved with the data collection and management throughout the entire study process would be helpful and provide the opportunity to make any adjustments to the data collection methods as needed in real time.

Additionally, another limiting factor in the study was the need for translation from the native languages of Madagascar and Bangladesh to English for textual data analysis. Data was collected in Malagasy in both the Itasy and Vatovavy Fitovinany districts in Madagascar and in Bangla in the Bhola and Kurigram districts in Bangladesh. As discussed in the Methodology section, textual data sourced from participants in Madagascar was translated from Malagasy to French (and then to English if needed), and textual data sourced from participants from Bangladesh was translated from Bangla to English. It is likely that, through the process of multiple translations, certain nuances to a participant's response in any of the three methods employed – focus group discussions, community workshops, or semi-structured interviews – could have been lost in the translation. In the future, identifying ways to analyze the textual data in the language in which it was collected will be imperative to ensuring the most comprehensive understanding of participants' responses as possible.

Finally, it is important to acknowledge that this study was only conducted during one season of the year in Madagascar and Bangladesh, meaning the effects of seasonal poverty and seasonal hunger might not be fully captured by the data collected in this study. In many low- and middle-income countries in which agrarian lifestyles dominate, the impacts of seasonal changes permeate domestic markets and household income, having great impact on the experience of poverty and hunger by people living in the country (Swan et al., 2009; Vaitla et al., 2009). This phenomenon has been well-documented within the study settings, specifically, as well. In Madagascar, seasonal changes in weather patterns coincide with seasonal food shortages and an increase in malnutrition during specific periods of the year (Dostie et al.,

2002; Golden et al., 2019). In Bangladesh, especially in rural districts, the same phenomenon occurs in which seasonal fluctuations in agriculture begets seasonal poverty and seasonal malnutrition (Ahamad et al., 2013; Khandker, 2012; Palis et al., 2016). Because of seasonal poverty and subsequent seasonal hunger, the findings from this study, only conducted during one season of the year, might not elucidate a full understanding of the nutrition-seeking behaviors of participants throughout the duration of one full year and through the seasonality of poverty and malnutrition. In future studies, utilizing a more longitudinal approach that allows for data collection throughout multiple seasons may help to provide deeper understanding into the ways in which maternal compliance with MMS might be affected by seasonal poverty and hunger.

Conclusion

The most salient determinants of a woman's potential compliance with Multiple Micronutrient Supplementation (MMS) in Madagascar and Bangladesh are similar at all investigated levels – the community level, institution level, interpersonal level, and individual level – despite geographic and cultural differences that exist between the two study settings. Ultimately, this suggests that the similar characteristics between study settings, namely the experience of all pregnant women participating in the study living in poverty, might act as a stronger diluter of any other cultural or geographic factor that also influenced these findings. It also suggests that poverty manifests similarly across study settings and that the experience of pregnant women living in poverty will be similar, regardless of their community's geographic or cultural niche. Even though many of the most salient determinants of a woman's potential compliance with MMS are similar, the determinants are still bound by the cultural and social fabric of these very unique study settings in Madagascar and Bangladesh, elucidating the importance of tailoring implementation strategies of MMS in a way that is culturally appropriate and locally tailored to the needs of a community and its members. Ultimately, these findings will help public health officials, researchers, and other invested parties develop implementation programs for MMS that lead to more optimal MMS compliance among pregnant and lactating women. Accomplishing this goal ultimately contributes to the goal of ensuring that every mother has the opportunity to reach an optimal level of nutrition during her pregnancy, improving maternal and fetal health outcomes globally and leading to a reduction in the global burden of maternal malnutrition and disease.

Appendix A

Study Instruments in Madagascar and Bangladesh

Participatory Workshop Data Collection Tool

Demographic Information:
Data Collector Name: _____ Date: _____

Location: _____ Number of participants: _____

Introduction: We would like to hear your suggestions on developing a brand for a micronutrient supplement specifically for pregnant women. Please express your ideas freely; there are no right or wrong answers. We will be asking you a series of questions and will vote on your responses.

Branding: Discuss common brands in the community focusing on colors, names, logos and slogans. Use brands like sports teams as examples.
Question 1: Now, we would like to discuss how a micronutrient supplement should look to make it attractive to pregnant women in this community. We will be asking for your ideas for the color, name, logo and slogan for this product. Let's start with color. Please brainstorm a color scheme that you think would suit a product like this.

- Let's vote on the color schemes. You have 5 votes and can use all 5 on one idea or split them up.

Question 2: Next, we would like you to think about a good name for a product like this. The name can be one, two or three words.

- Let's vote on the names. You have 5 votes and can use all 5 on one idea or split them up.

Question 3: Now, let's think about a good slogan to represent this product. The slogan could be a short phrase that is memorable.

- Let's vote on the slogans. You have 5 votes and can use all 5 on one idea or split them up.

Question 4: Now, let's discuss what a good logo would look like. The logo could be a simple picture that represents the name and the slogan of the product.

- Let's vote on the logo ideas. You have 5 votes and can use all 5 on one idea or split them up.

Thank you for your participation. Does anyone have any additional questions or comments?

Semi Structured Interview for Pregnant and Lactating Women Data Collection Tool

Demographic Information

Data Collector Name: _____ Date: _____

Location: _____

Introduction:

1. **Thank you for taking the time to speak with me. To start, can you please tell me about your family?**
2. **Could you please tell me about a typical day for you?**
3. **Now can you tell me about the resources available for pregnant women in this community?**

Antenatal Care:

Now I would like to know more about health during pregnancy in this community.

4. **Can you please describe what a healthy pregnancy should look like?**
5. **Can you please describe any changes to your diet after you became pregnant?**
    - Probe on any advice regarding diet during pregnancy received
    - Probe on who gave her the advice
    - Probe on foods that are good for pregnant women
    - Probe on foods that pregnant women should avoid
    - Probe on how easy or difficult it is to maintain a healthy diet during pregnancy
6. **Can you please describe the illnesses that pregnant women in this community suffer from?**
    - Probe on seriousness of illnesses
    - Probe on diseases she is most concerned about
    - Probe on consequences of untreated illness
    - Probe on the cause of each illness
    - Probe on prevention of each illness
    - Probe on treatment
7. **Can you describe any health care you have received from the time you knew you were pregnant to now?**
    - Probe on healthcare seeking practices
    - Probe on knowledge of when to seek care
8. **What barriers do women in this community face in staying healthy during pregnancy?**
    - Probe on community support
    - Probe on family support
    - Probe on access to care

Micronutrient Supplement

This is great information. Now I would like to hear your thoughts on micronutrient supplements.

9. **Can you describe how a micronutrient supplement could help you stay healthy during your pregnancy?**

- Probe on illness prevention

10. Can you describe any similar products that you or other pregnant women in your community use?

- Probe on source of supplements
- Probe on availability
- Probe on affordability
- Probe on sharing
- Probe on what makes them desirable
- Probe on products that are not desirable
- Probe on perception of product
- Probe on other medications used during pregnancy

11. Can you describe how these products were explained to you?

- Probe on who told her about these products
- Probe on how effective this explanation was
- Probe on how it could be improved

12. Can you please tell me how to best market a micronutrient supplement to pregnant women in this community?

- Probe on ways to promote the product
- Probe on effective distribution channels

13. Thank you for your time. Is there anything else you would like to discuss that was not brought up?

Semi Structured Interview for Health Workers Data Collection Tool

Demographic
Data Collector Name: _____ Date: _____

Location: _____

Introduction:

1. **Could you please tell me about your role in the community?**
2. **Tell me about a typical day as a health worker?**
3. **Can you please describe what health care resources there are for pregnant women in this community?**

Antenatal Care:
Now I would like to know more about health during pregnancy in this community.

4. **Can you please describe what a healthy pregnancy should look like?**

5. **Can you please describe the illnesses that pregnant women in this community suffer from?**
    a. Probe on seriousness of illnesses
    b. Probe on consequences of untreated illness
    c. Probe on the cause of each illness
    d. Probe on prevention of each illness
    e. Probe on treatment
6. **Can you tell me about illnesses that you are most concerned with?**
    a. Probe on specific stories/ narratives
7. **Tell me about the care that a pregnant woman receives over the course of her pregnancy**
    a. Probe on any nutritional advice given to pregnant women
    b. Probe on any resources provided to women
    c. Probe on if advice is followed
    d. Probe on if resources align with advice
    e. Probe on reasons why women may or may not follow advice
    f. Probe on healthcare seeking practices
8. **What barriers do women in this community face in staying healthy during pregnancy?**
    a. Probe on community/family support
    b. Probe on access to care

Micronutrient Supplement
This is great information. Now I would like to hear your suggestions about developing a program that will introduce a micronutrient food supplement

9. **Can you describe how a micronutrient supplement would help a woman stay healthy during her pregnancy?**
    a. Probe on illness prevention
10. **Can you describe similar products that pregnant women in this community use?**

a. Probe on source of medications/ supplements
b. Probe on affordability
c. Probe on sharing
d. Probe on what makes them desirable
e. Probe on products that are not desirable
f. Probe on acceptability of micronutrient supplement
g. Probe on perception of product

11. Please describe the most effective way to market a micronutrient supplement in this community?

a. Probe on trusted communication channels
b. Probe on distribution channels
c. Probe on how to explain the micronutrient supplement to women
d. Probe on best ways to ensure that the product is being used correctly

12. **Thank you for your time. Is there anything else you would like to discuss that was not brought up?**

Focus Group for Pregnant and Lactating Women Data Collection Tool

Demographic Information:
Data Collector Name: _____ Date: _____

Location: _____ Number of participants: _____

Introduction:
Thank you for taking the time to speak with us today. We would like to hear your thoughts on micronutrient supplement s and supplementation during pregnancy.

1. **To start, can everyone tell us a little about their family?**

Antenatal Care:

2. **What are some common challenges that women face during pregnancy? Can you tell us about your experience with these?**
    - Probe on challenges related to nutrition
    - Probe on social support

MMS Products:

3. **Now let's discuss your experience with supplements during pregnancy. We have heard that many pregnant women in this community use X (country specific). Can you tell me why that is?**
    - Probe on what makes these products desirable
    - Probe on products disliked by the community and reasons why
    - Probe on how these products are used
    - Probe on how easy or difficult it is to use the supplements
    - Probe on how important the use of these products are to pregnant women
4. **Can you describe any barriers in getting or using these supplements?**
    - Probe on availability
    - Probe on affordability
    - Probe on where supplements are sold
5. **Can you describe how these supplements might help you during pregnancy? Can you please explain why that is?**

MMS Promotion:
Now we would like to hear your thoughts on how these products should be promoted in this community.

6. **Can you describe what a product should look like to make it attractive to pregnant women?**
    - Probe on colors
    - Probe on logo
    - Probe on names
    - Probe on colors, names and logos that should not be used
7. **Can you tell us where this product should be promoted?**

- Probe on where pregnant women often get health advice
- Probe on health advertisements in the community

8. **Can you tell us who this product should be marketed to?**
    - Probe on advertising to fathers
    - Probe on differences in messaging depending on audience

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ACADEMIC VITA

Rachel Bruning

EDUCATION

B.S. Biochemistry and Molecular Biology, Molecular Biology option
B.S. French and Francophone Studies, Applied French
Minor in Global Health
Schreyer Honors College

Pennsylvania State University, University Park, PA
Graduation in Spring 2022

WORK EXPERIENCE

Research Assistant January 2021-Present
Kodish Lab, Pennsylvania State University *(University Park, PA)*

- Propose and an execute an individual research project and honors thesis investigating the conceptualization of nutrition among pregnant and lactating women in Madagascar and Bangladesh under the guidance of Dr. Steve Kodish.
- Collaborated with partners in Madagascar to co-author a formative report sponsored by UNICEF about the introduction of Multiple Micronutrient Supplementation in maternal antenatal care in Madagascar

Virtual Global Health Internship Summer 2021
Child and Family Health International *(Virtual)*

- Collaborate with medical partners in Quito, Ecuador to learn about and address health disparities and problems within the community

Teaching Assistant Fall 2020
BMB 297: Online Elementary Biochemistry Laboratory *(University Park, PA)*

- Develop weekly learning modules, assignments, and assessments for an asynchronous, online biochemistry lab
- Hold weekly office hours to solve problems directly with students; meet with students 1:1 as needed to address any questions related to course material; collaborate with Dr. Shawn Xiong and other BMB 297 TAs to create engaging learning modules and grade student work

Research Assistant Spring 2018-Fall 2019
Miyashiro Lab, Pennsylvania State University *(University Park, PA)*

- Propose and an execute an individual research project related to the mutualistic symbiosis existing between the Hawaiian Bobtail Squid and *Vibrio fischeri* bacteria under the guidance of Dr. Timothy Miyashiro and Dr. Kirsten Guckes

Assistant Coach May 2013-August 2020
Clopper's Mill Marlins Swim Team *(Germantown, MD)*

- Lead 150 swimmers, aged 5 to 18, in developing their swimming skills, with lessons tailored to each age group's individual needs
- Develop and communicate weekly team building events for 10 weeks

LEADERSHIP & INVOLVEMENT

Penn State College of Medicine Primary Care Scholars Program Summer 2021

- Connect with a multitude of primary care physicians working with the Penn State College of Medicine to discuss their work in the medical field and gain exposure to primary care specialties

President, Penn State Student Philanthropy Network 2020-2021

- Engage Penn State students in the philanthropic mission of the University and professional development opportunities within the Penn State Division of Donor and Alumni Relations

Member, Penn State Lion Ambassadors 2019-2021

- Plan, develop, and execute projects to encourage involvement in the Penn State community; provide tours of campus to visitors as a representative of the University
  - Member of the Professional Development Committee, 2020-2021
  - Member of the Strategic Planning Committee, 2019-2020

Member, Penn State Student Leader Roundtable 2020-2021

- Collaborate with 50 student leaders under the guidance of Damon Sims, Penn State Vice President for Student Affairs, to address issues affecting student life in the Penn State community

Schreyer Honors College (SHC) Ambassador Team 2018-2020
Penn State Class Gift Campaign Marketing Director 2019-2020
Schreyer Honors College SHO TIME Orientation Mentor Summer 2018
Penn State THON, Dancer Relations Committee Member 2018-2019
Leader, Project Veterans Appreciation (SHC) Fall 2017
Volunteer, Germantown Help Food Bank 2014-Present

HONORS

Penn State University Libraries Literacy Award,
Undergraduate Research Exhibition, Honorable Mention 2018

Women in Science Engineering and Research,
NASA PA Space Grant Consortium Research Internship Program 2018