THE EFFECT OF PLANT-BASED HOMESTEAD FOOD PRODUCTION WITH AND WITHOUT SMALL-SCALE AQUACULTURE ON DIETARY INTAKE OF WOMEN FARMERS AND THEIR CHILDREN IN PREY VENG, CAMBODIA

by

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Abstract

In 2011-2013, 15.4% of the Cambodian population was undernourished, compared to <5% in Canada. The Cambodian diet is rice-based and low in nutrient-dense animal-source foods. Homestead food production (HFP) and aquaculture are potential interventions to improve dietary intake. However, we lack comprehensive evidence that these interventions improve intake. Using a cluster randomized control trial, I aimed to determine whether women and children receiving HFP with or without aquaculture have higher intakes or lower prevalence of inadequate intakes of select nutrients, compared to controls in Prey Veng, Cambodia. Ninety villages of ten households each (n=900) were randomized to: HFP, HFP plus aquaculture, or control. After 22-months of intervention, interviewers collected 24-hour dietary recalls (24HRs) from women 18-50 y (n=429) and children 6 m-7 y (n=421). Repeat 24HRs were collected (n=139) to allow for adjustment of within-person variation in intake (using PC-SIDE software). Mean nutrient intakes were compared using generalized estimating equations (GEE) models. Prevalence of nutrient inadequacy was compared by applying the Estimated Average Requirement cut-point method or probability approach and using GEE models. After intervention, women in the HFP group had higher mean intakes of zinc (+1.0 mg) and vitamin A (+139 Retinol Activity Equivalent (RAE)), compared to controls ($p<0.05$). Women in the HFP plus aquaculture group had higher mean intakes of vitamin A (+191 RAE) and iron (+2.7 mg), and lower prevalence of inadequate vitamin A intake (-19%) and iron intake at 10% bioavailability (-7%) and 5% bioavailability (-2%) levels, compared to controls ($p<0.05$). Among groups of children and between the HFP and HFP plus aquaculture groups for both women and children, there were no significant differences in nutrient intakes or prevalence of nutrient inadequacy. This research provides evidence that intervention with HFP in Cambodia results in higher zinc and vitamin A intakes, and intervention with HFP plus aquaculture results in higher vitamin A and iron intakes and reduced prevalence of inadequate vitamin A and iron intakes among women, compared to controls. Future research should assess the impact of these changes on clinical outcomes, the effect of seasonal changes on intake, and the feeding relationship between women and children.

Preface

This research thesis is my original work and was completed with supervision from Dr. Tim Green and guidance from my committee members, Dr. Judy McLean, Dr. Susan Barr, and Dr. Larry Lynd. My research project is part of the Fish on Farms (FoF) project, which is funded by the International Development Research Centre (IDRC) and the government of Canada, provided through the Department of Foreign Affairs, International Trade, and Development (DFAITD). The FoF project is a collaboration between the Human Nutrition Graduate Program at the University of British Columbia (UBC), Helen Keller International (HKI) in Phnom Penh, Cambodia, Organization to Develop Our Villages (ODOV), Ministry of Agriculture, Forestry and Fisheries (MAFF), World Fish Centre, and the government of Cambodia. The principal investigators of the project are Dr. Tim Green and Dr. Zaman Talukder. Ethics approval was obtained in both Canada and Cambodia, from the UBC Research Ethics Board (approval number H12-00451) and the Cambodian Medial Ethics Board (approval number 010 NECHR). I have received funding to complete my thesis work from the Mary and David Macaree Fellowship, the Faculty of Land and Food Systems Graduate Award, the Indrajit and Manjula Desai Prize in Human Nutrition, and from the Fish on Farms project research fund.

My thesis work began after the Fish on Farms project was initiated, and my involvement in the project was concentrated around endline data collection (May 26 – June 10, 2014). Along with the team of staff from HKI Cambodia, I was primarily involved with developing the endline 24-hour dietary recall (24HR) forms and data collection protocols. I trained eight interviewers (recruited by HKI Cambodia) to conduct 24HR interviews and I helped facilitate and supervise endline 24HR data collection. After the data were collected, the staff at HKI Cambodia was responsible for translating 24HRs (from Khmer to English) and I was responsible for analyzing the 24HRs from both baseline (collected prior to my involvement in the project) and endline. I maintained a close working relationship with HKI Cambodia staff (namely Sok Hoing Ly and Many Eath) while completing my research in Canada, to clarify discrepancies in the data and obtain local knowledge about Cambodian foods. With assistance from a paid student (Ingrid Chandra) and student volunteer (Mandy Behnia), I entered baseline and endline 24HR data and analyzed the data independently, with guidance from my thesis committee and statisticians, Kathy (Huiqing) Li from the UBC Faculty of Pharmaceutical Sciences and support staff from the UBC Library Research Commons. A research fellow from the University of Otago in New Zealand, Dr. Claire Smith, completed PC-SIDE statistical adjustment of dietary intake data.

I have given oral presentations of my research in Edmonton at the International Food Security Dialogue in May 2014 titled, "Overcoming the challenges: analyzing Cambodian 24-hour dietary recalls," which summarized the challenges I faced when analyzing 24HR data from Cambodia and potential solutions for researchers tackling similar obstacles, and in Vancouver at the UBC Land and Food Systems Graduate Student Conference in March 2015 titled, "An exploration of energy and nutrient intake among rural women farmers in Prey Veng, Cambodia (participants of the Fish on Farms project)," which compared my endline dietary intake results against Canadian dietary intake data. I also presented a poster in Winnipeg at the Canadian Nutrition Society Annual Conference in May 2015, titled "The effect of plant-based homestead food production with and without aquaculture on dietary intake of women farmers in Prey Veng, Cambodia," which summarized and compared my endline dietary intake results across the intervention and control groups. I also intend to summarize results of this thesis for submission to peer reviewed journals for publication.

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List of Abbreviations

AMDR	Acceptable Macronutrient Distribution Range
AMPM	Automated Multiple Pass Method
BMI	Body Mass Index
CDHS	Cambodian Demographic Health Survey
CNF	Canadian Nutrient File
CONSORT	Consolidated Standards of Reporting Trials
DFAITD	Department of Foreign Affairs, International Trade, and Development
DRI	Dietary Reference Intake
EAR	Estimated Average Requirement
EER	Estimated Energy Requirement
ESHA	Elizabeth Stewart Hands and Associates (Food Processor software)
FAO	Food and Agriculture Organization
FFQ	Food Frequency Questionnaire
FoF	Fish on Farms
GEE	Generalized Estimating Equations
HFP	Homestead Food Production
HKI	Helen Keller International
IDRC	International Development Research Centre
IOM	Institute of Medicine
MAFF	Ministry of Agriculture, Forestry and Fisheries
MUAC	Mid-Upper Arm Circumference
NE	Niacin Equivalent
ODOV	Organization to Develop Our Villages
PA	Physical Activity Coefficient
PC-SIDE	PC Software for Intake Distribution Estimation
RAE	Retinol Activity Equivalent
RCT	Randomized Control Trial
RDA	Recommended Daily Allowance
RE	Retinol Equivalent

SD	Standard Deviation
SE	Standard Error
SEA	Southeast Asian
SPSS	Statistical Package for the Social Sciences
UBC	University of British Columbia
UN	United Nations
UNICEF	United Nations Children's Fund
USDA	United States Department of Agriculture
VMF	Village Model Farm
WFP	World Food Program
WHO	World Health Organization
24HR	24-Hour Dietary Recall
24-VASQ	24-Hour Vitamin A Semi-Quantitative (method for estimating vitamin A)
95% CI	95% Confidence Interval

Acknowledgements

Firstly, I would like to thank my advisor, Dr. Tim Green, for providing me with the focused guidance I needed, and a sense of clarity after each of our meetings together. I would also like to extend a heartfelt thank you to my committee member, Dr. Judy McLean, for introducing me to the world of international nutrition and recruiting me for the Fish on Farms project. My deepest thanks to Dr. Susan Barr, long-time mentor and committee member, who thoroughly reviewed each of my thesis drafts, research abstracts, and conference presentations, and enhanced my learning each step of the way. To my committee member, Dr. Larry Lynd, thank you for asking great questions and keeping me on my toes, right from the beginning.

I am also incredibly thankful for the entire team of staff at HKI Cambodia for putting so much care into my project. I am especially grateful to Sok Hoing Ly and Many Eath for their tireless efforts to answer my many questions about the Cambodian diet. Thank you to my data entry assistant, Ingrid Chandra, and volunteer, Mandy Behnia, for their hours of data entry and keen attention to detail. I am grateful for the UBC Land and Food Systems professors and administrative staff who helped me on this journey, through classroom instruction, technical support, and friendly banter. I am also indebted to my previous employers at St. Paul's Hospital, Frances Johnson and Valli Fraser, who supported and nurtured my interest in research and provided me with much-welcomed encouragement when I decided to pursue a Masters degree.

Thank you to my lab mates, whose collaboration and camaraderie made the past two years both enlightening and light-hearted; thank you Zach, Kyly, Crystal, Kristina, Phil, Amynah, Aviva, Abeer, Allison, and Kaela. Finally, I thank my husband, Eli, for encouraging me in my academic pursuits, for putting his own career move on hold, for being calm and patient when I was anxious and overwhelmed, and for bringing a little extra to joy to every day.

Chapter 1: **Introduction**

1.1 **Background on Cambodia**

Cambodia is located in Southeast Asia and borders Thailand, Laos, Vietnam, and the Gulf of Thailand. The country spans over 181,000 square kilometers and lies at 11 degrees North of the equator (WorldAtlas, 2015). There are two seasons in Cambodia, a wet season (May - October) and a dry season (October - April) (Ministry of Tourism of Cambodia, 2015). In 2012, Cambodia's population was an estimated 14.9 million people, with 80% living in rural areas (WHO, 2014). The rural population is particularly poor, compared to the urban population, and the Cambodian Ministry of Planning & UN World Food Programme (2012) identified the rural province of Prey Veng as one of the poorest provinces in Cambodia, with 27% of households classified as poor in 2010-2011; while this statistic matches the country-wide average of 27%, Prey Veng province is home to proportionately more poor households (66,689) compared to the average number of poor households per province in Cambodia (23,819) (Ministry of Planning & UN World Food Programme, 2012).

1.2 **Undernutrition among women and children in Cambodia**

In 2011-2013, 2.2 million people, or 15.4%, were undernourished in Cambodia, as compared to <5% in Canada (FAO, 2014). The FAO defines being *undernourished* as "A state, lasting for at least one year, of inability to acquire enough food, defined as a level of food intake insufficient to meet dietary energy requirements" (FAO, 2014). The FAO definition of *undernutrition* includes "being underweight for one's age, too short for one's age (stunted), dangerously thin for one's height (wasted) and deficient in vitamins and minerals (micronutrient malnutrition)" (FAO, 2014). Undernutrition is especially prevalent among women and children living in rural Cambodia.

According to the 2010 Cambodia Demographic and Health Survey, 19% of women were underweight (BMI <18.5kg/m^2) and 44% were anemic in 2010 (National Institute of Statistics, Directorate General for Health, & Measure DHS, 2011). These statistics were higher in rural Cambodia, with 20% of women being underweight in rural areas versus 17% in urban areas and 47% of women with anemia in rural areas versus 35% in urban areas. Six percent of Cambodian women are shorter than 145 cm, likely a consequence of undernutrition in early life. Again, this percentage is higher in rural areas (7%) versus urban areas (4%). These women, when they become pregnant, may be at greater risk of a difficult delivery, and delivery of a low birth weight baby (National Institute of Statistics et al., 2011). Furthermore, nighttime blindness (a consequence of vitamin A deficiency) was reported by 5.1% of mothers during their last pregnancy (National Institute of Statistics & Ministry of Planning, 2008). In 2008, the maternal mortality ratio in Cambodia was 461 per 100,000 live births, which remains unchanged from 2000 (National Institute of Statistics & Ministry of Planning, 2008).

Among children under five years of age in Cambodia, 28% are underweight, 40% are stunted, 11% are wasted, and 57% are anemic (National Institute of Statistics et al., 2011). As was observed among women, the prevalence of undernutrition among children in rural areas is even greater than in urban areas. For instance, 30% of rural children are underweight versus 19% of urban children and 42% of rural children are stunted versus 28% of urban children (National Institute of Statistics et al., 2011). In 2010, the mortality ratio among rural children under age five was 75 per 1,000 live births, versus 29 per 1,000 live births among urban children in Cambodia (National Institute of Statistics et al., 2011). In addition, children born to mothers in the poorest quintile are twice as likely to be underweight than children born into the wealthiest quintile (National Institute of Statistics et al., 2011).

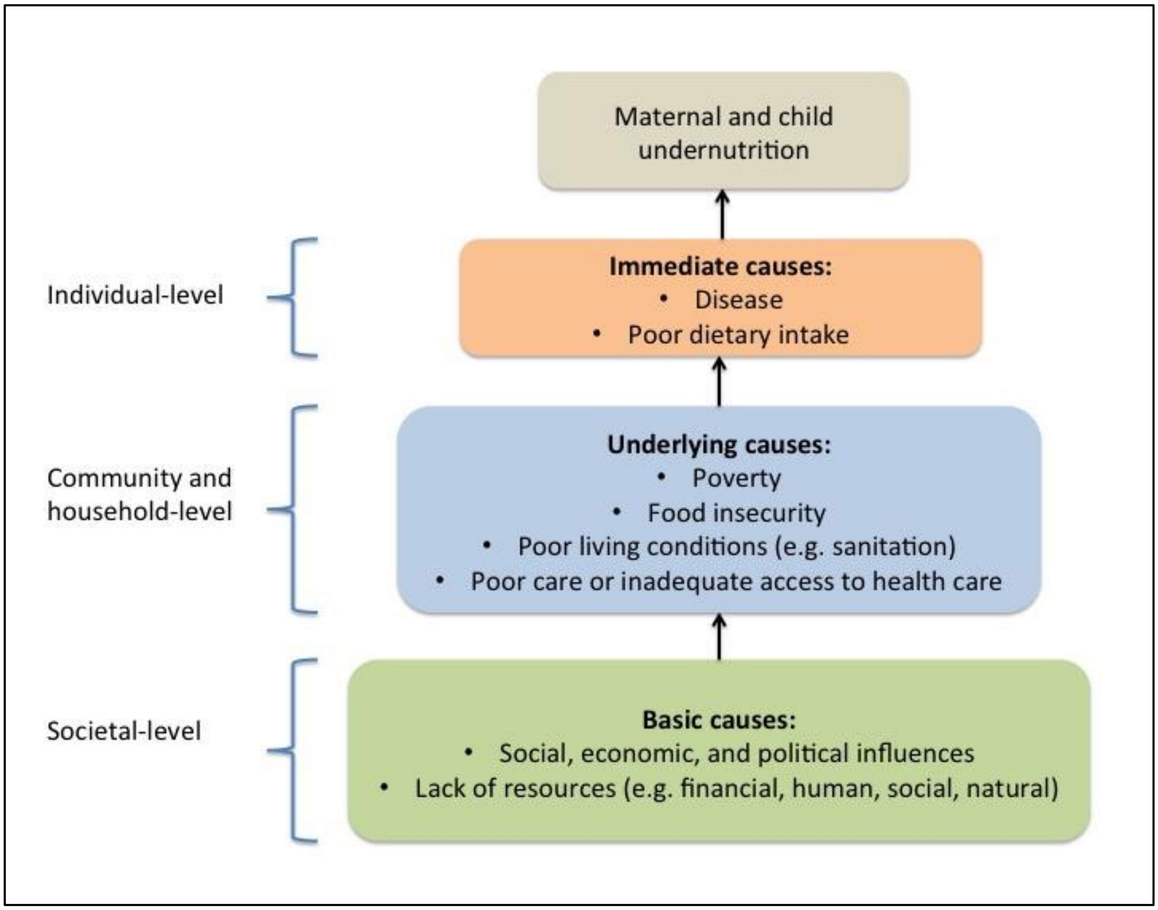
It is well known that maternal nutritional status predicts the nutrition status of offspring. In a review paper on *Intergenerational Influences on Child Growth and Undernutrition*, Martorell & Zongrone (2012) affirm that the first 1000 days of a child's life (from conception to age two), is the most important growth and developmental period in one's life. The authors list poor maternal weight gain, short maternal height, and being born small for gestational age as significant predictors of a woman's offspring's birth weight, risk of stunting, and being born small for gestational age, respectively (Martorell & Zongrone, 2012). Recently, a study of 299 children in Guatemala and another study of 300 children in Nigeria, both demonstrated that a mother's short stature was strongly and significantly associated with offspring stunting (Reurings, Vossenaar, Doak, & Solomons, 2013; Senbanjo, Olayiwola, Afolabi, & Senbanjo, 2013). In these studies, stunting among children was defined as two standard deviations (SD) below the height-for-age z-scores, based on the World Health Organization (WHO) Child Growth Standards (WHO, 1995; WHO, 2006). Note that international growth standards can be used, given that the effect of genetics/ethnicity on mean height and distribution about the mean is small when compared to environmental effects, including the effect of nutrition, access to health care, exposure to microbiological contaminants, or financial constraints (de Onis, Garza, Victora, Bhan, & Norum, 2004; WHO, 1995). Proportionately more children of underweight mothers are wasted (16%) than children of normal weight (11%) or overweight or obese (6%) mothers (National Institute of Statistics et al., 2011). A study of 319 stunted, but otherwise healthy, infants and toddlers in urban Cambodia revealed that 44% of children had two or more co-existing micronutrient deficiencies; overall, 73%, 71%, and 28% were zinc, iron, and vitamin A deficient, respectively (Anderson, Jack, et al., 2008). While these data do not describe micronutrient deficiency in non-stunted infants and toddlers, research by Gibson & Cavalli-Sforza (2012) is consistent with these findings, suggesting that the Cambodian diet as a whole is likely deficient in zinc, iron, and vitamin A, as well as calcium, thiamin, and riboflavin (based on analysis of Cambodian food balance sheets). Given the prevalence of undernutrition among children in Cambodia and the connection between a child's nutrition status and their mother's, targeting maternal nutrition is one way to mitigate undernutrition among young infants and children.

1.3 Causes of undernutrition: UNICEF conceptual framework

According to the United Nations Children's Fund (UNICEF) conceptual framework, the causes of undernutrition are categorized into three levels: basic causes, underlying causes, and immediate causes (UNICEF, 2008), see Figure 1. In an effort to combat immediate causes of undernutrition (e.g. poor dietary intake) in Cambodia, women receive iron and folic acid supplements during pregnancy and after giving birth. However, women in rural areas are less likely to take these supplements for the recommended duration; 73% of women in urban areas continued to take iron supplements for 90 days or more post-natal, compared to 54% of women in rural areas (National Institute of Statistics et al., 2011).

Considering the various causes of undernutrition outlined in the UNICEF conceptual framework, micronutrient supplementation is only one of many strategies needed to treat and prevent undernutrition. In Cambodia, disease (an immediate cause), poor hygiene, and poverty (underlying causes) have been identified as potential causes of undernutrition (Hong & Hong, 2007). Thus, future strategies must address each level of the framework. In particular, interventions aimed at ameliorating basic and underlying causes of undernutrition have the potential to lead to long-term, sustainable solutions. Consequently, there are opportunities for nutrition-focused interventions in rural Cambodia, aimed at reducing poverty and improving health outcomes related to each level of the UNICEF conceptual framework.

Figure 1.1: Simplified representation of the UNICEF conceptual framework, showing the relationship between basic, underlying, and immediate causes of maternal and child undernutrition.



Note: Figure adapted from Black et al. (2008).

1.4 The Cambodian diet

The diet in Cambodia primarily consists of rice and is low in animal source foods. According to the Food and Agriculture Organization (FAO) food balance sheets, the Cambodian diet in 2011 included 9% of energy from animal products and 72% of energy from cereals or root vegetables, with rice providing 63% of energy (FAOSTAT, 2014). Energy distribution was as follows: 10.5% protein, 12.6% fat, and 76.9% carbohydrate (FAOSTAT, 2014). In terms of absolute availability, 2411 kcal was available per capita per day, which would equate to 63.3 g/day of protein, 33.8 g/day of fat, and 463.5 g/day of carbohydrate (FAOSTAT, 2014). It should be noted that since these are per capita measures, unequal distribution of food, and food waste are not accounted for, which may result in under- or over-estimation of intake.

Using the Dietary Reference Intake (DRI) energy equations for a reference non-pregnant active woman[a] (aged 30 years, weighing 50 kg, and measuring 1.52 meters in height), the estimated energy requirement is 2143 kcal/day (Institute of Medicine, 2005). Comparing this value to the food availability data in Cambodia (2411kcal/day), energy intake does not appear to be a major concern. According to the DRI acceptable macronutrient distribution range (AMDR) for adults, protein should provide of 10-35% of energy and fat should provide 20-35% of energy (Institute of Medicine, 2005), which is borderline or above the current energy distribution for protein and fat in Cambodia, respectively (10.5% of energy as protein and 12.6% of energy as fat). Alternatively, the RDA for protein for women over age 19 years is set at 0.8 g/kg/day, which would equate to 40 g of protein/day for a reference 50 kg woman. In comparison to the food availability data for protein (63.3 g of protein/day), protein intake does not appear to be a major concern. Protein recommendations developed by the IOM apply to those who consume a mixture of high-quality animal protein and lower-quality plant proteins[b] (Institute of Medicine,

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[a] Estimated Energy Requirement (EER) = 354 – (6.91 x age [y]) + PA x {9.36 x weight [kg]) + 726 x height [m])}; active PA = 1.27.
[b]Protein quality is based on digestibility and the proportion of amino acids available for protein synthesis within the human body. Specifically, percentages of protein quality are based on

2005). Given the low percentage of energy from animal products (9%), the proportion of lower quality proteins consumed in the Cambodian diet is likely higher. While the IOM (2005) states that consuming a variety of complementary plant proteins increases protein quality, the Southeast Asian Recommended Dietary Allowances (SEA-RDAs) assume that most Southeast Asian populations consume diets of lower quality protein (70% quality); the SEA-RDAs recommend 1.14 g/kg/day or 57 g of protein/day for a reference non-pregnant 50 kg adult woman (International Life Sciences Institute, 2005). Furthermore, since food availability data do not account for unequal distribution or food waste, the amount of protein available to women is likely to be lower, when compared to men, for example. Consequently, it is possible that the average protein intake among women is below the recommended intake for diets with lower quality protein sources. The SEA-RDA recommendation for fat ranges from 15% to 35% of total energy needs (International Life Sciences Institute, 2005), which remains below the current energy distribution for fat in Cambodia (12.6% of energy as fat). In light of these comparisons, inadequate fat and possibly protein intake may be of concern among Cambodian women.

In a study analyzing micronutrient intakes using Cambodian food balance sheets and micronutrient densities (calculated from 95 food commodities), the intakes of eight micronutrients were compared against micronutrient density goals (Gibson & Cavalli-Sforza, 2012). Likely deficits were found in six of eight micronutrients, expressed per 1000 kcal: 2.4 mg iron (vs. 18 mg for low bioavailability diets), 3.2 mg zinc (vs. 10 mg), 57 mg calcium (vs. 350 mg), 184 Retinol Equivalents (RE) vitamin A (vs. 190 RE), 0.29 mg thiamin (vs. 0.35 mg), and 0.28 riboflavin (vs. 0.48 mg). Intake deficits were not likely for niacin and vitamin B12: 11.7

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amino acid scoring, biological value, protein efficiency ratio, and protein digestibility corrected amino acid scoring (International Life Sciences Institute, 2005).

Niacin Equivalents (NE) (vs. 6.5 NE) and 0.9 mcg vitamin B12 (vs. 0.80 mcg). Given this analysis, there is evidence that the nutrient density of food is poor in Cambodia, not only for fat and possibly protein, but also for a number of micronutrients.

In conclusion, Cambodian women, and by proxy, Cambodian children, are likely to consume adequate calories, but may not receive adequate calories from fat and protein, based on the incongruence between dietary intake recommendations and food availability data. In addition, Cambodian women and children may not consume adequate intakes of iron, zinc, calcium, vitamin A, thiamin, and riboflavin, based the analysis by Gibson & Cavalli-Sforza (2012). Thus, interventions are needed to improve access to high quality/nutrient-dense foods among women and children in Cambodia, while also considering the various causes of undernutrition (as outlined by the UNICEF conceptual framework).

Chapter 2: **Literature Review**

2.1 Overview of literature review

In this literature review, I will summarize the previous nutrition research conducted in Cambodia and other developing countries and provide a background for dietary assessment methods. I will start by explaining why integrated interventions are needed to improve nutrition status. I will also provide evidence for homestead food production[c] (HFP), animal-source food, and aquaculture as viable food-based methods to improve nutrition, while identifying the gaps in the research literature regarding these strategies. I will review the rationale for using 24-hour dietary recall (24HR) methodology to assess dietary intake and evaluate nutrition-based interventions. I will also explain the purpose of collecting repeat 24HRs in a subset of the research sample. By the end of the literature review, I will have communicated why intervention with homestead food production and aquaculture are potential interventions for improving the dietary intakes of women and children in rural Cambodia. I will also describe some key methodological considerations for evaluation of such interventions and outline my specific research questions and hypotheses.

2.2 Evidence for an integrative approach

Food-based interventions in developing countries encourage participation at all levels (individual, community, and government), while addressing the multiple causes of undernutrition (e.g. food insecurity, poverty, illness, etc.). In a study reflecting on Thailand's success in reducing rates of underweight among preschool children, support and coordination between

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[c] Homestead food production (HFP) is defined as the maintenance of a year-round garden, which includes micronutrient-rich produce and animal husbandry (Helen Keller International, 2014).

government-level facilitators and community-level volunteers were highlighted as key components in successful nutrition programs (Tontisirin & Gillespie, 1999). In another Thai review, successful strategies for increasing animal source food production and consumption included job creation, village development, and agricultural production, each of which are participatory and promote self-reliance (Smitasiri & Chotiboriboon, 2003). In a study assessing the impact of a HFP program in Bangladesh, Bushamuka et al. (2005) recommend partnering with local organizations and implementing strategies that empower women to promote successful large-scale food production interventions. In a review of integrated fish farming (aquaculture) as a means to mitigate food insecurity in East Africa, program failure was attributed to the lack of government support and legislation and poor infrastructure (Ogello, 2013). In consideration of these experiences in other developing countries, food-based interventions should gain support from all stakeholders and encourage participation at the individual, community, and government levels, to promote acceptability, sustainability, and successful implementation of food-based programs.

2.3 Current research on homestead food production

The implementation of HFP in developing countries has the potential to improve the nutrition status of women and children, household food security, and income generation, but the research in rural Cambodia is limited. For example, the implementation of a HFP program in Cambodia improved the diversity of vegetables produced from October 2005 to May 2007; the number of vegetable varieties increased by 2.2 (from 4.1 to 6.3) in the intervention group (n=300), compared to a marginal decrease of 0.3 (from 3.6 to 3.3) in the control group (n=200) (Olney, Talukder, Iannotti, Ruel, & Quinn, 2009). In a study in Bangladesh, households currently participating in a HFP program (n=720) and those who had participated in a HFP program more than 3 years prior (n=720) were more likely to maintain year-round gardens (78% and 50%, respectively), compared to a control group (n=720) (15%) (Bushamuka et al., 2005). While increased food production and year-round garden maintenance are positive outcomes, the impact on actual dietary intake was not assessed in these studies.

In an evaluation of vitamin A intake following intervention with HFP, including poultry and/or small livestock production in Bangladesh and Cambodia, food frequency questionnaires showed that 22% more households consumed chicken livers (from 24 to 46%) and doubled their egg consumption (from two to five eggs consumed/week/household), each of which are rich sources of vitamin A (Helen Keller International, 2010). While this study measured vitamin A intake, the overall impact on the diet is unclear in the absence of comprehensive dietary assessment. For example, eating more liver and eggs may mean eating less meat or fish.

In Vietnam, the successful implementation of VAC (which is Vietnamese for Vuon = garden, Ao = pond, and Chuong = cattle shed), along with other intervention programs aimed at increasing intakes of animal-source foods, has been credited for improving dietary intakes, reducing the prevalence of anemia, and increasing fish production and consumption in the Vietnamese population (Hop, 2003). From 1987 to 2000, fish consumption increased from 42 to 52 g/person/day, meat consumption increased from 24 to 51 g/person/day, and fruit consumption increased from 4 to 62 g/person/day in Vietnam, as measured by national surveys (Hop, 2003). Again, these data are positive, but a number of confounding variables or competing intervention programs may have contributed to these positive trends.

The potential for HFP to alleviate undernutrition is promising, as has been shown through improved production and availability of nutrient-dense foods. However, the majority of research lacks baseline data, adequate control groups, large enough sample sizes for powerful statistical interpretation, and/or thorough dietary assessment. Dietary assessment in the aforementioned studies relied on dietary diversity data, per capita food availability data, or assessment of specific nutrient intakes with food frequency questionnaires. Without comprehensive dietary intake data, there is not yet enough evidence to support the practice of using HFP as a strategy to improve dietary intake in Cambodia.

2.4 **Current research on fish consumption in Cambodia**

In Cambodia, fish is commonly eaten and incorporated into many traditional dishes, such as sour soup, pra hok (fermented fish paste), trey khor (caramelized fish), and trey pra (boiled and salted fish), to name a few. The consumption of indigenous small fish has been proposed as a viable way to improve vitamin A, iron, and other micronutrient intake in developing countries. In a study of women in Kandal province, Cambodia (n=67), focus group data revealed that women considered small fish as inexpensive and easily accessible, providing support for nutrition interventions that facilitate the raising of small fish year-round (Wallace et al., 2014).

In a study by Kawarazuka & Béné (2011), high levels of micronutrients have been found in the head, bones, and viscera of small fish species in developing countries (Kawarazuka & Béné, 2011). An analysis of 29 common fish species in Cambodia identified more vitamin A in older fish, as well as in the eyes and viscera (Roos, Chamnan, Loeung, Jakobsen, & Thilsted, 2007). In an another Cambodian study, examining the iron content of 16 common fish species, the *Esomus longimanus* species contained six times the amount of total iron than most other species (Roos, Thorseng, et al., 2007). In an analysis of cooked fish, where 30 Cambodian women each prepared traditional sour soup (typically using whole *E. longimanus),* an average serving of sour soup was found to provide 45% of a woman’s daily iron intake needs (Roos, Thorseng, et al., 2007). Consequently, fish in Cambodia appear to be both culturally acceptable and nutrient-dense.

These studies provide support for the recommendation of including whole, small indigenous fish in the diet as a culturally acceptable strategy to reduce undernutrition in Cambodia, particularly for vitamin A and iron. However, future research should evaluate the impact of consuming whole, small fish on daily dietary intake, including both micro- and macro-nutrient intakes.

2.5 Current dietary assessment research in Cambodia

A search of the literature for nutrition surveys or population-based nutrition assessment in Cambodia is limited, often using proxy measures for assessing dietary intake. For example, in the study by Gibson & Cavalli-Sforza (2012), Cambodian food balance sheets were used to assess micronutrient status, concluding that the Cambodian diet was likely deficient in vitamin A, thiamin, riboflavin, iron, zinc, and calcium. In a study by Jacobs & Roberts (2004), infant and child feeding practices of women from farming villages (victim of floods during 2001 in Takeo province, Cambodia) were explored through focus groups (n=252). It was found that acute malnutrition was associated with delayed breast feeding after birth, early weaning, delayed introduction of complementary foods, and poor hand-washing practices (Jacobs & Roberts, 2004). While food balance sheets and focus group data can indicate nutrients and health practices of concern, respectively, actual intakes should be assessed with comprehensive nutrition surveys and/or biochemical indicators.

In a study assessing the impact of daily micronutrient supplementation (in the form of packaged “Sprinkles”) on infants over a 12-month period, biochemical measures were used to assess hemoglobin and ferritin levels (Giovannini et al., 2006). The authors reported significant increases in both hemoglobin and ferritin concentrations, compared to baseline and a placebo. In contrast to micronutrient supplementation, biochemical indicators in food-based interventions may not change over a similar timeframe, since changes in food intake patterns would likely have a smaller, more gradual impact on biochemical measures, than a larger supplemental dose.

Very few researchers have collected comprehensive dietary intake data in Cambodia. In a study assessing the feeding practices among women living in a poor district of Phnom Penh, Cambodia, the dietary intake of non-breast milk foods among stunted toddlers was assessed (n=41 for partially breastfed and n=210 for non-breastfed toddlers) (Anderson, Cornwall, Jack, & Gibson, 2008). This study used a multiple-pass 24HR method, previously validated by Gibson & Ferguson (2008), and revealed that the diets of both partially breastfed and non-breastfed toddlers were very low in animal-source foods and vegetables (<4% of total food weight) (Anderson, Cornwall, et al., 2008). While this study provides a fairly good assessment of dietary intake among toddlers in an urban area, the intake among toddlers in rural areas was not assessed.

In a study reporting on national dietary intakes among women in 10 provinces across Cambodia, 24-hour Vitamin A Semi-Quantitative (24-VASQ) dietary recalls were completed (Semba, de Pee, Panagides, Poly, & Bloem, 2003). The 24-VASQ method was developed (and later published) by de Pee, Halati, & Bloem (2006) and was used to assess dietary vitamin A intake among non-pregnant Cambodian women (n=328 with night blindness and n=1009 without night blindness) (Semba et al., 2003). The authors reported that poor intake of animal source food was significantly associated with night blindness ($p<0.05$) (Semba et al., 2003). In a recent survey of 67 women living in peri-urban and rural areas of Kandal province, Cambodia, 24HRs validated by Gibson & Ferguson (2008) were used to assess vitamin A and iron intake (Wallace et al., 2014). The authors concluded that most women did not meet their daily recommended intake for iron and vitamin A (97% and 70%, respectively) (Wallace et al., 2014). These data provide valuable information on iron and vitamin A intakes of women in Cambodia, however, the sample size was small.

Most dietary assessment research in Cambodia focuses on infant and toddler nutrition in urban areas or on small sample sizes in rural areas, with minimal research on adult women. Previous research has also focused on specific micronutrient intakes, with no assessment of macronutrient intake and distribution. Currently, there is no large-scale randomized control trial (RCT) conducted in rural Cambodia that assesses macro- and micronutrient intakes with a validated nutrition assessment survey.

2.6 Review of the 24-hour dietary recall methodology

To estimate the dietary intake of a population, 24HRs are relatively inexpensive, easy to conduct, and an objective technique to use. An interviewer is trained to collect detailed dietary recalls from participants, recording all food and beverages consumed in the previous 24 hours (USDA, 2014). Interviewers ask probing questions and use food models or household measures to help participants remember what they ate and estimate portion sizes (USDA, 2014). In comparison, a weighed food record (where the food eaten by participants is actually weighed) is more burdensome to participants, time consuming, and expensive. Alternatively, a food frequency questionnaire can assess dietary intake fairly easily by asking participants how frequently they consume certain foods, however, the foods included on a food frequency questionnaire may not represent the usual foods or portion sizes consumed by participants (Lee & Nieman, 2013). As previously mentioned, food balance sheets are used to estimate average population intakes, however, they do not account for food distribution, food consumed by animals, or food waste. The 24HR is the method of choice to estimate both macro- and micro-nutrient intakes in a large sample of women and their children in rural Cambodia. While the 24HR method may underestimate dietary intake if commonly forgotten foods and additions to foods (such as oils and sauces) are not recorded, underreporting can be minimized by conducting a multiple-pass 24HR, where the interviewer reviews the previous day's intake multiple times to help participants remember any forgotten foods and obtain accurate and detailed information (USDA, 2014). Underreporting is discussed in more detail in section **2.7**.

The current gold standard for assessing dietary intake is the USDA automated multiple-pass method (AMPM) (USDA, 2014). The multiple-pass method has been shown to improve recall accuracy of energy and nutrient intake among men and woman in the United States (Blanton, Moshfegh, Baer, & Kretsch, 2006; Conway, Ingwersen, & Moshfegh, 2004; Moshfegh et al., 2008). The AMPM standardizes data collection through use of pre-programmed probing questions, guiding interviewers through the five passes of the 24HR. Prior to automation, the USDA multiple-pass method was validated by Conway et al. (2004), showing similar energy and macronutrient intake as compared to actual intake as measured by observation and food weighing. The multiple-pass method is more effective than a "single-pass" 24-hour recall, since it provides participants with multiple opportunities to recall forgotten foods (USDA, 2014).

The AMPM includes five passes: (1) *Quick list*: the interviewer provides cues about daily events, but encourages the participant to recall all foods and beverages consumed during the previous days' 24-hour period. (2) *Forgotten foods*: interviewers ask specific probing questions to enhance recall of commonly forgotten foods. (3) *Time and occasion*: interviewers clarify the time and place of each eating occasion. (4) *Detail cycle*: participants are asked about how foods were prepared or if they were purchased outside of the home; each eating occasion (clarified in the third pass) is also reviewed. (5) *Final probe*: participants are probed for any additional eating occasions that may have been forgotten. The AMPM includes questions, foods, and portion sizes specific to the North American diet and is not appropriate for use in developing countries or in countries where the diet differs. A multiple-pass 24HR method adaptable to the Cambodian diet would be more appropriate.

The manual authored by Gibson & Ferguson (2008), titled “An interactive 24-hour recall for assessing the adequacy of iron and zinc intakes in developing countries,” was originally published in 1999 and was validated for use with rural populations in developing countries. Unlike the aforementioned 24-VASQ method, the method developed by Gibson and Ferguson was designed to collect a more accurate recall of all foods and beverages consumed through use of a multiple-pass method. While this guide was developed to assess the intakes of iron and zinc, a validation study in Malawi (using mother-reported intakes of 15-month old children) found that Gibson & Ferguson's (2008) 24HR method overestimated mean energy, protein, fat, iron, zinc and vitamin A intakes (by 14-32%) when compared to weighed food records (Thakwalakwa et al., 2012). While a better comparison for validation would have been doubly-labeled water or another verified biochemical indicator, these overestimates may be due to an unconscious tendency for mothers to over-report their child’s intake, as suggested by Devaney et al. (2004) (described in section **2.7** below). Additional validation studies would be useful, especially for other macro- and micronutrients (aside from iron and zinc); however, it is the best guide currently available for collecting 24HR data in developing countries.

Similar to the USDA AMPM, the first pass of Gibson & Ferguson's (2008) 24HR method allows participants to list all foods and beverages consumed during the previous 24-hours; the second pass includes probing questions (in chronological order), including how foods were prepared and any brand names; the third pass focuses on estimating portion sizes and collecting recipe details (on a separate form); and the fourth pass involves reviewing all foods and beverages consumed, providing participants with one final opportunity to recall forgotten foods or correct any errors (Gibson & Ferguson, 2008). While this method includes four versus five passes, the second pass is a combination of pass (2) and (3) of the AMPM. The manual authored by Gibson & Ferguson (2008) also provides guidance regarding sampling strategies, determining sample size, preparing for the survey, conducting each of the four stages of the multiple-pass 24HR, measuring validity and reproducibility, compiling a nutrient database, estimating nutrient bioavailability of zinc and iron, evaluating nutrient adequacy through comparison with reference levels, and completing statistical analysis and evaluation of the data. Since the USDA's AMPM is not appropriate for use in Cambodia, the interactive 24HR method developed by Gibson & Ferguson (2008) was used to assess dietary intake for my research project.

2.7 **Strengths and limitations of the 24-hour dietary recall method**

One limitation of the 24HR method is the tendency of participants to under- or over-report dietary intake. For example, in the 2004 Canadian Community Health Survey, individuals 12 years of age and older underreported energy intake by 10% and overweight and obese adults under-reported energy intake by 12% and 21%, respectively, compared to normal weight adults (Garriguet, 2008). Similarly, in a study assessing the USDA AMPM, 10% of men and 12% of women underestimated energy intake (n=524), when compared against total energy expenditure as measured by doubly-labeled water (Moshfegh et al., 2008). However, the magnitude of underreporting was less for normal-weight participants than for overweight and obese participants: 7% of normal-weight men and 15% of normal-weight women were low energy reporters, whereas 19% of overweight men and 25% of overweight women, and 34% of obese men and 35% of obese women were low energy reporters (Moshfegh et al., 2008). These studies suggest that body weight may affect the tendency or magnitude of underreporting of dietary intake, but this trend might differ in different countries.

In contrast to the previous studies describing underreported intakes, one study found that the energy intake of infants and toddlers in the US (as reported by their mothers using a multiple-pass 24HR method) exceeded their estimated energy requirements; the authors suggest one reason for this observation may be due to mothers over-reporting their child's intake in an unconscious effort to portray healthy eating (Devaney et al., 2004). Thus, the tendency to under- or over-report dietary intake may have methodological and/or psychological origins, but future research is needed to understand these tendencies.

There are few studies that assess the validity of the 24HR method as a measure of dietary intake in developing countries or among children. In the Malawian study reporting overestimated intakes among 15-month old children (n=169) when using a multiple pass 24HR method, children were generally undernourished: they were underweight, with a mean (SD) weight of 9.0 kg (1.1) and stunted, with a mean (SD) length of 72 cm (2.7) (Thakwalakwa et al., 2012). This study highlights the possibility that dietary intake data may be affected differently when the research sample is undernourished, by different cultural factors, and/or by a mother's desire for her child to be eating well. Under- and over-reporting of dietary intake may also be a product of social desirability, which may differ for someone from a developed versus developing country, from region to region, for mothers reporting intakes of their children, and/or for those who are underweight versus overweight or obese.

In the Observing Protein and Nutrition Study (OPEN), measurement error of the multiple-pass 24HR (collected in person) and food frequency questionnaire was assessed by comparing energy and protein intake data against doubly-labeled water and urinary nitrogen, respectively (Subar et al., 2003). Of the 484 adult participants, 12-14% men and 16-20% women underreported energy using 24HR, versus 31-36% men and 34-38% women using FFQ; 11-12% men and 11-15% women underreported protein using 24HR, versus 30-34% men and 27-32% women using FFQ (Subar et al., 2003). This research shows that while both 24HR and FFQ underestimate energy and protein intakes, 24HRs result in more accurate estimates than FFQs.

While collecting 24HRs may be more accurate than FFQs, and more practical than weighed food records, under- and over-reporting of dietary intake is a probable shortcoming. As evidenced by the aforementioned validation studies, underreporting may be more common among overweight and obese adults and over-reporting may exist when mothers report on the intake of their young children. However, research on under- and over-reporting of dietary intake in developing countries and among undernourished adults and children is limited. Given the lack of 24HR validation studies in Cambodia, 24HR data should be assessed carefully.

2.8 Estimating prevalence of inadequacy

One shortcoming of a *single* 24HR is that inter-individual (between person) variation and intra-individual (within person variation) cannot be distinguished. Consequently, the usual intake distribution of a population (including only between-person variability) cannot be estimated. However, by collecting at least two non-consecutive 24HRs in a subset of the population, the effect of intra-individual variation can be removed in order to estimate the usual intake distribution for the whole sample population (Institute of Medicine, 2000b). The Institute of Medicine (2000) recommends collecting repeat 24HRs in samples of at least 30 to 40 individuals. A statistical adjustment can be made to estimate usual intake distributions using software, such as SAS or PRC IML, or PC-SIDE (PC Software for Intake Distribution

Estimation) from the Center for Survey Statistics and Methodology, Iowa State University (Institute of Medicine, 2000b; Iowa State University, 2015). The PC-SIDE program expands on the model developed by the National Research Council (1986); in brief, the PC-SIDE program estimates usual intake distributions in multiple steps: a power transformation is applied to data to reduce skewness, intra-individual intake variation (estimated from repeat recall data) is removed, and data are transformed back to the original scale. In other words, this statistical adjustment narrows intake distributions by removing the effect of intra-individual variation, providing more precise estimates of inter-individual intake distributions (Institute of Medicine, 2000b).

With estimates of usual dietary intake, the prevalence of inadequate intakes in the sample population can be estimated by using the Estimated Average Requirement[d] (EAR) cut-point method or the probability approach (Institute of Medicine, 2000b). To apply the EAR cut-point method, the following assumptions must be made: (1) "intake and requirements are independent," (2) "the requirement distribution is symmetrical around the EAR," (3) "the variance in intakes is larger than the variance of requirements," and (4) "true prevalence of inadequacy in the population is no smaller than 8 to 10 percent or no larger than 90 to 92 percent" (Institute of Medicine, 2000b). The EAR cut-point method may be used for nutrients with established EARs that do not violate these assumptions: vitamin A, thiamin, riboflavin, niacin, vitamins B6, B12, C, and E, folate, magnesium, phosphorus, selenium, zinc, carbohydrate, and protein (expressed in terms of g/kg/day) (Health Canada, 2006b). Regarding

[d] Estimated Average Requirement (EAR) is the level of intake that meets 50% of the population's nutrient needs, for each gender and age group; the proportion of individuals in a group below a nutrient's EAR estimates the prevalence of inadequacy for that nutrient in that group (Health Canada, 2006b). Note that the Recommended Daily Allowance (RDA) is based on the EAR + 2SDs, which is estimated to meet 97.5% of the population's needs (Health Canada, 2006b).

the nutrients analyzed in this thesis, the EARs for women are the same for those aged 19-30 years and 31-50 years, and consequently, the dietary intakes of all women were analyzed using these EAR cut-points. However, among children, the sample was divided into the DRI age categories for 6-12 month olds, 1-3 year olds, and 4-8 year olds, in order to apply the EAR cut-point method or probability approach.

The EAR cut-point method cannot be used to estimate the prevalence of inadequate energy intake, since energy intake correlates with energy requirements; for example, larger and/or more active individuals tend to have higher energy intakes because they have higher energy requirements, violating the first assumption, and consequently overestimating prevalence of inadequacy. There is no EAR for fat.

While iron has an established EAR, the EAR cut-point method cannot be applied in a sample of menstruating women or growing children, since iron requirement distributions are asymmetrical/skewed to the right, violating the second assumption, and consequently underestimating prevalence of inadequate intake (Institute of Medicine, 2000b). However, the full probability approach (which is an extension of the EAR cut-point method) can be used to estimate the prevalence of inadequate iron intake (National Research Council, 1986). In order to apply the probability approach, an assumed mean and distribution of the nutrient requirement is needed (National Research Council, 1986). A log normal distribution can be used to model iron requirements, upon which the probability approach can be applied to assess prevalence of inadequate iron intake (Institute of Medicine, 2000b). Iron requirement distributions for iron of lower bioavailability will be used in the following analyses, since the bioavailability of iron in Southeast Asian countries is estimated to range between 5% and 10%, according to the International Life Sciences Institute (2005). Inhibitors in foods (e.g. phytates and tannins) reduce the bioavailability of iron, however, data regarding the quantity of these components in Southeast Asian foods are limited, thus making it difficult to estimate iron bioavailability in the rural Cambodian diet (International Life Sciences Institute, 2005).

With regard to the third assumption, variance of nutrient requirements is not expected to be greater than the variance of intake, since the study sample is free-living. Regarding the fourth assumption, we expect the true prevalence of inadequate intakes for protein, iron, zinc, and vitamin A to be above 8-10% but below 90-92%, considering the high rates of undernutrition (stunting, wasting, underweight, anemia, estimated zinc deficiency, and vitamin A deficiency), as previously described in section **1.2**. However, the prevalence of inadequate intakes of calcium, thiamin, riboflavin, niacin, and vitamins B6 and B12 will also be assessed. Considering the possibility of under- or over-reporting of intakes using 24HRs, absolute values for estimated prevalence of inadequate intakes in the study sample may not be accurate, but relative values (comparisons across groups) are expected to be accurate.

2.9 Research questions and thesis hypotheses

According to the Council for Agricultural and Rural Development, recommendations for future interventions include diversifying homestead food production (HFP), diversifying animal source food production, integrating and coordinating government support, and focusing on child and maternal nutrition as a priority (Council for Agricultural and Rural Development, 2011). Following proceedings of a meeting convened by the WHO on the *Management of Moderate Malnutrition in Children under 5 Years of Age*, the inclusion of nutrient-dense foods, along with adequate energy intakes, is needed for adequate growth and restoration of biological and immune functions in moderately undernourished children (Shoham & Duffield, 2009). In addition, moderately wasted children need a diet with at least 30% of energy as fat and 10-12% of energy as protein (Shoham & Duffield, 2009). The current availability of these nutrients (12.6% of energy as fat and 10.5% of energy as protein), based on the FAO Cambodian food balance sheets (FAOSTAT, 2014), is borderline or below recommended levels. In light of these recommendations, increasing the production and intake of vegetables, fruit, and animal source foods is a possible solution for mitigating undernutrition in Cambodia, especially when implemented as part of a robust initiative that addresses other underlying causes of undernutrition.

The purpose of this research project is to evaluate the effect of intervention with diversified HFP with and without small-scale aquaculture on dietary intake among rural Cambodian women and children, compared to a control group, as part of the Fish on Farms[e] (FoF) project (described in section **3.2**). In particular, I will evaluate intakes of protein, fat, iron, zinc, and vitamin A. Repeat dietary recall data will be collected from a subset of the study sample to adjust for within-person variation in intake and assess the prevalence of inadequate intakes of protein, iron, zinc, and vitamin A. This research will provide valuable information that will contribute to the overall evaluation of the FoF intervention as a strategy to mitigate undernutrition among rural Cambodian women and children.

My research questions are as follows:

1) Do dietary intakes of protein, fat, iron, zinc, and vitamin A differ among women and children living in households that receive intervention with HFP, HFP plus aquaculture, or control?

[e] Fish on Farms (FoF) is a project conducted in partnership between the University of British Columbia and Helen Keller International in Cambodia. The FoF project aims to improve food security (by increasing production and access to fish and produce), while also endeavoring to improve household income generation, gender equity, and sanitation.

2) Does the prevalence of inadequate intake for protein, iron, zinc, and vitamin A (based on the EAR cut-point method or probability approach) differ among women and children living in households that receive intervention with HFP, HFP plus aquaculture, or control?

Hypotheses:

- H_{O1}: There will be no differences in dietary intakes of protein, fat, iron, zinc, and vitamin A between the intervention and control groups and between interventions.
- H_{A1}: There will be differences in dietary intakes of protein, fat, iron, zinc, and vitamin A, between the intervention and control groups and between interventions.
- H_{O2}: There will be no differences in the prevalence of inadequate intakes of protein, iron, zinc, and vitamin A between the intervention and control groups and between interventions.
- H_{A2}: There will be differences in the prevalence of inadequate intakes of protein, iron, zinc, and vitamin A between the intervention and control groups and between interventions.

Chapter 3: **Methods**

3.1 **Overview of methods**

In this section, I will outline the research design of the FoF project and the methods used for dietary assessment. I will discuss the development of data collection documents and equipment, training of interviewers, pre-testing, and quality control during data collection. I will review the strategies used to improve accuracy during data collection and the techniques used to enhance accuracy and reliability during data entry. Finally, I will provide a description of how data were statistically analyzed.

3.2 **Fish on Farms project overview**

The University of British Columbia (UBC), in partnership with Helen Keller International (HKI) Cambodia, received funding from the Canadian International Food Security Research Fund from the Department of Foreign Affairs, International Trade, and Development (DFAITD) in order to conduct a cluster- RCT among women farmers and their children in Prey Veng, Cambodia. Ethical approval was granted from the UBC Research Ethics Board (H12-00451) and Cambodian Medical Ethics Board (010 NECHR). Goals of the project included evaluating whether intervention with HFP with and without aquaculture improves the dietary intake of women and children, as well as food security, household income generation, and women's empowerment (Talukder & Green, 2011). I will refer to this project as the *Fish on Farms (FoF)* project. The focus of my project was to analyze the effect of HFP with and without aquaculture on dietary intakes and prevalence of inadequate intakes of protein, fat, iron, zinc, and vitamin A among intervention women and children compared to controls.

3.2.1 **Research design**

The FoF project utilized a parallel cluster research design in Prey Veng, Cambodia. Prey Veng province was chosen as the target population, as it was identified as one of the poorest provinces in Cambodia in 2010-2011 (Ministry of Planning & UN World Food Programme, 2012). Ninety villages (clusters) were randomly selected throughout Prey Veng and randomly assigned to one of three research arms: (1) HFP (diversified home gardens), (2) HFP plus aquaculture (small fishponds), or (3) control. I will refer to the HFP and HFP plus aquaculture research arms as the *intervention groups*. Villages were not included if they were already participating in other developmental programs. Within each village, ten households (n=900) were purposely selected by the Organization to Develop Our Villages (ODOV), commune councils, and village health workers according to specific criteria (described in section 3.2.3). In addition to the ten participant households per village, an eleventh household per village was selected to function as a Village Model Farm (VMF). These VMFs were not included in the research sample, but received HFP and aquaculture inputs and training, and in turn, provided resources and technical expertise to the research participants throughout implementation of the FoF project. Another purpose of the VMFs was to become profitable/sustainable in order to provide the participant households with inputs (e.g. seeds and seedlings) post-project.

3.2.2 **Sample size and power calculation**

A sample size of 90 clusters (villages) and 900 households in total was chosen based on a number of primary outcomes specific to the FoF project, to achieve a minimum power of 80% and two-tailed *a priori* p-value of p=0.025, accounting for multiple comparisons (Talukder & Green, 2011). With regard to dietary intake, an estimated mean daily fish intake of 50 g and an estimated standard deviation of 50 g would produce 100% power to measure a mean increase of

50 g in daily fish intake among the intervention and control groups, as described by Talukder & Green (2011). However, this is a large increase in fish intake. Alternatively, to measure a mean increase of half that amount (25 g) in daily fish intake, the power is reduced, but remains high at 97%. Due to limited resources, half of the FoF sample (450 households) participated in the dietary analysis component of the project, which further lowered the power of the study (to detect a 25 g mean increase in fish intake) to 79%, which remains at an acceptable level.

The initial FoF project sample size calculation was based on the grams of fish intake, rather than nutrient intake, which is the focus of my research project. I reverse-calculated the power of measuring a meaningful difference in fat intake, considering that I was interested in measuring the intake of five nutrients (protein, fat, iron, zinc, and vitamin A). I used the pre-determined sample size (n=150 households/intervention group, n=30 clusters/intervention group, and five households/cluster) and adjusted for the effect of clustering (similarity among individuals within clusters) (Barratt & Kirwan, 2009). The estimated adjusted sample size for each intervention group was calculated to be 75 households per intervention group[f]. I used a two-tailed alpha of 0.01, calculated by applying the Bonferroni correction for multiple comparisons[g]. I calculated the power for fat, based on Cambodian food availability data, with an estimated mean of 34 g of fat/day (FAOSTAT, 2014). Since dietary intake distribution data was not available, a standard deviation equaling 1.3 times the mean for fat was used, based on intake

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[f] ESS = (m x k)/DE = (m x k)/[1 + (n-1)p] = (5 x 30)/[1 + (5-1)0.25] = 150/2 = 75 households
ESS = effective sample size, m = number of subjects in a cluster, k = number of clusters, DE = design effect, n = average cluster size, and p = intra-class correlation for the desired outcome (conservatively estimated to be 0.25 or 25%) (Barratt & Kirwan, 2009).

[g] Bonferonni adjusted alpha = 0.05/5 comparisons (protein, fat, iron, zinc, and vitamin A) = 0.01 or 1%.

distribution data from Canada[h] (Health Canada, 2006a). For an average intake of 34 g fat/day and an estimated standard deviation of 44 g fat/day, an adjusted sample size of 75 households per intervention group would have a power of 79% to detect a difference in intake of 20 g fat/day[i]. An increase in intake of 20 g/fat/day (for a mean of 54 g fat/day) would be the difference between consuming 12.6% of energy as fat and 20% of energy as fat (to meet the low end of the DRI acceptable macronutrient distribution range for fat: 20-35% of energy as fat/day). Based on this calculation, I assume that the current study is powered to detect a substantial difference (59% increase) in fat intake. I did not do a power calculation for iron, zinc, vitamin A and protein, due to the lack of knowledge on micronutrient intake in the Cambodian diet and the borderline-low/sufficient protein available in Cambodia.

3.2.3 **Participant selection criteria**

Households of the FoF project were selected if they had a woman of childbearing age, were considered poor based on local wealth rankings, had access to land and labour for HFP and a fish pond, had at least one child under five years of age, and were interested in participating in the FoF project (Talukder & Green, 2011). Each participant provided informed oral consent and was assigned a unique identification number (ID) to ensure confidentiality.

For my research project, 450 participants were randomly selected from the original 900 participants for 24-hour dietary recall (24HR) interviews. Five household IDs were randomly selected from the original ten households in each village. At endline, when a household/participant was not available during data collection in the field (e.g. had moved

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[h] The coefficient of variation (SD/mean) was 1.3 for fat among Canadian women aged 19-30 years in 2004 (Health Canada, 2006a)

[i] Power calculations were completed using the UBC online power/sample size calculator (Brant, 2015).

away), a new household was selected by pulling a number(s) from a hat, from the remaining five households in each village/cluster.

3.2.4 **Data collection**

Interviewers collected data at baseline (July 4-19, 2012) and after 22-months (May 26 – June 10, 2014). Data collection for the FoF project included survey questions, anthropometric measures, biochemical testing, and 24HRs. Interview questions related to general household information (e.g. household size, age of children, education level, employment, sources of income etc.), water and sanitation (e.g. whether or water was treated), homestead food production (e.g. land size and types of fruits and vegetables grown), food consumption (e.g. dietary diversity), mother's nutrition and health (e.g. pregnancy status and night blindness), knowledge and attitudes (e.g. infant and young child feeding practices), and household food security. Anthropometric measures included height/length, weight, and mid-upper-arm circumference (MUAC) (measured using armbands), obtained from each woman and child less than five years of age at baseline (or less than seven years of age at endline). Hemoglobin levels were measured using HemoCue finger prick kits. In half of the sample (n=450 women and n=450 children), urine and blood (venipuncture) samples were also collected. Urinary iodine, complete blood count, serum ferritin, serum retinol binding protein (RBP), serum transferrin receptor, C-reactive protein (CRP), and alpha-1 glycoprotein (AGP) concentrations were measured. Aside from 24HR data and baseline anthropometric measures, hemoglobin levels, and participant/household characteristics, the aforementioned measures are not reported in my study.

At baseline, 24HRs were collected from 450 women (150 per research arm) and their youngest child, between six months and five years of age (mothers provided 24HR data for their children). At this stage of the project, the 24-hour vitamin A semi-quantitative (24-VASQ) method was chosen by HKI research staff to collect dietary intake data, as outlined by de Pee et al. (2006). This method was developed to quantify a population's vitamin A intake. While the 24-VASQ was not designed to measure other nutrient intakes, it is a type of 24HR, where all foods and drinks consumed during the previous day are listed, including portion sizes (de Pee et al., 2006). However, the 24-VASQ does not employ a multiple-pass method, which has been shown to improve recall (discussed previously in section **2.6**). Consequently, the 24-VASQ method is likely to underestimate dietary intake. I analyzed baseline 24HRs in this thesis, to assess similarity between groups at baseline. However, baseline 24HRs were not compared against endline 24HRs, due to the differing data collection methodology used at endline (discussed below in section **3.3**).

Since my research questions were developed after the FoF project commenced, and included the assessment of protein, fat, iron, and zinc, as well as vitamin A, a more appropriate 24HR method was chosen for endline data collection. While the current gold standard for assessing dietary intake is the USDA AMPM, it is inappropriate for use in developing countries (discussed previously in section **2.6**). I chose to use the guide developed by Gibson & Ferguson (2008), "An interactive 24-hour recall for assessing the adequacy of iron and zinc intakes in developing countries" (described in section **2.6**). Given resource and time constraints, this guide was adapted for our use. We planned to collect a single 24HR at endline from the original 450 woman and child pairs from baseline. We also planned to collect repeat 24HRs on a non-consecutive day in a subset of the study sample (n=150 woman and child pairs).

3.3 Developing the endline 24-hour dietary recall survey instrument

The 24HR method developed by Gibson & Ferguson (2008) was used to guide the development of 24HR forms and protocols, obtain accurate food measurement data, facilitate interviewer training, and execute pre-testing of the forms and interviewer selection, described below.

3.3.1 Endline 24-hour dietary recall forms

The forms used for 24HR data collection were adapted from examples provided in the guide by Gibson & Ferguson (2008). Forms were developed in English and translated into Khmer by HKI staff. For both women and children, each form included a place to indicate the participant/mother's ID number, the interviewer's name, and the date. For recording 24HR data, a table was designed with columns for time of eating occasion, food or drink (or name of recipe) consumed, a detailed description of the food, cooking method, and amount eaten (using household measures, the weight in grams, or liquid volumes in milliliters). As an adaptation to the guide developed by Gibson & Ferguson (2008), the place eaten, weight equivalent in grams, and food code columns were not included on the 24HR form, to match the Cambodian context and suit our research needs. According to staff at HKI, most meals would be eaten at home and the "place eaten" column was omitted to streamline questioning. The "weight equivalent" column was also omitted, since interviewers would be instructed to note the weight in grams in the amount eaten column, if known by participants. No food codes were developed since the chosen food analysis program (ESHA[j] Food Processor) does not employ food codes for data

[j] ESHA stands for Elizabeth Stewart Hands and Associates.

entry. However, coded responses were created for a number of columns in the table, including time (codes: 1 = daybreak to 10:00 am, 2 = 10:00 am to 3:00 pm, 3 = 3:00 pm to 7:00 pm, and 4 = 7:00 pm to daybreak) and cooking method (codes: 1 = raw, 2 = boiled, 3 = steamed, 4 = roasted, 5 = fried, 6 = other). The amount eaten was recorded using graduated sizes of various household measures, labeled as #1, #2, and #3 for each bowl, soup bowl, water bowl, plate, glass, mug, slice, piece, ladle, spoon, and serving spoon. Small, medium, and large measures were also used for fruit and some vegetables. The weight in grams was recorded when known.

Recipe forms were also developed for when participants consumed a mixed dish. A separate recipe form was completed for each mixed dish, when the recipe was known. The form included a place for the mother's ID number, interviewer's name, date, recipe name, recipe description (e.g. soup, paste, sauce, etc.), total recipe amount (using household measures or the weight in grams), and proportion/amount of the recipe consumed by participant (which would also be included on the 24HR form). Again, a table was designed to collect recipe details, including columns for ingredients, a detailed description of the ingredients, and the amount of raw ingredients used (using household measures or the weight in grams). In contrast to the recommendations by Gibson & Ferguson (2008), the "weight/volume of empty pot" and the "weight/volume of the cooked dish + pot" were not collected, since interviewers would not have scales to measure food in the field, nor the time to be present to weigh freshly prepared recipes. Columns for weight of raw ingredients consumed, weight of cooked ingredients in recipe, and weight of cooked ingredients consumed were not included in the form because the recipe would be analyzed separately in the ESHA Food Processor program and the amount consumed would be calculated as a proportion of the total recipe. See **Appendix 1** for the 24HR and recipe forms used for data collection (in English and Khmer).

3.3.2 Interviewer and field supervisor protocols

Interviewers were provided with a protocol that they carried with them during data collection. They were instructed to use the protocol as a guide and reference for probing questions, as needed. The first side of the page included a review of how to greet participants and the purpose of the 24HR. The four passes of the 24HR were outlined with example statements/questions on how to move the interview forward, using neutral language. The second side of the page included a table of probing questions for obtaining detailed descriptions of specific food categories (e.g. meat, fish and seafood, insects, grains, sauces or pastes, etc.). These questions were adapted from the examples provided in Gibson & Ferguson's (Table 5.2, 2008) guide. For example, probing questions for meat included “What kind of meat?” and “Was it lean meat or lean meat plus fat?” These questions were developed in collaboration with HKI staff, familiar with Khmer cuisine and the diet of rural Cambodians.

In a group meeting, field supervisors were provided with an overview of the multiple-pass 24HR method and the forms used by interviewers. Field supervisors were also provided with a protocol, which was developed to help them supervise and monitor for quality and consistency. The field supervisor’s protocol outlined three roles to fulfill when monitoring 24HR interviewers in the field: (1) check for errors, (2) ensure interviewers follow their protocol (multiple-pass method), and (3) ensure interviewers have been thorough. Field supervisors were instructed to observe 24HR interviews in the field, as time allowed. Field supervisors were also instructed to review 24HR and recipe forms as they were completed, to correct any errors, ensure legibility, and/or to instruct interviewers to collect additional data from participants if the forms were incomplete. See **Appendix 2** for protocols (in English and Khmer for the interviewer protocol and in English only for the field supervisor protocol, since field supervisors spoke English well).

3.3.3 Developing the household measures kit and obtaining food measurement data

At baseline, HKI staff composed a kit of common household measures, which was used again at endline. However, some vague measures were used during baseline data collection, including "piece," "slice," "one finger," and "two fingers" (typically used for meat, poultry, seafood, fruit, or vegetable). These measures were not standardized before data collection at baseline and were not used again at endline, in order to improve accuracy. To provide suitable substitutes, graduated food models for "piece" and "slice" were molded from plasticine and included in each kit of household measures. To ensure all models were of equal size/weight, a scale was used during model creation. Afterwards, the food models were measured via water displacement, as outlined by Gibson & Ferguson (Box 5.6, 2008), to calculate the volume for each piece and slice. Food items were then weighed using the known volumes for each piece and slice measure. Actual foods, salted food replicas, and graduated photographs of food were not used to estimate portion sizes, due to a lack of time and the labour required to prepare each of these food measurement tools.

After baseline data collection, HKI staff measured each food item using each household measure. In the guide by Gibson & Ferguson (2008), a more standardized approach is recommended. For instance, the participant's own cups and bowls could be calibrated in milliliters with a graduated pitcher of water. Alternatively, each household measure (in the interviewer's kit) could be calibrated in milliliters. Each food volume could then be converted into weight equivalents by a variety of methods, such as direct weighing or converting the volume into grams by multiplying the reported volume by the food's specific gravity (density) to obtain the grams of food consumed (Gibson & Ferguson, 2008). When using household measures, it is recommended that each food be weighed multiple times for a single known volume; the volume/weight ratio can then be used to calculate weight equivalents for the other household measures (Gibson & Ferguson, 2008). This differs from our food measurement data, where each food was weighed once for each household measure (there were multiple measures for a variety of volumes rather than a single known volume).

At endline, many food measures were missing from the original baseline food measurement tables, so HKI staff was requested to measure a number of additional foods and/or household measures. Due to time and labour constraints, the previous method used to obtain food measurement data was not changed/updated to follow Gibson & Ferguson's (2008) recommendation. See **Appendix 3** for food measurement data collected at endline. Baseline food measurement data are not included, but are available upon request.

3.3.4 **Interviewer training and pretesting**

According to Gibson & Ferguson's (2008) guide, seven days were suggested for interviewer training and pretesting. However, we were limited to three days of training, due to time and budgetary constraints. While the schedule was condensed, we covered all recommended activities and pretested our forms and protocols. HKI staff recruited nine interviewers for training, eight of whom were selected for endline data collection. HKI staff also organized a field test in a community outside of Phnom Penh, thought to be similar to our study sample. I condensed the training schedule, based on Gibson & Ferguson's (2008) suggested schedule. I also facilitated the interviewer training with one (sometimes two) HKI staff, who acted as translator(s) and helped facilitate training. Training was designed to be interactive and participative to enhance learning. Most discussions took place in small groups and/or as a class, using flip chart paper to document topics covered. Trainees were also given as much time as possible to practice the multiple-pass 24HR method with each other in class and with volunteer participants during the field test.

Day 1: After introductions, training started with a group discussion and experience sharing among those who have collected 24HR's in the past. The study objectives were reviewed, the 24HR forms and kit of household measures were introduced, and the four passes of the 24HR were reviewed. Trainees observed a 24HR role-play, and practiced the four passes of the 24HR in pairs, using the 24HR form and kit of household measures (for estimating portion size). General interviewing techniques were also discussed, to help interviewers build rapport, be respectful, and use non-judgmental language and questioning.

Day 2: After a review and discussion of the previous day's activities, the recipe form was introduced. Trainees observed a recipe collection role-play and then practiced using the recipe form (in pairs). Trainees were given another opportunity to practice conducting the four passes of the 24HR and collecting recipe information, to complete the multiple-pass 24HR process. The group also discussed how to deal with difficult situations (e.g. dealing with distractions, participants giving socially desirable answers, etc.). The logistics of the field test (to be conducted on the following day) were also reviewed and any remaining questions were answered.

Day 3: On the final day of training, the field test and pretesting of the forms and protocols were completed. Four pairs of trainees (one group of three) completed one 24HR each from a woman volunteer and/or her youngest child over six months of age (mothers reported on their children's intake). One partner observed, while the other partner conducted the interview. Once one interview was completed, the partners changed roles. After the field test, we reconvened at the HKI office and debriefed on the day's events. Trainees shared their learnings from the day. Trainees also provided feedback on the forms and minor edits were suggested for the 24HR form (e.g. adding a second page of rows for entering food items).

Despite the short training timeframe, trainees expressed general comfort with collecting 24HRs following the three-day training and field test. It should be noted that Gibson & Ferguson (2008) recommend at least five practice interviews during the field test. However, due to both limited time and number of volunteer participants, this was not possible. Gibson & Ferguson (2008) also recommend meeting with participants two days prior to collecting 24HR data, to provide participants with standardized household measures and to train participants on portion size estimation. Again, due to time constraints, visiting participants beforehand was not possible. However, a wide variety of household measures were included in the interviewer's kit, providing many options for estimating portion size during the interview. Furthermore, participants were expected to be familiar with estimating portion size amounts, since many women living in rural Cambodia sell produce and portion out/weigh a variety of foods. See **Appendix 4** for interviewer training schedule and lesson plans.

3.3.5 **Interviewer selection**

Two HKI staff and I observed trainee practice interviews in class and during the field test. In particular, trainees were observed for their use of appropriate body language, exercising a non-judgmental questioning style, and completing the multiple-pass 24HR method as instructed. Together, we reviewed the forms completed in class and during the field test for clarity and completeness. While I did not speak the Khmer language, I was able to observe most of these criteria. Based on our observations, we individually ranked trainees from one to nine and compared our rankings. We then selected the top eight trainees to become our 24HR interviewers for endline. These interviewers were informed of their selection over the phone and given instructions about when to meet for endline data collection. Six interviewers were chosen to collect the initial 24HRs for endline and two interviewers were selected to collect the repeat 24HRs, ensuring that the same interviewer would not collect two recalls from the same participant. This was done to reduce interviewer bias (when calculating estimated usual intakes for the study sample, using repeat recall data).

3.3.6 Data collection and quality control

During endline data collection, three teams of two interviewers visited two villages/day/team for 15 days to collect the initial 24HRs. Each interviewer collected ten 24HRs per day (from five women and five children). By the end of data collection, all three teams were expected to collect 900 24HRs in total (from 450 women and 450 children). During the final eight days of data collection, a second team of two interviewers revisited 30 villages, randomly selected from the original 90 villages (using www.random.org), to collect repeat 24HRs. This "repeat team" was expected to collect 300 24HRs in total (from 150 mothers and 150 children).

I was present for the first seven days of the 16-day endline data collection period. I observed two interviewers each day, debriefed with each interviewer following 24HR data collection (sometimes with a translator present), and corrected any errors and addressed any problems/questions. For example, I noticed one interviewer laugh when a participant was describing a large portion of rice consumed. After the interviewer described her experience, I again emphasized the importance of staying neutral and non-judgmental when participants describe how much they eat and we agreed that humor could be used at other times to develop rapport, but to remain neutral when recounting foods and portion sizes. Field supervisors also translated a number of 24HRs for me, and we addressed any omissions, sending interviewers back to see the participants to fill in the blanks when necessary. When I was not present, field supervisors continued to observe interviewers and review the 24HR forms at the end of each data collection day, using their "24-hour dietary recall data collection protocol for field supervisors" (as described in section **3.3.2**). At the end of each day, the entire interview team met briefly to address any questions or difficulties encountered in the field.

3.4 Data entry: compiling a local food composition database

The ESHA food processor program (SQL 10.12) was chosen for data entry of 24HR data, as it contained more than 55,000 foods, compiled, updated, and reviewed by researchers. A breakdown of the total daily intake of macro- and micronutrients into spreadsheets is also possible using the ESHA program, which was needed to address my two research objectives.

Since food composition is affected by climate, soil, and other environmental factors, local food composition data were entered into the ESHA database when available. Since Cambodian food composition data were rarely available, data from neighboring Southeast Asian countries were used. The ASEAN food composition table (released in February, 2014) was used most often, including data from Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam (Institute of Nutrition, 2014). The Vietnamese food composition table was used when a food item could not be found in the ASEAN database (Institute of Nutrition, 2007). When no local data were available, Cambodian food composition data from research conducted by Anderson, Cornwall, et al. (2008) were used.

Some foods in the Southeast Asian databases did not include all pertinent nutrient values. When this was observed for protein, fat, iron, zinc, or vitamin A (the nutrients pertaining to my research questions), as well as energy, carbohydrate, calcium, water, thiamin, riboflavin, niacin, and vitamins B6 and B12, a value was imputed for these nutrients using USDA or Canadian

Nutrient File (CNF) equivalents. When appropriate food equivalents could not be found, values were imputed from similar foods, from USDA, CNF, and/or ASEAN foods. See **Appendix 5** for a list of food items added to the ESHA database, as well as a record of the nutrients imputed.

A student was hired (through UBC student funding) to help enter baseline 24HR data (from September 2013 to April 2014). We received additional funding (through FoF project funding) for the student to help with endline recipe data entry (September 2014 to April 2015). We met on a regular basis to develop a data entry protocol and make assumptions as needed (described below in section **3.4.1**). I entered endline 24HR data and obtained some assistance from a volunteer during this stage of data entry (July 2014 to April 2015). I closely reviewed all of the volunteer's data entries. The three of us used a Google Doc (online word document), which was updated regularly as assumptions were developed. This was done to ensure that we entered data systematically and consistently when faced with vague or unknown foods and measures.

3.4.1 Developing assumptions during data entry

I encountered a number of challenges during data entry, including unusual foods, missing food weight measurements, and limited local food composition data (e.g. data for fresh but not for dried foods). To ensure data were entered consistently and enhance reliability, a list of assumptions was developed. When no food composition data were available for exotic foods, similar foods were used in substitute. For example, honeydew was used in place of "cucumis melo" or "muskmelon" (a type of melon). Many snack packages in Cambodia lacked nutritional facts panels; to represent these foods, a similar product with nutritional information was found in a local grocery store in Canada (i.e. T&T) or a USDA/CNF equivalent was chosen, based on the snack ingredients or description.

For missing food measurement data, similar foods were used as weight equivalents. For example, pork weight measures were used for missing chicken measures. Raw to cooked (or fresh to dry) weight conversions were also made, by multiplying the raw (or fresh) food by a constant, calculated from USDA/CNF data. For example, the USDA calorie value for fresh mango is 67 kcal/100 g and 350 kcal/100 g for dry mango. The ASEAN calorie value for fresh mango is 62 kcal/100 g (similar to the USDA value) and was multiplied by a constant of five (350 kcal/67 kcal = 5.2 = 5) to estimate the calories (and other nutrients) for 100 g of dried mango (e.g. 62 kcal/100 g ASEAN fresh mango x 5 = 310 kcal/100 g dried mango). See **Appendix 6** for the list of assumptions made during endline.

3.5 Statistical analysis

For all statistical analyses, Statistical Package for the Social Sciences (SPSS) (version 22) was used. Descriptive statistics for baseline characteristics and baseline 24HR data were summarized for each of the intervention and control groups. Endline 24HR data were compared across intervention and control groups. Prevalence of inadequate intake was also assessed at endline and compared across intervention and control groups. All summaries and analyses were completed for both women and children.

3.5.1 Independent and dependent variables

The independent variable is categorical: intervention with (1) HFP, (2) HFP plus aquaculture, or (3) control. The independent variable consists of 30 clusters (villages) per intervention group, with five woman-child participant pairs per cluster. Recall that clusters were randomly selected and randomized to one of the intervention or control groups, as part of the FoF project. Since clustering data is expected to reduce statistical power (for the reason that clusters are not truly independent since similarities may exist among individuals within a cluster), the effect of clustering was adjusted for in statistical modeling.

Dependent variables used to assess dietary intake at endline include daily intakes of protein, fat, iron, zinc, and vitamin A. Daily intakes of energy, carbohydrate, calcium, water, thiamin, riboflavin, niacin, and vitamins B6 and B12 were also included in the results. Univariate analyses of these data revealed that all continuous nutrient intake distributions were right-skewed. Consequently, a Generalized Estimating Equations (GEE) gamma regression model with log link was used to adjust for clustered data and account for data with skewed distributions. The benefit of using a GEE model for clustered data, is that within-cluster similarities/correlations are calculated and used to estimate regression parameters and the resulting standard errors of the regression, producing confidence intervals of sufficient coverage and accuracy[k] (Hanley, Negassa, Edwardes, & Forrester, 2003). Furthermore, the GEE model also allows for inclusion of a dependent variable with non-normal distributions. The GEE takes a quasi-likelihood approach, which allows for widely dispersed data (Zeger & Liang, 1986). GEE options for modeling continuous data include both linear responses (for normally distributed data) and gamma with log link responses (for positive and right skewed data). For these reasons, the GEE model was used to adjust for the effect of clustering and model non-normally distributed data, rather than using a simpler linear regression model, using transformed data (for non-linear data), and including the effect of clustering as a random factor.

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[k] By calculating and adjusting for within-cluster similarities, the resulting standard errors (and consequent confidence intervals) in GEE models are more accurate than other statistical models that include clustering as a random, multilevel, or hierarchical effect, where instead, the between-cluster variation is incorporated into the resulting standard errors (Hanley et al., 2003).

Dependent variables used to assess the prevalence of inadequate intake at endline include protein, iron, zinc, and vitamin A, as well as calcium, thiamin, riboflavin, niacin, and vitamins B6 and B12. After statistical adjustment to estimate the usual intake variation of the sample (described in section **3.5.4** below), each dependent variable (except for iron) was dichotomized into values above and below established EARs. When approximating the prevalence of inadequate iron intake, the estimated usual intake distributions for iron were compared against iron requirement distribution percentiles; see **Appendix 7**. Note that categorical values for the probability of inadequate iron intake were used (0, 4, 8, 15, 25, 35, 45, 55, 65, 75, 85, 93, 96, and 100%), as outlined in **Appendix 7**. For example, dietary iron intakes ranging from 8.77 to 9.63 mg iron/day were assigned a 35% risk of inadequate iron intake. The probability of inadequate iron intake was then treated as a continuous variable. Since the distribution of the probabilities of inadequate iron intake was also right-skewed, a GEE gamma regression model with log link was used to account for the skewed distribution.

3.5.2 Baseline analyses

Sample characteristics and 24HR summaries at baseline are presented. Sample characteristics were summarized from the questionnaire data collected at baseline. Characteristics of women include age, weight (average of two measures), height (average of two measures), mid-upper arm circumference (average of two measures), blood hemoglobin levels, number of pregnant participants, parity, number of people living in the same household, number of children under age five living in the same household, number of participants with treated water, number of years of schooling, total income over the previous two months, and the calculated BMI, prevalence of anemia, and total estimated energy requirement (EER) (kcal) using the Canadian/US DRI energy equations. Characteristics of children include age, number of female/male participants, weight (average of two measures), height (average of two measures), mid-upper arm circumference (average of two measures), blood hemoglobin levels, and the calculated prevalence of anemia. Z-scores for weight-for-age, length/height-for-age, and weight-for-length and prevalence of underweight, stunting, wasting, and severe acute malnutrition were calculated using the WHO plug-in for SPSS (WHO, 2011b).

Baseline 24HR data were reviewed for any errors and implausible values. No outliers were removed, since the most extreme values observed were considered to be plausible. Baseline data were summarized with means (95% CI) for intakes of protein, fat, iron, zinc, and vitamin A, as well as calcium, water, thiamin, riboflavin, niacin, and vitamins B6 and B12. Since each village was randomly selected to receive one of the two interventions or control, no difference in dietary intake was expected across groups before intervention. Baseline 24HR data were compared across intervention and control groups, however, any significant differences observed are likely due to chance rather than bias, according to the Consolidated Standards of Reporting Trials (CONSORT) (2010) statements. Note that the CONSORT (2010) statements also state that "tests of baseline differences are not necessarily wrong, just illogical." Baseline data were not compared against endline data (as repeated measures over time), since baseline 24HRs were collected using the 24-VASQ method, which differs from the multiple-pass 24HR method used at endline, and would not produce a valid comparison. Baseline data were also not adjusted for in the final model, due to the high rate of attrition of participants from baseline.

Both baseline characteristics and 24HR data were compared across intervention and control groups using a GEE gamma regression model with log link (or GEE binary logistic model), adjusted for the effect of clustering and using a two-tailed alpha ($p<0.05$) and the

Bonferroni correction for multiple comparisons[1]. The intervention and control groups (independent variable) were entered into the model as the "main effect" and the effect of clustering was entered into the model as a "subject variable" (to adjust for similarity within clusters). Note that in the statistical models used, the reported "Bonferroni adjusted p-values" were calculated by multiplying p-values by three (which were truncated on the upper end at 1.00). In the results section, $p<0.05$ signifies the threshold for significance.

3.5.3 **Endline analysis**

Prior to analysis, endline data were also reviewed for errors and implausible values, and corrections were made when data entry errors were found. No outliers were removed, since the most extreme values observed were considered to be plausible (e.g. it is possible to consume 0 g or 200 g of fat/day or 0 RAE or 10,000 RAE of vitamin A/day, though uncommon). Endline 24HR data were summarized with means (95% CI) for protein, fat, iron, zinc, and vitamin A intake, as well as calcium, water, thiamin, riboflavin, niacin, and vitamins B6 and B12.

Endline 24HR data were compared across intervention and control groups using a GEE gamma regression model with log link, adjusted for the effect of clustering and using a two-tailed alpha ($p<0.05$) and the Bonferroni correction for multiple comparisons. The intervention and control groups (independent variable) were entered into the model as the "main effect" and the effect of clustering was entered into the model as a "subject variable" (to adjust for similarity within clusters). Mean differences in intakes (95% CI) are presented for nutrients where intakes differed significantly between groups.

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[1] The Bonferroni correction ($p=0.05/3$ comparisons = 0.0167) was made to account for each pairwise comparison between intervention and control groups.

3.5.4 **Assessing prevalence of inadequate nutrient intakes**

During endline data collection, repeat 24HRs were collected from a subset of the study sample. Recall that by collecting repeat 24HRs, sample intake distributions can be adjusted to remove the effect of daily intra-individual variations in intake, providing inter-individual (usual) intake estimates (Institute of Medicine, 2000b). The program PC-SIDE was used to statistically adjust intake distributions using the repeat 24HR data (Iowa State University, 2015).

Using the EAR cut-point method:

Using the estimated usual nutrient intake distributions, continuous data were recoded into dichotomous data above and below the EAR for nutrients in which the EAR cut-point method can be applied (described in section **2.8**): protein (in terms of g/kg/day), zinc, and vitamin A, as well as carbohydrate, calcium, thiamin, riboflavin, niacin, and vitamins B6 and B12. The prevalence of inadequate intake for each of these nutrients is summarized as counts (%) for each of the intervention and control groups.

The dichotomous variables were also compared across the intervention and control groups using a GEE binary logistic regression model, adjusted for the effect of clustering and using a two-tailed alpha ($p<0.05$) and the Bonferroni correction for multiple comparisons. The intervention and control groups (independent variable) were entered into the model as the "main effect" and the effect of clustering was entered into the model as a "subject variable" (to adjust for similarity within clusters). The mean percent difference in inadequate intakes (95% CI) is presented for each comparison between intervention and control groups.

Using the probability approach:

To assess the prevalence of inadequate iron intake, the EAR cut-point method cannot be applied, since iron requirement distributions are non-symmetrical (skewed to the right) for menstruating women and growing children (Institute of Medicine, 2000a). Thus, the full probability approach was used to estimate the prevalence of inadequate iron intake. The estimated usual iron intake distributions for women and children were compared against IOM (2000a) iron requirement distribution percentiles (18% bioavailability), as well as requirement distribution percentiles for iron at lower bioavailability levels (15%, 10%, and 5% bioavailability), as outlined by Gibson & Ferguson (2008), to estimate the probability of inadequate iron intake. See **Appendix 7** for the categorical iron requirement distribution percentiles and the associated ranges of usual intake for women and children. Categorical values were deemed adequate, since percentile ranges were closely spaced; however, the precision of estimating the prevalence of inadequate iron intake with categorical values is less than if discrete/continuous values for the probability of inadequate iron intake were calculated for each iron intake value. Consequently, the reduced precision may make it more challenging to detect significant differences between the intervention and control groups. The average probability of inadequate iron intake was used to estimate the prevalence of inadequate iron intake, summarized as the mean percent of inadequate intake (95% CI) in each of the intervention and control groups.

The estimated prevalence of inadequate iron intake (at each bioavailability level) was compared across groups using a GEE gamma regression model with log link, adjusted for the effect of clustering and using a two-tailed alpha ($p<0.05$) and the Bonferroni correction for multiple comparisons. The intervention and control groups (independent variable) were entered into the model as the "main effect" and the effect of clustering was entered into the model as a "subject variable" (to adjust for similarity within clusters). The mean difference in prevalence of inadequate iron intake (95% CI) is presented for each comparison between intervention and control groups.

3.5.5 Intra-rater reliability testing

Two coders entered the majority of the 24HR data: one coder entered baseline 24HRs and endline recipes (hired student), and I entered the endline 24HRs. While a volunteer assisted with the endline 24HR data entry, I carefully reviewed her work. Intra-rater reliability was tested to measure the degree of agreement for each primary coder (testing each coder's reliability independently). Inter-rater reliability was not measured, since each coder entered sections of data independent from each other.

To test intra-rater reliability, the hired student re-entered 44 endline recipes and I re-entered endline 24HRs from a total of 22 women and 22 children participants (5% of the total data entered at endline). The re-entered 24HRs (and associated recipes) were systematically selected by choosing every 20th participant from the study sample. Intraclass correlation was used to measure agreement for each coder (correlating the first and second entries for the selected recipes and 24HRs). Intraclass correlation coefficients were calculated for each dependent variable measured (protein, fat, iron, zinc, and vitamin A, as well as energy, carbohydrate, calcium, thiamin, riboflavin, niacin, and vitamins B6 and B12).

Chapter 4: **Results**

4.1 **Overview of results**

In this section, I will start by outlining participant recruitment and attrition. Baseline results will include sample characteristics and 24HR summary statistics. Endline (after intervention) results will include: (1) average nutrient intakes from 24HR data and (2) estimated prevalence of inadequate intake using estimated usual intake distributions (derived from 24HR data). Test results for intra-rater reliability (of data entry for 24HRs and recipes) will also be presented.

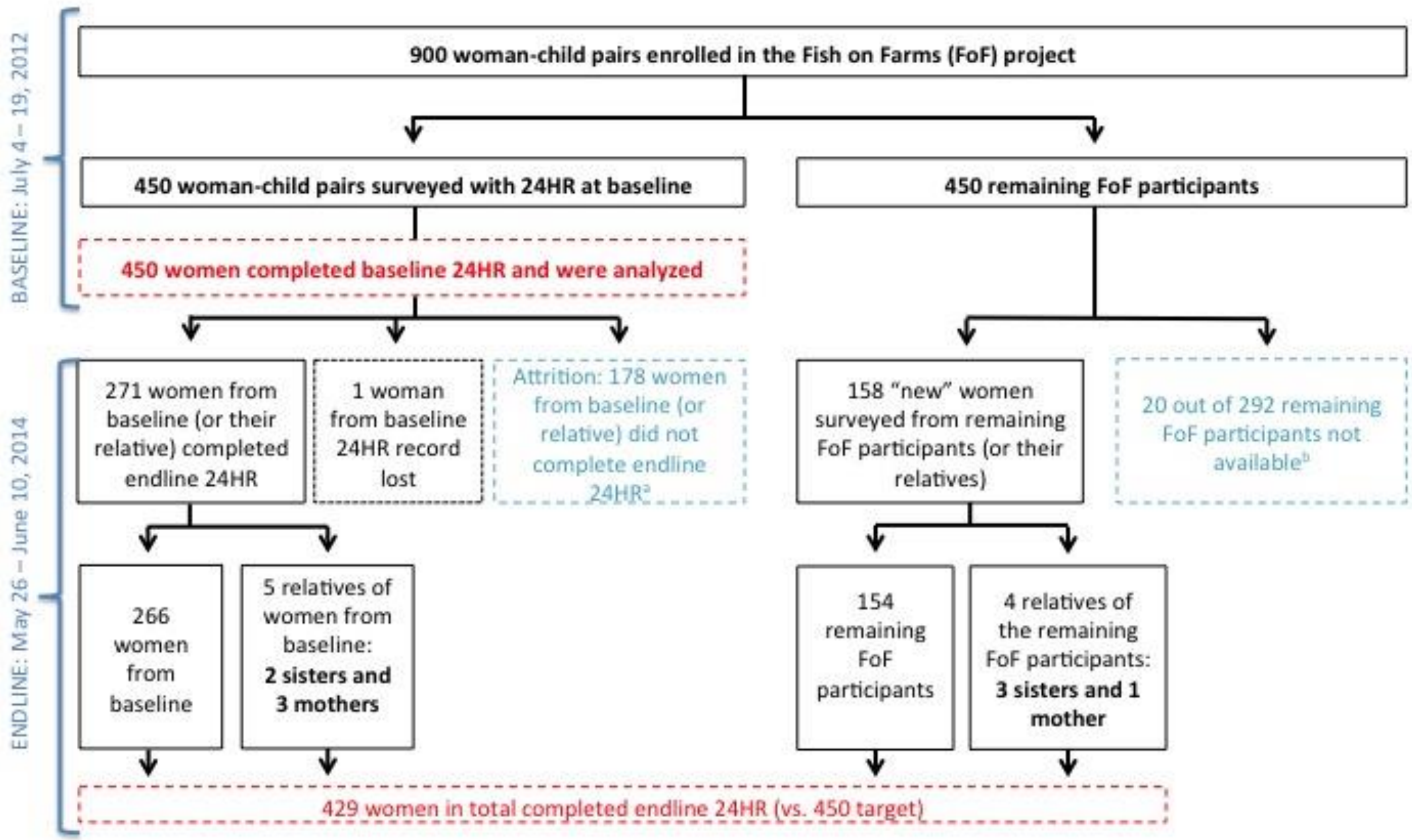
4.1.1 **Participant inclusion and attrition**

At baseline, half of the full FoF participant sample (n=450 vs. n=900 woman-child pairs) was surveyed with 24HR. However, all participants (n=900) completed the baseline survey questionnaire (results not presented in this thesis). The goal at endline was to collect another 24HR from the original 450 baseline participants. I will explain the resulting endline participant sample in the following paragraphs, as depicted in **Figure 2** and **Figure 3**.

Among women at endline, 266 participants from baseline and five relatives of the baseline women (two sisters and three mothers) completed the endline 24HR. One food record was lost and the remaining 178 women from baseline were not available due to attrition. To achieve the desired sample size at endline, an additional 154 women from the remaining FoF participant pool (who did not complete a 24HR at baseline) and four relatives of the remaining FoF participants (three sisters and one mother) completed the endline 24HR. In total, 429 women completed endline 24HRs; see **Figure 2**.

Among children, 261 participants from baseline and five children with relatives of the baseline women (two sisters and three mothers) completed the endline 24HR. Six children surveyed with baseline mothers at endline did not complete the endline 24HR and the remaining 177 children from baseline were not available due to attrition. To achieve the desired sample size at endline, an additional 152 children from the remaining FoF participant pool (who did not complete a 24HR at baseline) and three children with relatives of the remaining FoF participants (three sisters and one mother) completed the endline 24HR. In total, 421 children completed endline 24HRs; see **Figure 3**.

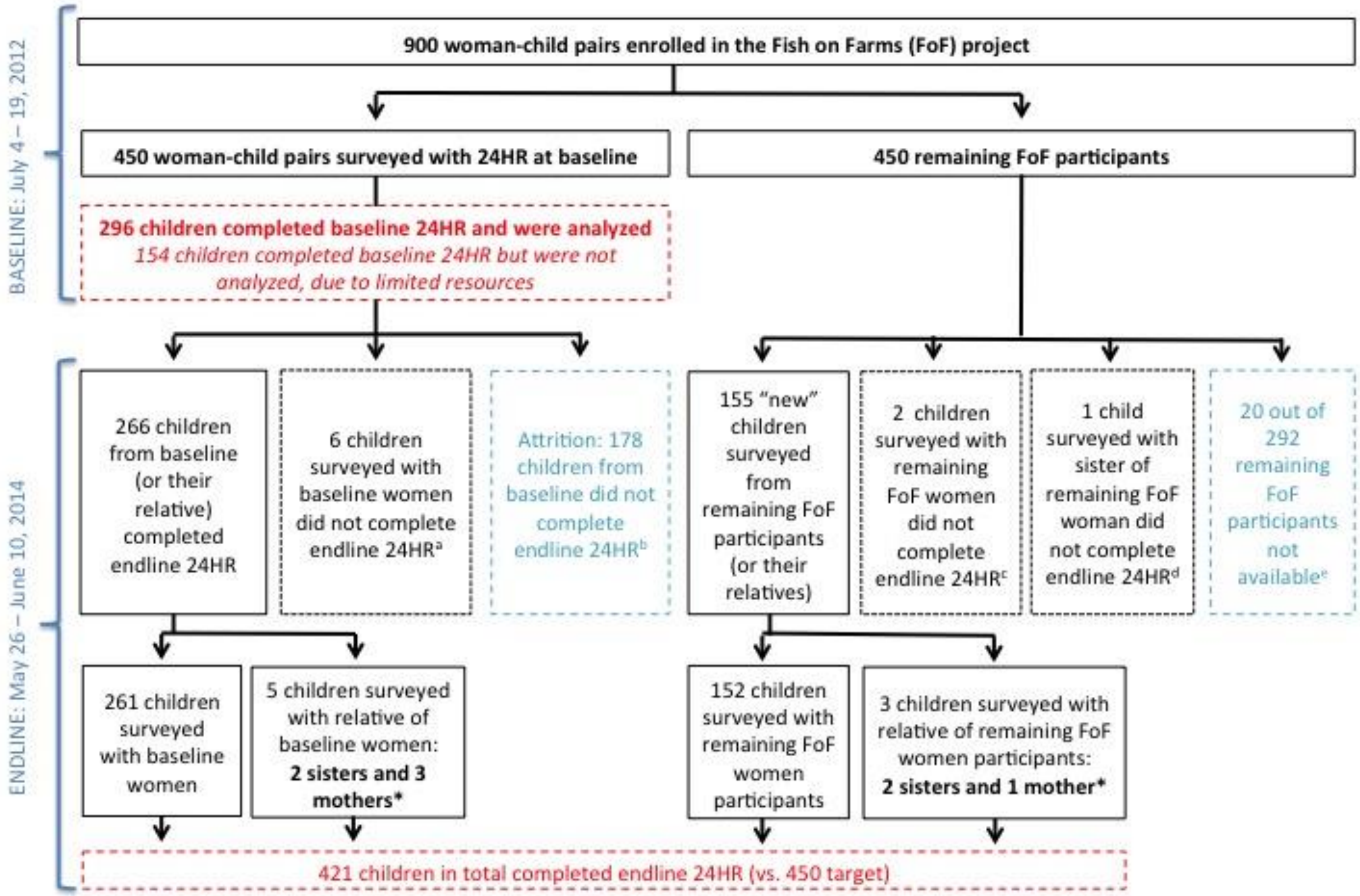
Figure 4.1: Participation flowchart for women.



[a] *Reasons for attrition in baseline 24HR sample*: moved to Phnom Penh (n=52), moved to undisclosed location (n=43), moved to Thailand (n=42), moved to another village/district/province (n=11), denied to participate (n=17), dropped out of project (n=9), just delivered baby one month ago (n=1), empty house (n=1), in hospital (n=1), and brought child to hospital (n=1) (total n=178).

[b] *Reasons for attrition in remaining FoF participants*: reasons not documented, however, based on the known reasons for attrition in the baseline 24HR sample, an estimated ~80% of participants emigrated.

Figure 4.2: Participation flowchart for children.



* It was not documented whether the child was the offspring of the baseline mother (original FoF participant) or the mother's relative.

[a] *Reasons children surveyed with baseline women did not complete endline 24HR*: with grandmother (n=2), in Phnom Penh visiting relative (n=1), in Phnom Penh (n=1), died three weeks ago (n=1) (total n=5).

[b] *Reasons for attrition in baseline 24HR sample (regarding child's mother)*: moved to Phnom Penh (n=52), moved to undisclosed location (n=43), moved to Thailand (n=42), moved to another village/district/province (n=11), denied to participate (n=17), dropped out of project (n=9), just delivered baby one month ago (n=1), empty house (n=1), in hospital (n=1), and brought child to hospital (n=1) (total n=178).

[c] *Reasons children surveyed with remaining FoF women did not complete endline 24HR*: reason not documented (n=2).

[d] *Reason child surveyed with sister of remaining FoF woman did not complete endline 24HR*: in Phnom Penh (n=1).

[e] *Reasons for attrition in remaining FoF participants (regarding child's mother)*: reasons not documented, however, based on the known reasons for attrition in the baseline 24HR sample, an estimated ~80% of participants emigrated.

4.1.2 **Participant characteristics**

Baseline sample characteristics of women and children, collected pre-intervention from the FoF baseline survey, are summarized below. There were no significant differences between intervention and control groups for both women and children, except for the proportion of households with treated water. Significantly more women in HFP group had treated water (71%) and there was a tendency for more women in the HFP plus aquaculture to have treated water (68%), compared to controls (53%).

Women in the intervention and control groups were similar in age, weight, height, MUAC, blood hemoglobin level, and estimated energy requirements. Most women had a normal/healthy BMI (18.5-24.9 kg/m^2), with similar rates of underweight (14-17%) and anemia (53-60%) in each group. Women in the intervention and control groups also had similar rates of pregnancy (6-7%) and had given birth to a mean of two children and attended school for a mean of four years. Regarding household characteristics, a similar mean number of people lived in each household (four people), including children less than five years of age (one child), in each group. While it appears that women in the HFP plus aquaculture group had a higher mean yearly income ($776 USD), compared to the HFP ($625 USD) and control ($565 USD) groups, there were no significant differences between groups; see **Table 4.1**.

Children in the intervention and control groups were similar in age, height/length, and weight. Gender was equally split, with a marginally lower proportion of female children in the three groups (44-49%). Hemoglobin levels were also similar across groups, with a fairly high proportion of children defined as having anemia (59-66%). MUAC measurements were also similar for each of the intervention and control groups, with no children having a MUAC that classified them as having Severe Acute Malnutrition (SAM). Children in the intervention and control groups had similar rates of moderate and severe underweight (25-29%), wasting (6-11%), and stunting (23-34%). Rates of severe underweight (1-6%) and stunting (3-8%) were very low in each of the three groups; see **Table 4.2**.

Table 4.1: Sample characteristics of women (n=450) from Prey Veng, Cambodia, participating in the Fish on Farms baseline survey.

	Control (n = 150)	HFP (n = 150)	HFP & aquaculture (n = 150)
	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)
Age (years)	30 (29, 31)	30 (29, 31)	29 (28, 30)
Height (cm) [i]	152 (151, 153)	153 (152, 154)	153 (152, 153)
Weight (kg) [i]	49 (48, 50)	50 (49, 51)	49 (48, 51)
BMI (kg/m^2)	21.2 (20.7, 21.7)	21.4 (20.9, 21.8)	21.2 (20.8, 21.6)
MUAC (cm) [i]	25.7 (25.2, 26.1)	25.8 (25.3, 26.2)	25.7 (25.3, 26.1)
Hemoglobin (g/L)	120 (118, 122)	122 (120, 124)	121 (119, 124)
Non-pregnant EER (kcal/d) [ii]	2130 (2109, 2151)	2156 (2138, 2174)	2149 (2130, 2169)
Parity	2 (2, 3)	2 (2, 3)	2 (2, 2)
Years of schooling	4 (3, 4)	4 (4, 5)	4 (4, 5)
People in household	5 (5, 5)	5 (4, 5)	5 (4, 5)
Children <5 y in household	1 (1, 1)	1 (1, 1)	1 (1, 1)
Total yearly income (USD)	565 (479, 650)	625 (516, 734)	776 (642, 910)
	Count (%)	Count (%)	Count (%)
Pregnant	10 (7)	10 (7)	9 (6)
Unsure if pregnant	0 (0)	1 (1)	1 (1)
Households with treated water	79 (53) [a]	107 (71) [b]	102 (68) [ab]
Underweight [iii]	26 (17)	22 (15)	21 (14)
Anemic [iv]	88 (59)	80 (53)	90 (60)

Notes: For continuous data, means (95% CI) are presented. For binary data, counts (%) are presented. When significant differences were found between groups, superscripts are used; different letters identify which groups differed significantly (p<0.05). Detailed results of significant comparison analyses are presented in **Table A-8.1** in **Appendix 8**. HFP: Homestead Food Production, BMI: Body Mass Index, MUAC: Mid-upper Arm Circumference, EER: Estimated Energy Requirement.

[i] Values are an average of two measures.

[ii] Non-pregnant EER was calculated from the IOM Dietary Reference Intakes (DRI) energy equations. Participants were assumed to be active (Physical Activity Coefficient [PA] = 1.27):

EER = 354 – (6.91 x age [y]) + PA x {9.36 x weight [kg]) + 726 x height [m])} (Health Canada, 2010).

[iii] Underweight is defined as a BMI <18.5 kg/m^2 (WHO, 2006b).

[iv] For non-pregnant women, anemia is defined as having a hemoglobin level of less than 120 g/L (WHO, 2011a).

Table 4.2: Sample characteristics of children (n=430) from Prey Veng, Cambodia, participating in the Fish on Farms baseline survey.

	Control (n = 145)	HFP (n = 145)	HFP & aquaculture (n = 140)
	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)
Age (months)	28 (25, 30)	28 (26, 31)	27 (25, 29)
Height/length (cm) [i]	83 (81, 85)	83 (82, 85)	82 (80, 84)
Weight (kg) [i]	10 (10, 11)	10 (10, 11)	10 (10, 11)
Hemoglobin (g/L)	106 (104, 109)	104 (102, 106)	104 (102, 106)
MUAC (cm) [i]	14.3 (14.1, 14.5)	14.4 (14.3, 14.5)	14.4 (14.3, 14.6)
Weight-for-age z-score	-1.51 (-1.68, -1.34)	-1.41 (-1.54, -1.27)	-1.37 (-1.51, -1.22)
Length/height-for-age z-score	-1.52 (-1.71, -1.33)	-1.42 (-1.57, -1.27)	-1.57 (-1.74, -1.41)
Weight-for-length z-score	-0.96 (-1.11, -0.80)	-0.89 (-1.02, -0.76)	-0.71 (-0.86 -0.56)
	Count (%)	Count (%)	Count (%)
Female children	64 (44)	65 (45)	69 (49)
Anemic [ii]	86 (59)	92 (63)	93 (66)
Moderate/severe underweight	41 (28)	42 (29)	35 (25)
Severe underweight	8 (6)	2 (1)	5 (4)
Moderate/severe stunting	45 (31)	34 (23)	47 (34)
Severe stunting	11 (8)	4 (3)	11 (8)
Moderate-severe wasting	16 (11)	12 (8)	9 (6)
SAM (MUAC <110 mm)	0 (0)	0 (0)	0 (0)

Notes: For continuous data, means (95% CI) are presented. For binary data, counts (%) are presented. Data collected from 20 children were incomplete and not included in the analysis. No significant differences (p<0.05) or tendencies to be significantly different (p<0.10) were found between groups. HFP: Homestead Food Production, BMI: Body Mass Index, MUAC: Mid-upper Arm Circumference, SAM: Severe Acute Malnutrition.

[i] Values are an average of two measures.

[ii] For children 6-59 months of age, anemia is defined as having a hemoglobin level of less than 110 g/L (WHO, 2011a).

4.2 Findings of 24-hour dietary recall data (Objective 1)

I will summarize baseline and endline 24HR data collected from women and children participating in the FoF project. I will also compare nutrient intakes across the intervention and control groups at baseline and endline. The primary nutrients of interest include protein, fat, iron, zinc, and vitamin A. However, I will also include summaries and analyses for energy, carbohydrate, calcium, water, thiamin, riboflavin, niacin, and vitamins B6 and B12.

4.2.1 Baseline 24-hour dietary recall summaries and comparison analyses

Among women participants at baseline, there were no significant differences in mean intakes of energy, carbohydrate, protein, iron, zinc, calcium, vitamin A, thiamin, riboflavin, niacin, and vitamins B6 and B12 across the intervention and control groups. Women in the HFP group had a significantly higher mean fat intake, compared to controls, and the HFP plus aquaculture group had a significantly higher mean water intake, compared to controls ($p<0.05$). The overall calorie intake (~1500 kcal/day) appears to be greatly underestimated, falling ~ 30% below the total estimated energy requirements (~2145 kcal/day). Water intake also appears to be unrealistically low for each of the three groups; see **Table 4.3**.

Among children, there were no significant differences in mean intakes of energy and all nutrients analyzed across the intervention and control groups. There were tendencies for children in the HFP plus aquaculture group to have higher mean intakes of zinc, calcium, and niacin, compared to controls, and a tendency for the HFP plus aquaculture group to have a higher vitamin A intake, compared to the HFP group ($p<0.10$); see **Table 4.4**. While there were no other significant differences (or tendencies to be different) among women and children, the intervention groups appear to have marginally higher intakes of most other nutrients, compared to controls at baseline.

Table 4.3: Baseline results from 24-hour dietary recalls collected from women between 18 and 50 years of age (n=450) in Prey Veng, Cambodia in each of the intervention and control groups.

	Control* (n =150)	HFP (n =150)	HFP & aquaculture** (n = 150)
	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)
Energy (kcal/d)	1424 (1322, 1527)	1524 (1420, 1628)	1547 (1448, 1646)
Carbohydrate (g/d)	244 (227, 262)	252 (234, 270)	263 (246, 280)
Protein (g/d)	60 (53, 66)	64 (58, 70)	61 (56, 67)
Fat (g/d)	21 (18, 24) [a]	27 (23, 30) [b]	26 (23, 29) [ab]
Iron (mg/d)	10.78 (9.53, 12.04)	10.48 (9.58, 11.37)	11.93 (10.50, 13.35)
Zinc (mg/d)	4.43 (3.95, 4.91)	4.14 (4.02, 4.81)	4.69 (4.23, 5.15)
Calcium (mg/d)	373 (279, 467)	306 (273, 338)	311 (267, 354)
Vitamin A (RAE/d)	434 (336, 533)	422 (346, 498)	503 (405, 601)
Thiamin (mg/d)	0.75 (0.65, 0.86)	0.83 (0.70, 0.95)	0.76 (0.66, 0.86)
Riboflavin (mg/d)	0.83 (0.73, 0.93)	0.86 (0.78, 0.94)	0.90 (0.77, 1.02)
Niacin (mg/d) [i]	13.29 (12.15, 14.42)	13.65 (12.55, 14.76)	13.72 (12.57, 14.87)
Vitamin B6 (mg/d)	1.16 (1.05, 1.27)	1.24 (1.14, 1.35)	1.31 (1.18, 1.43)
Vitamin B12 (mcg/d)	4.08 (3.35, 4.81)	4.61 (3.80, 5.42)	4.35 (3.71, 4.99)
Water (g/d)	438 (389, 487) [a]	504 (453, 554) [ab]	549 (492, 606) [b]

* One participant in the control group was 51 years of age.
** One participant in the HFP plus aquaculture group was 17 years of age.

Notes: Data are presented as the mean (95% CI). When significant differences were found between groups, superscripts are used; means with different letters are significantly different ($p<0.05$). Detailed results of comparison analyses are presented in **Table A-8.2** in **Appendix 8**. HFP: Homestead Food Production.

[i] Note that niacin (mg/d) is measured as preformed niacin.

Table 4.4: Baseline results from 24-hour dietary recalls collected from children between six months and five years of age (n=296) in Prey Veng, Cambodia in each of the intervention and control groups.

	Control (n = 102)	HFP (n = 99)	HFP & aquaculture (n = 95)
	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)
Energy (kcal/d)	820 (730, 910)	887 (789, 985)	903 (818, 989)
Carbohydrate (g/d)	138 (122, 154)	147 (129, 165)	143 (129, 157)
Protein (g/d)	26 (22, 30)	31 (26, 36)	33 (27, 38)
Fat (g/d)	18 (15, 21)	19 (16, 22)	22 (19, 25)
Iron (mg/d)	4.80 (4.00, 5.60)	5.02 (4.27, 5.77)	5.98 (4.86, 7.10)
Zinc (mg/d)	2.20 (1.95, 2.45)	2.52 (2.18, 2.86)	2.77 (2.42, 3.13)
Calcium (mg/d)	153 (135, 171)	178 (149, 208)	184 (161, 207)
Vitamin A (RAE/d)	365 (246, 484)	252 (209, 295)	441 (283, 599)
Thiamin (mg/d)	0.40 (0.33, 0.48)	0.46 (0.37, 0.54)	0.51 (0.42, 0.60)
Riboflavin (mg/d)	0.37 (0.32, 0.43)	0.43 (0.36, 0.50)	0.47 (0.39, 0.55)
Niacin (mg/d) [i]	5.76 (5.02, 6.51)	6.54 (5.66, 7.42)	6.60 (5.74, 7.46)
Vitamin B6 (mg/d)	0.54 (0.45, 0.64)	0.58 (0.49, 0.67)	0.64 (0.54, 0.74)
Vitamin B12 (mcg/d)	1.92 (1.40, 2.45)	2.34 (1.73, 2.95)	2.43 (1.79, 3.06)
Water (g/d)	574 (517, 631)	619 (549, 688)	602 (553, 650)

Notes: Data are presented as the mean (95% CI). No significant differences ($p<0.05$) were found between groups. Detailed results of comparison analyses are presented in **Table A-8.3** in **Appendix 8**. HFP: Homestead Food Production.

[i] Note that niacin (mg/d) is measured as preformed niacin.

4.2.2 **Endline 24-hour dietary recall summaries and comparison analyses**

Mean (95% CI) intakes at endline are summarized in **Table 4.5(a)** and **Table 4.6**. A GEE gamma regression model with log link was used to compare endline mean intakes across the intervention and control groups, adjusted for the effect of clustering and using a two-tailed alpha ($p<0.05$) and the Bonferroni correction for multiple comparisons. Note that this study was only powered to detect a significant difference in five key nutrients (protein, fat, iron, zinc, and vitamin A), and consequently, there is a risk of making Type I errors when interpreting results for energy and the remaining nutrients analyzed (carbohydrate, calcium, water, thiamin, riboflavin, niacin, and vitamins B6 and B12).

<u>HFP vs. control:</u>

Among women in the HFP group, mean intakes of zinc, vitamin A, and vitamin B6 were significantly higher, compared to controls ($p<0.05$), and there was a tendency to have a higher mean intake of niacin, compared to controls ($p<0.10$). Among children in the HFP group, there were no significant differences (or tendencies to be different) in mean intakes of energy and all nutrients analyzed, compared to controls.

<u>HFP plus aquaculture vs. control:</u>

Among women in the HFP plus aquaculture group, mean intakes of iron, vitamin A, and riboflavin were significantly higher, compared to controls ($p<0.05$), and there were tendencies to have higher mean intakes of zinc and vitamin B6, compared to controls ($p<0.10$). Among children in the HFP plus aquaculture group, there were no significant differences (or tendencies to be different) in mean intakes of energy and all nutrients analyzed, compared to controls.

HFP plus aquaculture vs. HFP:

Among both women and children, there were no significant differences (or tendencies to be different) between the HFP and HFP plus aquaculture groups in mean intakes of energy and all nutrients analyzed; see **Table 4.5(a), Table 4.5(b),** and **Table 4.6**.

Across groups, there were no significant differences in mean intakes of energy, carbohydrate, protein, fat, calcium, thiamin, vitamin B12, and water. As was observed at baseline for both women and children, the HFP and HFP plus aquaculture groups had marginally higher intakes of most nutrients, compared to the control group, which may be a product of marginally higher energy intakes. The overall calorie intake (~1725 kcal/day) appears to be underestimated, falling ~ 20% below the total estimated energy requirements (~2145 kcal/day).

Table 4.5(a): Endline summary results from 24-hour dietary recalls collected from women between 19 and 50 years of age (n=429) in Prey Veng, Cambodia after receiving 22-months intervention with HFP, HFP plus aquaculture, or control.

	Control* (n = 140)	HFP** (n = 146)	HFP & aquaculture (n = 143)
	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)
Energy (kcal/d)	1606 (1482, 1730)	1784 (1674, 1895)	1790 (1651, 1929)
Carbohydrate (g/d)	260 (240, 279)	290 (271, 308)	288 (263, 313)
Protein (g/d)	64 (58, 69)	68 (63, 72)	70 (64, 76)
Fat (g/d)	31 (26, 36)	35 (30, 39)	36 (32, 42)
Iron (mg/d)	13.24 (11.98, 14.50) [a]	15.16 (13.50, 16.81) [ab]	15.93 (14.22, 17.64) [b]
Zinc (mg/d)	5.33 (4.80, 5.85) [a]	6.31 (5.68, 6.93) [b]	6.24 (5.67, 6.82) [ab]
Calcium (mg/d)	401 (369, 434)	444 (411, 477)	449 (405, 493)
Vitamin A (RAE/d)	392 (330, 453) [a]	531 (446, 615) [b]	582 (425, 740) [b]
Thiamin (mg/d)	0.88 (0.78, 0.97)	0.96 (0.86, 1.05)	1.00 (0.89, 1.10)
Riboflavin (mg/d)	0.90 (0.80, 0.99) [a]	1.00 (0.89, 1.10) [ab]	1.07 (0.97, 1.18) [b]
Niacin (mg/d) [i]	14.67 (13.32, 16.01)	16.96 (15.39, 18.53)	16.60 (15.14, 18.07)
Vitamin B6 (mg/d)	1.37 (1.24, 1.50) [a]	1.69 (1.47, 1.92) [b]	1.59 (1.43, 1.75) [ab]
Vitamin B12 (mcg/d)	3.93 (3.27, 4.60)	4.35 (3.82, 4.88)	5.01 (3.71, 6.31)
Water (g/d)	3132 (2932, 3333)	3463 (3255, 3671)	3319 (3055, 3584)

* Three women in the control group were between 51 and 53 years of age.
** Two women in the HFP group were between 51 and 53 years of age.

Notes: Data are presented as the mean (95% CI). When significant differences were found between groups, superscripts are used; means with different letters are significantly different ($p<0.05$). Detailed results of comparison analyses are presented in **Table 4.5(b)**. HFP: Homestead Food Production.

[i] Note that niacin (mg/d) is measured as preformed niacin.

Table 4.5(b): Pairwise comparisons from endline 24-hour dietary recall results, collected from women between 19 and 50 years of age (n=429) in Prey Veng, Cambodia after receiving 22-months intervention with HFP, HFP plus aquaculture, or control.

	HFP** (n=146) - control* (n=134)		HFP & aquaculture (n=139) - control* (n=134)		HFP & aquaculture (n=139) - HFP** (n=146)	
	Mean difference in intake (95% CI)	Bonferroni adjusted p-value	Mean difference in intake (95% CI)	Bonferroni adjusted p- value	Mean difference in intake (95% CI)	Bonferroni adjusted p-value
Iron (mg/d)	1.92 (-0.64, 4.47)	0.22	2.69 (0.26, 5.12)	0.02	0.77 (-2.02, 3.57)	1.00
Zinc (mg/d)	0.98 (0.01, 1.95)	<0.05	0.92 (-0.11, 1.94)	<0.10	-0.06 (-1.08, 0.95)	1.00
Vitamin A (RAE/d)	139 (5, 273)	0.04	191 (9, 372)	0.04	52 (-153, 257)	1.00
Riboflavin (mg/d)	0.10 (-0.08, 0.28)	0.57	0.17 (0.02, 0.33)	0.03	0.07 (-0.09, 0.24)	0.86
Niacin (mg/d) [i]	2.29 (-0.15, 4.74)	0.08	1.94 (-0.41, 4.28)	0.14	-0.35 (-2.91, 2.20)	1.00
Vitamin B6 (mg/d)	0.32 (0.02, 0.63)	0.03	0.22 (-0.03, 0.46)	<0.10	-0.11 (-0.43, 0.22)	1.00

* Three women in the control group were between 51 and 53 years of age.
** Two women in the HFP group were between 51 and 53 years of age.

Notes: Data are presented as the mean difference in intake (95% CI). Differences between intervention and control groups were examined using a generalized estimating equations gamma regression model with log link, adjusted for the effect of clustering and using a two-tailed alpha (p<0.05) and the Bonferroni correction for multiple comparisons. Only significant differences or tendencies to be different (p<0.10) are displayed. No significant differences (or tendencies to be different) in mean intakes of energy, carbohydrate, protein, fat, calcium, thiamin, vitamin B12, or water were found among the intervention and control groups. HFP: Homestead Food Production.

[i] Note that analyses of niacin were based on intakes of preformed niacin.

Table 4.6: Endline results from 24-hour dietary recalls collected from children between 6 months and 7 years of age (n=421), after receiving 22-months intervention with HFP, HFP plus aquaculture, or control.

	Control (n = 135)	HFP (n = 144)	HFP & aquaculture (n = 142)
	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)
Energy (kcal/d)	991 (909, 1072)	1016 (945, 1087)	1090 (1010, 1170)
Carbohydrate (g/d)	166 (153, 179)	172 (160, 185)	186 (171, 201)
Protein (g/d)	31 (28, 34)	33 (30, 36)	33 (30, 36)
Fat (g/d)	22 (19, 25)	20 (18, 23)	23 (20, 25)
Iron (mg/d)	7.96 (7.06, 8.86)	8.70 (7.61, 9.78)	9.12 (8.01, 10.23)
Zinc (mg/d)	3.04 (2.76, 3.33)	3.33 (3.01, 3.66)	3.36 (3.05, 3.68)
Calcium (mg/d)	233 (207, 259)	244 (220, 267)	246 (220, 273)
Vitamin A (RAE/d)	271 (219, 322)	373 (282, 463)	331 (253, 410)
Thiamin (mg/d)	0.56 (0.49, 0.62)	0.64 (0.55, 0.74)	0.58 (0.50, 0.65)
Riboflavin (mg/d)	0.53 (0.46, 0.59)	0.62 (0.52, 0.71)	0.56 (0.49, 0.63)
Niacin (mg/d) [i]	7.74 (6.82, 8.65)	9.04 (7.69, 10.40)	8.61 (7.53, 9.69)
Vitamin B6 (mg/d)	0.82 (0.64, 1.01)	1.00 (0.71, 1.29)	0.93 (0.73, 1.13)
Vitamin B12 (mcg/d)	2.33 (1.61, 3.05)	2.29 (1.82, 2.76)	2.11 (1.65, 2.57)
Water (g/d)	1408 (1298, 1518)	1536 (1413, 1660)	1488 (1364, 1612)

Notes: Data are presented as the mean (95% CI). No significant differences ($p<0.05$) or tendencies to be significantly different ($p<0.10$) were found between the intervention and control groups. HFP: Homestead Food Production.

[i] Note that niacin (mg/d) is measured as preformed niacin.

4.3 Assessing prevalence of inadequate intakes (Objective 2)

The EAR cut-point method and probability approach were applied to assess prevalence of inadequate intakes among the intervention and control groups. To apply these methods, an estimate of the sample's usual intake distribution (between-person variation) was needed. Within-person variation (estimated from repeat 24HRs collected from a subset of participants) was removed with PC-SIDE adjustment (Iowa State University, 2015). Thirty-three percent of the study sample completed repeat 24HR on non-consecutive days of the week (control: n=46, HFP: n=50, and HFP plus aquaculture: n=43). Dr. Claire Smith, a research fellow from the University of Otago in New Zealand, completed PC-SIDE adjustment on the data used in this thesis.

All women were analyzed using the same EAR cut-points and iron requirement distribution percentiles, since they are the same for women aged 19-30 years and 31-50 years. Children were divided into three groups, those aged 6-12 months (n=23), 1-3 years (n=232), and 4-7 years (n=166), since the EARs (and iron requirement distribution percentiles) differ for these age categories. Data for children were then pooled together for subsequent analyses.

4.3.1 Prevalence of inadequate intake (summaries)

Notably, the overall percent of women with carbohydrate and protein intakes below the EAR was very low (0-1%) and the percent of women with calcium intakes below the EAR was very high (99-100%). The percent of women with niacin and vitamins B6 and B12 intakes below the EAR was also fairly low (≤20%). The percent of women with intakes below the EAR was moderately high (27-83%) for zinc, vitamin A, thiamin, and riboflavin. The average probability of inadequate iron intake among women was low (6-8%) using the IOM distribution percentiles (18% bioavailability), but was higher (up to 98%) when distribution percentiles for lower iron bioavailability were used (15%, 10%, and 5% bioavailability); see **Table 4.7**.

Similar to what was observed in women, the percent of children with carbohydrate, protein, and vitamins B6 and B12 intakes below the EAR was low (0-9%) and the percent of children with calcium intakes below the EAR was very high (98-100%). The percent of children with niacin intakes below the EAR was also fairly low (≤14%). The overall percent of children with intakes below the EAR was moderately high (21-53%) for zinc, vitamin A, thiamin, and riboflavin. Again, as was observed in women, the average probability of iron inadequacy among children was lower using the IOM distribution percentiles (9-12%), but was higher (up to 77%) when distribution percentiles for lower iron bioavailability were used (15%, 10%, and 5% bioavailability); see **Table 4.8**.

Table 4.7: Prevalence of inadequate nutrient intakes using EAR cut-points or the probability approach among women aged 19-50 years (n=429) in Prey Veng, Cambodia after receiving 22-months intervention with HFP, HFP plus aquaculture, or control.

	EAR (19-50 y)	Control* (n=134)	HFP** (n=146)	HFP & aquaculture (n=139)
		Count (%)	Count (%)	Count (%)
Carbohydrate	100 g	1 (1)	0 (0)	0 (0)
Protein	0.66 g/kg	1 (1)	1 (1)	1 (1)
Zinc	6.8 mg	111 (83)	106 (73)	105 (76)
Calcium	800 mg	134 (100)	146 (100)	138 (99)
Vitamin A	500 RAE	89 (66)	79 (54)	66 (47)
Thiamin	1.1 mg	73 (55)	64 (44)	58 (42)
Riboflavin	0.9 mg	59 (44)	48 (33)	38 (27)
Niacin [i]	14 mg (NE)	17 (13)	9 (6)	10 (7)
Vitamin B6	1.1 mg	27 (20)	11 (8)	18 (13)
Vitamin B12	2.0 mcg	9 (7)	4 (3)	11 (8)
		Mean percent (95% CI)	Mean percent (95% CI)	Mean percent (95% CI)
Iron (18% bioavailability)	8.1 mg	8 (6, 9)	6 (5, 8)	6 (5, 7)
Iron (15% bioavailability)		17 (15, 19)	15 (13, 16)	14 (12, 15)
Iron (10% bioavailability)		50 (46, 54)	45 (42, 49)	43 (40, 47)
Iron (5% bioavailability)		98 (97, 98)	96 (95, 97)	96 (94, 97)

* Three women in the control group were between 51 and 53 years of age.
** Two women in the HFP group were between 51 and 53 years of age.

Notes: Counts (%) of women with intakes below the EAR for carbohydrate, protein, zinc, calcium, and vitamin A, thiamin, riboflavin, niacin, and vitamins B6 and B12 are summarized for each intervention group. Since the distribution of iron requirements is non-symmetrical in this sample, the mean percent (95% CI) of women with inadequate iron intake is presented. The mean percent of inadequate iron intake was estimated using the IOM iron distribution percentiles (18% bioavailability) and adjusted distribution percentiles for diets with lower iron bioavailability (15%, 10%, and 5% bioavailability) (Gibson & Ferguson, 2008; Institute of Medicine, 2000b). HFP: Homestead Food Production, EAR: Estimated Average Requirement.

[i] Note that analyses of niacin were based on intakes of preformed niacin.

Table 4.8: Prevalence of inadequate nutrient intake using EAR cut-points or the probability approach among children aged 6-12 months (n=26), 1-3 years (n=232), and 4-7 years (n=163) in Prey Veng, Cambodia after receiving 22-months intervention with HFP or HFP plus aquaculture, compared to control (total n=421).

	EAR (6-12 m)	EAR (1-3 y)	EAR (4-8 y)	Control (n=135)*	HFP (n=144)*	HFP & aquaculture (n=142)*
				Count (%)	Count (%)	Count (%)
Carbohydrate	N/A	100 g/d	100 g/d	11 (9)	5 (4)	4 (3)
Protein**	1.0 g/kg/d	0.87 g/kg/d	0.76 g/kg/d	1 (1)	0 (0)	1 (1)
Zinc	2.5 mg/d	2.5 mg/d	4.1 mg/d	72 (53)	65 (45)	64 (45)
Calcium	N/A	500 mg/d	800 mg/d	128 (99)	134 (100)	131 (98)
Vitamin A	N/A	210 RAE/d	275 RAE/d	59 (45)	45 (34)	44 (33)
Thiamin	N/A	0.4 mg/d	0.5 mg/d	37 (29)	28 (21)	35 (26)
Riboflavin	N/A	0.4 mg/d	0.5 mg/d	40 (31)	31 (23)	30 (22)
Niacin [i]	N/A	5 mg/d (NE)	6 mg/d (NE)	18 (14)	9 (7)	15 (11)
Vitamin B6	N/A	0.4 mg/d	0.5 mg/d	7 (5)	5 (4)	8 (6)
Vitamin B12	N/A	0.7 mg/d	1.0 mg/d	2 (2)	1 (1)	5 (4)
				Mean percent (95% CI)	Mean percent (95% CI)	Mean percent (95% CI)
Iron (18% bioavailability)	6.9 mg/d	3.0 mg/d	4.1 mg	10 (7, 12)	12 (8, 15)	9 (6, 12)
Iron (15% bioavailability)				16 (12, 19)	17 (13, 21)	14 (11, 18)
Iron (10% bioavailability)				36 (32, 41)	36 (31, 40)	32 (28, 37)
Iron (5% bioavailability)				77 (74, 80)	74 (71, 78)	72 (68, 76)

* For nutrients where the EAR is not available for children aged 6-12 months, sample sizes for the intervention and control groups are as follows: control (n=130), HFP (n=134), and HFP plus aquaculture (n=134).
** Two participants in the control group were missing a measure for body weight, and consequently, the prevalence of inadequate protein intake could not be calculated, based on the EAR for protein in terms of g/kg/d (n=133 vs. n=135).

Notes: Counts (%) of children with intakes below the EAR for carbohydrate, protein, zinc, calcium, vitamin A, thiamin, riboflavin, niacin, and vitamins B6 and B12 are summarized for each intervention group. Since the distribution of iron requirements is non-symmetrical in this sample, the mean percent (95% CI) of children with inadequate iron intake is presented. The mean percent of inadequate iron intake was estimated using the IOM iron distribution percentiles (18% bioavailability) and adjusted distribution percentiles for diets with lower iron bioavailability (15%, 10%, and 5% bioavailability) (Gibson & Ferguson, 2008; Institute of Medicine, 2000b). Data were pooled from each age category (6-12 months, 1-3 years, and 4-7 years), using the age-specific EAR cut-points or iron distribution percentiles. HFP: Homestead Food Production, EAR: Estimated Average Requirement.

[i] Note that analyses of niacin were based on intakes of preformed niacin.

4.3.2 Comparing prevalence of inadequate intake (using the EAR cut-point method)

To compare the prevalence of inadequate intake across the intervention and control groups, the EAR cut-point method was applied to each suitable nutrient (i.e. has an EAR and a symmetrical requirement distribution), and the prevalence of inadequate intake was compared across the intervention and control groups.

HFP vs. control:

Among women in the HFP group, there was a significantly lower prevalence of inadequate vitamin B6 intake (mean difference=-13%; 95% CI -24, -2; p=0.02), compared to controls. There were also tendencies for women in the HFP group to have lower prevalence of inadequate zinc (mean difference=-10%; 95% CI -21, 1; p=0.09) and vitamin A (mean difference=-12%; 95% CI -26, 1; p=0.09) intakes, compared to controls. Among children in the HFP group, there were no significant differences (or tendencies to be different) in the prevalence of inadequate intake, compared to controls.

HFP plus aquaculture vs. control:

Among women in the HFP plus aquaculture group, there were significantly lower prevalence of inadequate vitamin A (mean difference=-19%; 95% CI -30, -7; p<0.01) and riboflavin (mean difference=-17%; 95% CI -30, -3; p=0.01) intakes, compared to controls. Among children in the HFP plus aquaculture group, there were no significant differences (or tendencies to be different) in the prevalence of inadequate intake, compared to controls.

HFP plus aquaculture vs. HFP:

Among both women and children, there were no significant differences in the prevalence of inadequate intake of all nutrients analyzed between the HFP and HFP plus aquaculture groups; see **Table 4.9** and **Table 4.10**.

Table 4.9: Comparisons between prevalence of inadequate nutrient intakes among women aged 19-50 years (n=419) in Prey Veng, Cambodia after receiving 22-months intervention with HFP, HFP plus aquaculture, or control.

	HFP** (n=146) - control* (n=134)		HFP & aquaculture (n=139) - control* (n=134)		HFP & aquaculture (n=139) - HFP** (n=146)	
	Percent difference (95% CI)	Bonferroni adjusted p-value	Percent difference (95% CI)	Bonferroni adjusted p-value	Percent difference (95% CI)	Bonferroni adjusted p-value
Protein	0 (-2, 2)	1.00	0 (-2, 2)	1.00	0 (-2, 2)	1.00
Zinc	-10 (-21, 1)	0.09	-7 (-19, 4)	0.40	3 (-9, 14)	1.00
Calcium [i]	N/A		N/A		N/A	
Vitamin A	-12 (-26, 1)	0.09	-19 (-30, -7)	<0.01	-7 (-19, 6)	0.63
Thiamin	-11 (-24, 3)	0.18	-13 (-27, 2)	0.10	-2 (-17, 13)	1.00
Riboflavin	-11 (-15, 3)	0.18	-17 (-30, -3)	0.01	-6 (-18, 6)	0.81
Niacin [ii]	-7 (-15, 2)	0.18	-5 (-14, 3)	0.39	1 (-5, 8)	1.00
Vitamin B6	-13 (-24, -2)	0.02	-7 (-19, 5)	0.43	5 (-3, 14)	0.34
Vitamin B12	-4 (-11, 3)	0.43	1 (-6, 9)	1.00	5 (-2, 12)	0.20
Iron (18% bioavailability)	-1 (-3, 1)	0.94	-2 (-4, 1)	0.07	-1 (-3, 1)	0.69
Iron (15% bioavailability)	-2 (-5, 1)	0.27	-3 (-6, >0)	0.07	-1 (-4, 2)	1.00
Iron (10% bioavailability)	-5 (-11, 1)	0.14	-7 (-13, -1)	0.02	-2 (-7, 4)	1.00
Iron (5% bioavailability)	-1 (-3, >0)	0.15	-2 (-3, <0)	0.02	-1 (-2, 1)	1.00

* Three women in the control group were between 51 and 53 years of age.
** Two women in the HFP group were between 51 and 53 years of age.

Notes: The mean difference in percent of inadequate intake (95% CI) for protein, zinc, vitamin A, thiamin, riboflavin, niacin, vitamins B6 and B12, and iron are presented for each comparison between intervention and control groups. For each nutrient except iron, the EAR cut-point method was applied and the mean difference in percent of inadequate intake was calculated using a generalized estimating equations binary logistic regression model, adjusted for the effect of clustering and using a two-tailed alpha ($p<0.05$) and the Bonferroni correction for multiple comparisons. For iron, the full probability approach was applied and the mean difference in percent of inadequate iron intake was calculated using a generalized estimating equations gamma regression model with log link, adjusted for the effect of clustering and using a two-tailed alpha ($p<0.05$) and the Bonferroni correction for multiple comparisons. The mean differences in percent of inadequate iron intake are presented for iron of varying bioavailability levels, determined from distribution percentiles for iron from the Institute of Medicine (2000b) and adjusted distribution percentiles from Gibson & Ferguson (2008). Note that usual intake distributions of the study sample were used, estimated from repeat 24-hour dietary recalls and PC-SIDE statistical adjustment (Iowa State University, 2015). HFP: Homestead Food Production.

[i] Only one subject had a calcium intake above the EAR for calcium.

[ii] Note that analyses of niacin were based on intakes of preformed niacin.

Table 4.10: Comparisons between prevalence of inadequate nutrient intakes among children aged 6-12 months (n=26), 1-3 years (n=232), and 4-7 years (n=163) in Prey Veng, Cambodia after receiving 22-months intervention with HFP or HFP plus aquaculture, compared to control (total n=421).

	HFP (n=144) - control (n=135)*		HFP & aquaculture (n=142) - control (n=135)*		HFP & aquaculture (n=142) - HFP (n=144)*	
	Percent difference (95% CI)	Bonferroni adjusted p-value	Percent difference (95% CI)	Bonferroni adjusted p-value	Percent difference (95% CI)	Bonferroni adjusted p-value
Carbohydrate	-5 (-12, 3)	0.40	-5 (-13, 2)	0.23	-1 (-6, 4)	1.00
Protein [i]	N/A		N/A		N/A	
Zinc	-8 (-24, 7)	0.61	-8 (-23, 7)	0.58	0 (-14, 13)	1.00
Calcium [i]	N/A		N/A		N/A	
Vitamin A	-12 (-29, 6)	0.31	-13 (-27, 2)	0.12	-1 (-16, 15)	1.00
Thiamin	-8 (-20, 5)	0.41	-2 (-17, 12)	1.00	5 (-9, 19)	1.00
Riboflavin	-8 (-22, 7)	0.60	-8 (-23, 6)	0.47	-1 (-14, 13)	1.00
Niacin [ii]	-7 (-16, 2)	0.20	-3 (-13, 8)	1.00	4 (-4, 13)	0.64
Vitamin B6	-2 (-8, 4)	1.00	1 (-6, 7)	1.00	2 (-3, 8)	1.00
Vitamin B12	-1 (-4, 2)	1.00	2 (-2, 7)	0.70	3 (-1, 7)	0.23
Iron (18% bioavailability)	6 (-3, 15)	0.37	0 (-8, 7)	1.00	-6 (-16, 3)	0.35
Iron (15% bioavailability)	4 (-5, 13)	0.84	1 (-6, 8)	1.00	-3 (-11, 5)	1.00
Iron (10% bioavailability)	1 (-7, 9)	1.00	-1 (-9, 7)	1.00	-2 (-10, 6)	1.00
Iron (5% bioavailability)	-3 (-9, 3)	0.84	-5 (-12, 2)	0.26	-2 (-9, 4)	1.00

* For nutrients where the EAR is not available for children aged 6-12 months (carbohydrate, calcium, vitamin A, thiamin, riboflavin, niacin, vitamin B6, and vitamin B12), sample sizes are as follows: control (n=130), HFP (n=134), and HFP plus aquaculture (n=134).

Notes: The mean difference in percent of inadequate intake (95% CI) for carbohydrate, zinc, vitamin A, thiamin, riboflavin, niacin, vitamins B6 and B12, and iron are presented for each comparison between intervention and control groups. For each nutrient except iron, the EAR cut-point method was applied and the mean difference in probability of inadequate intake was calculated using a generalized estimating equations binary logistic regression model, adjusted for the effect of clustering and using a two-tailed alpha ($p<0.05$) and the Bonferroni correction for multiple comparisons. For iron, the full probability approach was applied and the mean difference in percent of inadequate iron intake was calculated using a generalized estimating equations gamma regression model with log link, adjusted for the effect of clustering and using a two-tailed alpha ($p<0.05$) and the Bonferroni correction for multiple comparisons. The mean differences in the percent of inadequate iron intake are presented for iron of varying bioavailability levels, determined from distribution percentiles for iron from the Institute of Medicine (2000b) and adjusted distribution percentiles from Gibson & Ferguson (2008). Note that usual intake distributions of the study sample were used, estimated from repeat 24-hour dietary recalls and PC-SIDE statistical adjustment (Iowa State University, 2015). Analyses were completed on pooled data, from each age category (6-12 months, 1-3 years, and 4-7 years).
HFP: Homestead Food Production.

[i] Very few (2-5) subjects had protein intakes below the EAR and calcium intakes above the EAR.

[i] Note that analyses of niacin were based on intakes of preformed niacin.

4.3.3 **Comparing prevalence of inadequate iron intake (using the probability approach)**

To compare the prevalence of inadequate iron intake across the intervention and control groups, the full probability approach was applied. Estimated usual intakes were compared against iron requirement distribution percentiles and the probabilities of inadequate intakes were averaged and compared across groups.

<u>HFP vs. control:</u>

Among women and children in the HFP group, there were no significant differences (or tendencies to be different) in the prevalence of inadequate iron intake (at each bioavailability level), compared to controls.

<u>HFP plus aquaculture vs. control:</u>

Among women in the HFP plus aquaculture group, there was a significantly lower prevalence of inadequate iron at the 10% bioavailability level (mean difference=-7%; 95% CI -13, -1; p=0.02) and the 5% bioavailability level (mean difference=-2%; 95% CI -3, <0; p=0.02), compared to controls. There was a tendency among women in the HFP plus aquaculture group to have a lower prevalence of inadequate iron intake at the 18% bioavailability level (mean difference=-2%; 95% CI -4, 1; p<0.07) and the 15% bioavailability level (mean difference=-3%; 95% CI -6, >0; p=0.07), compared to controls. Among children in the HFP plus aquaculture group, there were no significant differences (or tendencies to be different) in the prevalence of inadequate iron intake (at each bioavailability level), compared to controls.

<u>HFP plus aquaculture vs. HFP:</u>

Among both women and children, there were no significant differences in the prevalence of inadequate iron intake (at each bioavailability level) between the HFP and HFP plus aquaculture groups; see **Table 4.9** and **Table 4.10**.

4.4 **Intra-rater reliability**

Intra-rater reliability testing results are presented in **Table 4.11**. Among the nutrients tested for the re-entered 24HRs and recipes, intraclass correlations were very high (over 90% for almost all nutrients) ($p<0.001$); see **Table 4.11**.

Table 4.11: Intra-rater reliability testing using duplicate entries of 24HR and recipe data from 22 women and children participants of the Fish on Farms project in Prey Veng, Cambodia.

	Women (n=22) Intraclass correlation (p-value)	Children (n=22) Intraclass correlation (p-value)	Recipes (n=44)* Intraclass correlation (p-value)
Energy (kcal)	0.98 (p=<0.001)	0.95 (p=<0.001)	1.00 (p=<0.001)
Carbohydrate (g)	0.98 (p=<0.001)	0.96 (p=<0.001)	1.00 (p=<0.001)
Protein (g)	0.96 (p=<0.001)	0.96 (p=<0.001)	1.00 (p=<0.001)
Fat (g)	0.99 (p=<0.001)	0.96 (p=<0.001)	1.00 (p=<0.001)
Iron (mg)	0.95 (p=<0.001)	0.99 (p=<0.001)	0.98 (p=<0.001)
Zinc (mg)	0.99 (p=<0.001)	0.98 (p=<0.001)	1.00 (p=<0.001)
Calcium (mg)	0.97 (p=<0.001)	0.97 (p=<0.001)	1.00 (p=<0.001)
Vitamin A (RAE)	0.99 (p=<0.001)	0.95 (p=<0.001)	1.00 (p=<0.001)
Thiamin (mg)	0.97 (p=<0.001)	1.00 (p=<0.001)	0.84 (p=<0.001)
Riboflavin (mg)	0.96 (p=<0.001)	0.99 (p=<0.001)	1.00 (p=<0.001)
Niacin (mg)	0.98 (p=<0.001)	0.96 (p=<0.001)	1.00 (p=<0.001)
Vitamin B6 (mg)	0.99 (p=<0.001)	0.99 (p=<0.001)	0.99 (p=<0.001)
Vitamin B12 (mcg)	0.98 (p=<0.001)	0.86 (p=<0.001)	1.00 (p=<0.001)
Water (g)	1.00 (p=<0.001)	0.99 (p=<0.001)	0.99 (p=<0.001)
Median (Range)	0.98 (0.95 – 1.00)	0.97 (0.86 – 1.00)	0.99 (0.84 – 1.00)

* A total of 44 recipes were tested, but were obtained from a total of 22 woman-child participant pairs, with 1-3 recipes provided per participant pair.

Notes: Intraclass correlation coefficients are presented for duplicate analyses of 24HR and recipe data, collected from 22 women and 22 children (5% of the total sample). Duplicate 24HRs and recipes were re-entered into the ESHA Food Processor program by the same person who entered the original 24HRs and recipes (one coder entered the original and duplicate 24HRs and another coder entered the original and duplicate recipes). Bivariate reliability analysis was completed for each nutrient of interest, between the original 24HR/recipe and the duplicate 24HR/recipe, with a two-tailed alpha ($p<0.05$).

Chapter 5: **Discussion**

5.1 Overview of discussion

Undernutrition is a major problem in Cambodia, with an estimated 15.4% of the population not meeting dietary requirements (FAO, 2014). The FoF project was designed to improve the economic and nutrition status of women and their children in Prey Veng, Cambodia through implementation of HFP with or without aquaculture. My research focused on assessing whether a difference in dietary intake or prevalence of inadequate intake was observed across the intervention and control groups. Given that the Cambodian diet appears to be low or borderline in fat and protein intake (FAOSTAT, 2014), and likely deficient in iron, zinc, and vitamin A (Anderson, Jack, et al., 2008; Bhutta et al., 2004; Gibson & Cavalli-Sforza, 2012), my research looked specifically at these nutrients. This is the first study to directly assess dietary intake following intervention with HFP with or without aquaculture in Cambodia. In the following sections, I will review my salient research findings, highlight the strengths and limitations of my research project, and outline some considerations for future research.

5.2 Overall findings

Baseline comparisons of sample characteristics and nutrient intakes among women and children participants revealed that the intervention and control groups were similar pre-intervention. Following intervention, significantly higher intakes of zinc and vitamin A were observed among women in the HFP group, compared to controls, and higher intakes of iron and vitamin A were observed in the HFP plus aquaculture group, compared to controls. Significantly lower prevalence of inadequate vitamin A and iron (10% and 5% bioavailability) intakes were observed among women in the HFP plus aquaculture group, compared to controls. Among children, no significant differences in nutrient intakes or prevalence of inadequate intakes were observed. No significant differences in nutrient intakes or prevalence of inadequate intakes were observed between the HFP and HFP plus aquaculture groups. This latter finding indicates that no additional benefit was observed when aquaculture was included with HFP. The following sections will discuss these findings in more detail.

5.3 Baseline observations

Notably high rates of attrition were observed from baseline to endline, primarily due to emigration. Only 62% of women and their children from baseline were surveyed again at endline (266/429 = 62% women and 261/421 = 62% children). Since a large proportion of women moved out of Prey Veng province, future research could examine the impact of emigration on the health and nutrition status of women and their children.

At baseline, women and children in each intervention group shared similar anthropometric, biochemical, and household characteristics. One exception is that significantly more women in the HFP group had treated water, compared to controls (mean percent difference=19; 95% CI: 2, 35; p=0.02), which could be expected to reduce rates of illness and may also affect health outcomes. However, no significant differences in anemia and underweight were observed in women, and no significant differences in anemia, underweight, stunting, and wasting were observed in children, when comparing the intervention and control groups.

Baseline characteristics compare to what was found in the 2010 Cambodia Demographic and Health Survey: 20% of rural Cambodian women were underweight and 47% were anemic (National Institute of Statistics et al., 2011), compared with an overall average of 15% underweight and 57% anemia in the FoF study. Among children under five years of age, 28% were underweight, 40% were stunted, 11% were wasted, and 57% were anemic in 2010

(National Institute of Statistics et al., 2011), compared with an overall average of 27% underweight, 29% stunting, 8% wasting, and 63% anemia in the FoF study.

Among the nutrients of interest (protein, fat, iron, zinc, and vitamin A), fat intake was significantly higher among women in the HFP group at baseline, compared to controls (mean difference: 5.7 g/d; 95% CI: 0.1, 11.2; p=0.04). However, recall that according to the CONSORT (2010) statements for reporting on randomized control trials, any significant differences observed at baseline are likely due to chance rather than bias. No other significant differences in the intakes of the nutrients of interest were observed across the intervention and control groups at baseline, among both women and children.

5.4 **Endline observations**

To assess the effect of HFP with or without aquaculture on dietary intake, the nutrients of interest included protein, fat, iron, zinc, and vitamin A. However, energy, calcium, water, thiamin, riboflavin, niacin, and vitamins B6 and B12 were also included in the results. Given that this study was not powered to statistically interpret all nutrients analyzed, I will focus the following discussion on the primary nutrients of interest, to reduce the risk of making a Type 1 error (finding a significant result when none exists).

5.4.1 **Comparison of nutrient intakes between groups**

Among the nutrients of interest, my research showed that, compared to women controls, vitamin A intakes were significantly higher in both the HFP (mean difference=139 RAE; 95% CI: 5, 273; p=0.04) and HFP plus aquaculture groups (mean difference=191 RAE; 95% CI: 9, 372; p=0.04), zinc intakes were significantly higher in the HFP group (mean difference=1.0 mg; 95% CI: >0, 2.0; p<0.05), and iron intakes were significantly higher in the HFP plus aquaculture group (mean difference=2.7 mg; 95% CI: 0.3, 5.1; p=0.02). While the difference in zinc intake was small, mean intakes were below the EAR (6.8 mg/d), and consequently, the observed difference in zinc intake may be considered valuable, as it helps move the sample mean towards intake recommendations. The difference in iron intake was similarly small; however, mean iron intakes were well above the EAR (8.1 mg/d), and consequently, higher iron intakes would not provide additional benefit, unless iron bioavailability is particularly low in this study sample. The differences in vitamin A were more notable (larger in magnitude) and also moved sample means above the EAR (500 RAE/d) in the intervention groups, compared to controls, which is a desirable outcome. Whether or not these differences are clinically significant, remains to be determined. Biochemical measures or other clinical indicators would provide evidence for whether these differences in intakes have a meaningful impact.

In comparison, a research project that introduced orange sweet potato production in rural Mozambique observed an increase in mean vitamin A intake after a three-year intervention period, compared to a control group, among women (adjusted mean difference=221 RAE; SE=96; $p<0.01$) and children aged 6-35 months (adjusted mean difference=261 RAE; SE=49; $p<0.01$) (Hotz et al., 2012). In a Malawian research project designed to increase production and consumption of agricultural products and flesh foods, including whole dried fish, children aged 3-7 years consumed significantly higher median zinc in the intervention group (median=6.6 mg; IQR 5.1-8.7), compared to controls (median=6.0 mg; IQR 4.5-7.3), $p=0.04$ (Yeudall, Gibson, Cullinan, & Mtimuni, 2005). The magnitude of these differences is comparable to the differences observed in my research project. However, in both my research project and these studies, it is unclear whether or not the differences in intake are clinically significant, without an assessment of biochemical or other clinical indicators of vitamin A and zinc status. Future research should examine what magnitude of difference in dietary intake of vitamin A and zinc translates to improved biochemical and/or clinical outcomes, following intervention with HFP with and without aquaculture in Cambodia.

In contrast to their mothers, no significant differences in mean iron, zinc, or vitamin A intakes were observed among children in the intervention and control groups of the this study. It is unclear why micronutrient intakes of children did not mimic their mothers, when comparing intervention and control groups. Perhaps children are fed more processed snack foods than is consumed by their mothers (as was anecdotally observed during data collection and data entry), and consequently, less likely to increase their intake of produce or fish (sources of micronutrients) from HFP or aquaculture. For example, among children aged 6-23 months in urban Cambodia, 56% (n=125) consumed a snack food the day before and 82% (n=182) consumed a snack food in the last week (Pries et al., 2015). In another study assessing toddler feeding practices of women living in urban Cambodia, vegetables and animal-source foods were scarce (Anderson, Cornwall, et al., 2008). Future research is needed to assess dietary intake habits of children in rural Cambodia and the relationship between maternal and child dietary intakes in this context.

No significant differences in mean protein and fat intakes were observed among both women and children. Interestingly, results from this research reveal proportionately higher protein and fat intakes when compared to Cambodian food availability and energy distribution data. At endline, women consumed ~15% of calories as protein and ~ 18% of calories as fat, versus 10.5% of calories as protein and 12.6% of calories as fat, as reported by the Cambodian FAO food balance sheets (FAOSTAT, 2014). While proportionately more calories were consumed as fat and protein, compared to national data, fat intakes among women at endline remained below the AMDR (20-35% of calories as fat), and protein intakes remained within the

AMDR (10-35% of calories as protein) (Institute of Medicine, 2005). Similarly, children consumed ~13% of energy as protein and ~19% of energy as fat, with fat intakes below the AMDR (30-40% of calories as fat for 1-3 year olds and 25-35% for 4-18 year olds) and protein intakes within the AMDR (5-20% of calories as protein for 1-3 year olds and 10-30% for 4-18 year olds). Future research should elucidate whether poor fat intake is a problem among rural Cambodian women and children and whether future intervention is needed to improve intake. In addition, assessing the effect of aquaculture at different times of the year would provide valuable evidence regarding the impact of aquaculture on protein and fat intakes (described in more detail in the paragraph below).

Among both women and children, no significant differences were observed between the HFP and HFP plus aquaculture groups. While this finding suggests that there was no additional benefit of aquaculture on dietary intakes of the nutrients assessed in this project, the data does not capture the average yearly consumption of fish from aquaculture production. Fish production from aquaculture was presumably at its lowest during endline 24HR data collection, since it occurred at the end of the dry season and after most fishponds had been harvested. Seventy percent of participants in the HFP plus aquaculture group reported that they had harvested their fishponds at the time of endline data collection (data not presented, but available upon request). Consequently, future research should plan to collect 24HR data throughout the year, to measure seasonal fluctuations in fish (as well as produce) production and consumption.

5.4.2 **Comparison of prevalence of inadequate nutrient intakes between groups**

When comparing the prevalence of inadequate intake among women in the HFP group, there were no significant differences, compared to the control group, but there was a tendency for lower prevalence of inadequate zinc (mean difference=-10%; 95% CI -21, 1; $p<0.10$) and vitamin A (mean difference=-12; 95% CI -26, 1; p<0.10) intakes. Given the fairly wide confidence intervals, a larger sample size may have produced significant results. Women in the HFP plus aquaculture group had significantly lower prevalence of inadequate vitamin A (mean difference=-19%; 95% CI -30, -7; p<0.01), 10% bioavailable iron (mean difference=-7%; 95% CI -13, -1; p=0.02), and 5% bioavailable iron (mean difference=-2%; 95% CI -3, <0; p=0.02) intakes, compared to controls. While there were tendencies for women in the HFP plus aquaculture group to have lower prevalence of inadequate iron intake at the 18% and 15% iron bioavailability levels as well, the overall prevalence of inadequate iron intake at these levels was low, ranging from 6% to 17%. While the bioavailability of iron is estimated to range between 5% and 10% in Southeast Asian countries, according to the International Life Sciences Institute (2005), the lack of Cambodian food composition data makes it difficult to estimate iron bioavailability in the Cambodian diet, which also makes it difficult to determine the prevalence of inadequate iron intake in this study sample. Future research is needed to assess food composition of Cambodian foods and evaluate the bioavailability of iron in the rural Cambodian diet. Furthermore, the tendency to under- or over-report dietary intake is largely unknown in Cambodia and future research is needed. Given that energy intake at endline was underestimated by ~20%, the absolute values for the prevalence of inadequate intakes are likely to be overestimates of actual values and should be considered carefully.

While the differences in prevalence of inadequate intakes were small (for vitamin A and iron), the differences observed have the potential to be clinically significant, given that a higher proportion of women in the two intervention groups are consuming adequate intakes of vitamin A, zinc, and/or iron, compared to controls. Since the EARs are based on requirements for growth, prevention of illness, and/or maintenance of adequate nutrient stores, reducing the prevalence of inadequate intakes could be expected to reduce the prevalence of nutrient-specific illnesses and/or poor growth (Institute of Medicine, 2000a). However, data on these outcomes would confirm whether or not reductions in the prevalence of inadequate intakes translate to meaningful improvements in health. In comparison to the study in rural Mozambique, the prevalence of inadequate vitamin A intake significantly decreased among women receiving three years intervention with orange sweet potato by ~35% and ~60% (in two groups receiving more or less support in the final two years of intervention, respectively[13]), $p<0.05$ (Hotz et al., 2012). As was also noted by the authors of that study, biochemical and clinical data are needed to explore the impact of increased intake or reduced prevalence of inadequate intake on health.

Among children, there were no significant differences in the prevalence of inadequate protein, iron, zinc, or vitamin A intakes across intervention and control groups. Confidence intervals for the mean differences in prevalence of inadequate nutrient intakes were fairly wide (particularly for zinc and vitamin A) and consequently, a larger sample size may have produced significant results.

While no differences in the prevalence of inadequate protein intake were observed across the intervention and control groups among both women and children, it is interesting to note that the prevalence of inadequate protein intake was very low (0-1%). Consistent with what was observed regarding mean protein intakes (which fell within the AMDRs for both women and children), protein intake and prevalence of inadequate protein intake does not seem to be a major concern among the research sample. Another interesting observation is that the overall

[13] Note that providing more support in the Mozambique study (to improve intakes of orange sweet potato) did not provide any additional benefit, but rather, the group receiving less support were observed to have a lower prevalence of inadequate vitamin A intake at follow up (Hotz et al., 2012).

prevalence of inadequate zinc among women (ranging from 73-83%) and children (ranging from 45-53%) was high, and highlights the importance of continuing to investigate and focus on improving zinc intakes in the research sample. Furthermore, no significant differences in prevalence of inadequate intakes were observed between the HFP and HFP plus aquaculture groups among both women and children.

These results show that women participants who received intervention with HFP had significantly higher vitamin A and zinc intakes, compared to controls. Women who received intervention with HFP plus aquaculture had significantly higher vitamin A and iron intakes, and lower prevalence of inadequate vitamin A and iron intakes, compared to controls. However, whether the differences observed are clinically significant remains to be established. Again, no additional benefit was observed among participants receiving HFP plus aquaculture versus HFP alone, and no differences in intakes or prevalence of inadequate intakes were observed among children.

5.4.3 **Additional findings**

While not included in my research objectives, calcium, thiamin, and riboflavin intakes were observed to be poor. There was a high prevalence of inadequate calcium intake among both women and children (≥98%). There was also a moderately high prevalence of inadequate intake for thiamin and riboflavin among women (~47% and ~35%, respectively) and children (~25% for both thiamin and riboflavin). These findings are consistent with what was observed by Gibson & Cavalli-Sforza (2012), suggesting that the Cambodian diet is likely deficient in calcium, thiamin, and riboflavin (as well as iron, zinc, and vitamin A). One benefit of intervention with aquaculture is that consumption of whole small fish (with the bones) is a good source of calcium, thiamin, and riboflavin, as well as protein, fat, iron, zinc, and vitamin A. The recommendation of consuming whole small fish in Cambodia and other developing countries has been supported by previous research. For instance, Roos et al. (2003) found that consumption of small indigenous fish in Bangladesh contributed 300 mg of calcium/person/day during peak fish season. In the study by Roos, Thorseng, et al. (2007), consumption of whole small fish (specifically, the *E. longimanus* species) in a single serving of traditional sour soup provided up to 45% of a woman's daily iron requirements. Research regarding the impact of fish on thiamin and riboflavin intakes is limited. Future research should continue to investigate the prevalence of inadequate intakes of these nutrients in the Cambodian diet.

5.5 Strengths and limitations

There are a number of limitations that need to be considered when interpreting the results of the current study. In consideration of the FoF study design, the choice of cluster randomization reduces the overall power of the study, however, a large sample size was used to account for this. Furthermore, to account for the potential similarity among participants in each cluster, the statistical analyses used in my study adjusted for this effect. Another source of bias inherent in the FoF study design is the purposeful selection of study participants. However, the findings of my research may be applied to similar groups of women (poor, rural women farmers in Cambodia, with at least one child under age five). The clinical significance of my findings remains to be established. Additional research on biochemical indicators or clinical outcomes (i.e. longitudinal measures of stunting or illness) following intervention with HFP with and without aquaculture is needed.

A major strength of this research is that a multiple-pass 24HR method was used, which has been shown to reduce the tendency to underestimate dietary intakes when compared with other dietary assessment methods (i.e. 24-VASQ or food frequency questionnaire). However, challenges with recall, potential bias from under- or over-weight individuals, or a mother's bias when reporting a child's intake (from wanting to believe or portray that their child is eating well) may have affected precision of the 24HR data. At baseline, the energy intakes of women appeared to be underestimated using the 24-VASQ method by approximately 30%, versus approximately 20% using the multiple-pass 24HR method at endline. While both methods appear to produce underestimates, the multiple-pass 24HR method appears to have improved accuracy. It is important to note that underestimated intakes may have lead to overestimates in the absolute prevalence of inadequacy.

While the 24-VASQ method is a type of 24-hour recall, developed to quantify vitamin A intake, the method was considered to differ substantially from the 24HR method used at endline. Consequently, a comparison of dietary intake over time (over the FoF intervention period) was not completed. Furthermore, controlling for baseline differences in endline statistical analyses would have produced more robust data. However, this was not done in my study due to the high rates of attrition at baseline. A large proportion of the sample at endline (38%) was composed of other women participating in the FoF project, but who did not complete a 24HR at baseline. Considering the marginally (though insignificantly) higher intakes of most nutrients in the intervention groups, compared to the control group, inclusion of these data would have attenuated the significant differences observed at endline.

During data collection, the forms and protocols developed for interviewers and field supervisors helped to enhance the reliability of 24HR data. The presence of field supervisors also provided an additional check on the accuracy and consistency of the data collected. The use of a household measures kit also helped participants estimate portion sizes. Alternatively, using real food replicas, graduated food photographs, and/or weighing prepared foods would have likely produced more accurate portion size estimates. Another limitation regarding portion size estimation relates to how food measures were calculated; rather than using known volume/weight ratios for each food (for calculating weight equivalents for standardized household measures), each food was measured once for each household measure, a likely source of error. Since this work was completed at the start of the FoF study (before my research project commenced), there were not enough resources to develop more accurate food weight measures. Despite these shortcomings, the potential errors are systematic errors and likely to average out among the intervention and control groups, and not likely to affect comparisons across intervention and control groups.

Analyzing the Cambodian diet was also a major challenge, since Cambodian food composition data were rarely available or incomplete. To deal with this challenge, food composition data from nearby Asian countries were used and missing nutrient values were imputed from USDA data. For foods with no known nutritional information, similar foods were used as a substitute. For foods that did not have English translations, or to address suspected errors made during translation (e.g. a portion of meat listed as 500 g was translated in error from 50 g), I obtained guidance and clarification from HKI staff in Cambodia through email correspondence. The development of a Cambodian food composition database would greatly enhance future dietary assessment studies in Cambodia. While not included in my research objectives, niacin intakes were also assessed, and it is important to note that food composition data used in this research primarily consisted of preformed niacin (rather than mg NE, which includes niacin derived from the conversion of tryptophan). Consequently, when looking at niacin intakes in the results, values are underestimated. Since the EAR for niacin is based on mg NE, the prevalence of inadequate niacin intake is similarly overestimated.

Another crucial limitation of my research is that 24HR data was collected at one time point only. The National Research Council (1986) recommends collecting 24HR data across seasons and on weekdays and weekend days to account for seasonal and weekly variations in intake. While the seasonal effect is worth addressing, big differences between weekdays and weekend days are not likely, given the rural environment and daily work schedule. Endline 24HR data were collected at the end of the dry season (May 26 – June 10, 2014), when most fishponds had been harvested. Fish from the rice paddies tend to be collected during the wet season and fishponds are re-stocked once water levels rise again. Consequently, fish intake is likely to vary throughout the year, sourced from both aquaculture and/or rice paddies. Future research should consider this seasonal effect on fish production and consumption, as well as on produce production and consumption, which is also likely to vary with the seasons.

5.6 Future directions

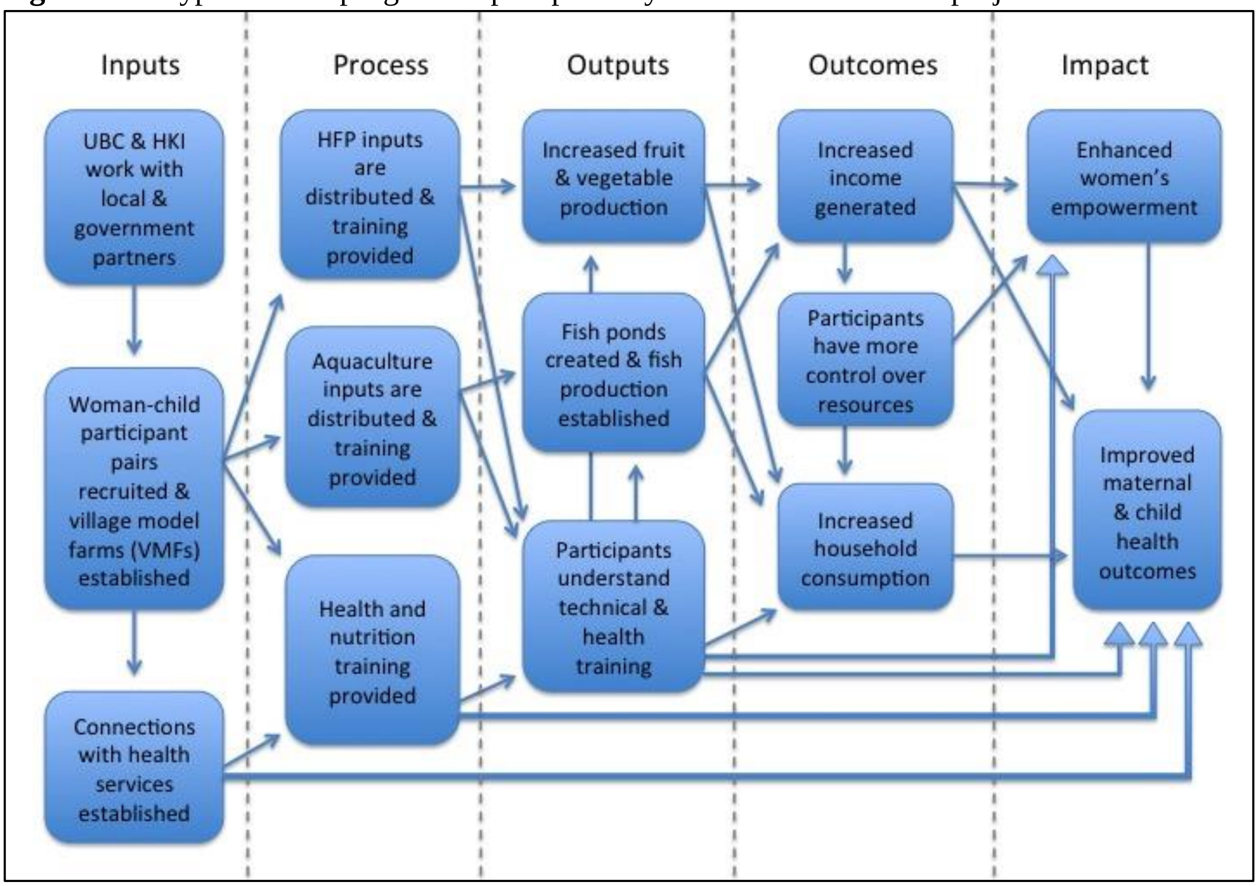
There are a number of ways to improve future nutrition assessment research in Cambodia. First, future research should include ongoing or periodic dietary assessment to assess the effect of HFP and aquaculture on dietary intake throughout the wet and dry seasons in Cambodia, using a multiple-pass 24HR method or other validated dietary assessment method. Second, the analysis of local Cambodian foods and the development of a Cambodian food database would help future researchers conduct dietary research in Cambodia. Third, ongoing measurement of biochemical measures and/or other health outcomes/indicators (i.e. underweight, stunting, and wasting in children) over time would provide evidence for whether intervention with HFP with or without aquaculture improves health. Fourth, an assessment of iron bioavailability in the Cambodian diet would help identify the true prevalence of inadequate iron intake in the study sample. For instance, at the 18% or 15% bioavailability level, the prevalence of inadequate iron intake was generally low (~5-20%), whereas at the 10% and 5% bioavailability levels, the prevalence of inadequate iron intake was moderate to high (~30-100%). Determining whether iron intake is a major cause of anemia among rural Cambodian women farmers is an important prerequisite for future interventions aimed at reducing anemia. Future researchers should also consider other causes of anemia, investigating the effect of poor sanitation and illness, poverty, or genetics, using the UNICEF (2008) conceptual framework as a guide. Fifth, additional research is needed to ascertain whether the diets of children differ substantially from their mothers and the reasons for any differences. Further research is needed on the feeding practices of young children in rural Cambodia.

5.7 Role within the program impact pathway

As part of the FoF project, my research evaluates one component of the overall FoF project. As depicted in **Figure 4**, the projected outcomes of the FoF interventions include improved dietary intake and enhanced financial security, which ultimately impact health and women's empowerment. The outcomes are measured by dietary intake and the sale of HFP and aquaculture outputs. My research provides an assessment of dietary intake (one of the outcomes) following intervention with HFP or HFP plus aquaculture, compared to a control group. As part of the FoF project, the impact on maternal and child health outcomes is measured by anthropometric and biochemical measures.

While my research shows significantly higher intakes of vitamin A and zinc in the HFP group, compared to the control group, and a significantly higher intake of iron and vitamin A in the HFP plus aquaculture group, compared to the control group, the differences were small. When comparing the prevalence of inadequate intakes, the HFP plus aquaculture group showed significantly lower prevalence of inadequate vitamin A and iron intakes, compared to the control group for women, with no differences observed among children. There were no significant differences between the HFP and HFP plus aquaculture intervention groups. Standing alone, my research does not support wide-scale implementation of HFP with or without aquaculture to improve dietary intakes among women and children in rural Cambodia. However, my research findings may be considered in conjunction with other research collected as part of the FoF project, including assessment of clinical outcomes, to build a more complete evaluation of the project as a whole.

Figure 5.1: Hypothesized program impact pathway for the Fish on Farms project.



Note: Program impact pathway adapted from Olney et al. (2013).

Chapter 6: **Conclusion**

The aim of my research was to evaluate whether intervention with HFP or HFP plus aquaculture resulted in higher dietary intakes of select nutrients among women aged 19-50 years and their children aged six months to seven years in Prey Veng, Cambodia, compared to a control group. My first objective was to compare mean protein, fat, iron, zinc, and vitamin A intakes across the FoF intervention and control groups. After adjusting for the effect of clustering, women in the HFP group had higher mean intakes of zinc and vitamin A, and the HFP plus aquaculture group had a higher mean intake of iron and vitamin A, compared to controls ($p<0.05$). No significant differences in mean intakes were observed among children or between the HFP and HFP plus aquaculture groups.

My second objective was to compare the prevalence of inadequate intakes of protein, zinc, vitamin A, and iron across the FoF intervention and control groups. To compare prevalence of inadequate intakes, the EAR cut-point method was used to evaluate protein, zinc, and vitamin A, and the full probability approach was used to evaluate iron. After adjusting for the effect of clustering, the mean difference in prevalence of inadequate vitamin A and iron (10% and 5% bioavailability) intakes among women in the HFP plus aquaculture group were lower than controls ($p<0.05$). No significant differences in prevalence of inadequate intakes were observed among groups of children, between women in the HFP group and controls, or between the HFP and HFP plus aquaculture groups for both women and children. These results provide some evidence for HFP with or without aquaculture to result in higher dietary intakes of zinc, vitamin A, and/or iron and lower prevalence of inadequate vitamin A and iron intakes among rural women farmers in Cambodia, compared to controls, but not for their children. However, additional data is needed to explore the clinical significance of these findings.

No differences were observed in protein or fat intakes or prevalence of inadequate protein intake. However, overall protein intake fell within the AMDRs and prevalence of inadequate protein intake was very low, suggesting that protein intake is not a major concern among women and children participating in this study. However, the overall fat intake fell below the AMDRs and future research should investigate whether poor fat intake is a problem among rural Cambodian women and children. While not included among the nutrients of interest, the overall prevalence of inadequate calcium, thiamin, and riboflavin intakes were observed to be high. Future research should also investigate these nutrients and whether future intervention is needed to improve intake.

There were a number of limitations that could have affected the results of this study. In particular, seasonal variation in production and consumption were not captured; any potential effect of aquaculture on dietary intake was likely at its lowest at the time of endline data collection. Other major limitations are inherent in the 24HR data collection methodology; the general tendency to underestimate intake and make errors in estimating portion sizes were likely to reduce the accuracy of nutrient intake data. However, these inaccuracies are not likely to affect comparisons between the intervention and control groups at endline.

Additional research is needed to strengthen the evidence of HFP and aquaculture as interventions to improve the dietary intakes of women and children in rural Cambodia and to identify whether any resulting changes in dietary intakes are clinically significant. Future researchers should collect 24HR data throughout the year and compare significant differences in dietary intake to biochemical measures or other health outcomes, to evaluate whether or not differences in dietary intakes resulting from HFP with or without aquaculture have meaningful effects on health, when compared to controls.

Bibliography

Anderson, V. P., Cornwall, J., Jack, S., & Gibson, R. S. (2008). Intakes from non-breastmilk foods for stunted toddlers living in poor urban villages of Phnom Penh, Cambodia, are inadequate. *Maternal and Child Nutrition*, *4*, 146–159.

Anderson, V. P., Jack, S., Monchy, D., Hem, N., Hok, P., Bailey, K. B., & Gibson, R. S. (2008). Co-existing micronutrient deficiencies among stunted Cambodian infants and toddlers. *Asia Pacific Journal of Clinical Nutrition*, *17*(1), 72–9. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/24726668

Barratt, H., & Kirwan, M. (2009). Clustered data - effects on sample size and approaches to analysis. Retrieved from http://www.healthknowledge.org.uk/public-health-textbook/research-methods/1a-epidemiology/clustered-data

Bhutta, Z., Brown, K. H., Gibson, R. S., Hotz, C., King, J. C., Lonnerdal, B., … Wasantwisut, E. (2004). Appendix 1: Estimated risk of zinc deficiency by country. *Food and Nutrition Bulletin*, *25*(1).

Black, R. E., Allen, L. H., Bhutta, Z. A., Caulfield, L. E., de Onis, M., Ezzati, M., … Rivera, J. (2008). Maternal and child undernutrition: global and regional exposures and health consequences. *The Lancet*, *371*(9608), 243–260. doi:10.1016/S0140-6736(07)61690-0

Blanton, C. A., Moshfegh, A. J., Baer, D. J., & Kretsch, M. J. (2006). The USDA Automated Multiple-Pass Method accurately estimates group total energy and nutrient intake. *The Journal of Nutrition*, *136*(10), 2594–2599.

Brant, R. (2015). *Power/sample size calculator*. *University of British Columbia.* Retrieved from http://www.stat.ubc.ca/~rollin/stats/ssize/n2.html

Bushamuka, V. N., de Pee, S., Talukder, A., Kiess, L., Panagides, D., Taher, A., & Bloem, M. (2005). Impact of a homestead gardening program on household food security and empowerment of women in Bangladesh. *Food & Nutrition Bulletin*, *26*(1), 17–25.

CONSORT. (2010). *Consort-statement: baseline data. Consolidated Standards of Reporting Trials*. Retrieved from http://www.consort-statement.org/checklists/view/32-consort/510-baseline-data

Conway, J. M., Ingwersen, L. A., & Moshfegh, A. J. (2004). Accuracy of dietary recall using the USDA five-step multiple-pass method in men: an observational validation study. *Journal of the American Dietetic Association*, *104*, 595–603. doi:10.1016/j.jada.2004.01.007

Council for Agricultural and Rural Development. (2011). *Strategic Framework for Food Security and Nutrition in Cambodia 2008-2012 (SFFSN)*. Phnom Penh, Cambodia.

De Onis, M., Garza, C., Victora, C. G., Bhan, M. K., & Norum, K. R. (2004). The WHO Multicentre Growth Reference Study (MGRS): rationale, planning, and implementation. *Food and Nutrition Bulletin*, *25*(S1), 1–45. Retrieved from http://archive.unu.edu/unupress/food/fnb25-1s-WHO-1.pdf

De Pee, S., Halati, S., & Bloem, M. W. (2006). *24-VASQ Method for Estimating Vitamin A Intake (DRAFT)*. Central-Java, Indonesia.

Devaney, B., Ziegler, P., Pac, S., Karwe, V., & Barr, S. I. (2004). Nutrient intakes of infants and toddlers. *Journal of the American Dietetic Association*, *104*(S1), 14–21. doi:10.1016/j.jada.2003.10.022

FAO. (2014). *Hunger Portal: Hunger Statistics: Cambodia. Food and Agriculture Organization of the United Nations.* Retrieved from http://www.fao.org/hunger/en/

FAOSTAT. (2014). *Food Balance Sheets: Cambodia*. Food and Agriculture Organization of the United Nations Statistics Division. Retrieved from http://faostat.fao.org/site/368/DesktopDefault.aspx?PageID=368#ancor

Garriguet, D. (2008). Under-reporting of energy intake in the Canadian Community Health Survey. *Health Reports*, *19*(4), 37–46.

Gibson, R. S., & Cavalli-Sforza, T. (2012). Using reference nutrient density goals with Food Balance Sheet data to identify likely micronutrient deficits for fortification planning in countries in the Western Pacific Region. *Food & Nutrition Bulletin*, *33*(S3), 214–220.

Gibson, R. S., & Ferguson, E. L. (2008). *An interactive 24-hour recall for assessing the adequacy of iron and zinc intakes in developing countries*. Washington, D.C.

Giovannini, M., Sala, D., Usuelli, M., Livio, L., Francescato, G., Braga, M., … Riva, E. (2006). Double-blind, placebo-controlled trial comparing effects of supplementation with two different combinations of micronutrients delivered as sprinkles on growth, anemia, and iron deficiency in cambodian infants. *Journal of Pediatric Gastroenterology and Nutrition*, *42*(3), 306–312. doi:10.1097/01.mpg.0000189363.07040.4b

Hanley, J. A., Negassa, A., Edwardes, M. D. deB, & Forrester, J. E. (2003). Statistical analysis of correlated data using generalized estimating equations: An orientation. *American Journal of Epidemiology*, *157*(4), 364–375. doi:10.1093/aje/kwf215

Health Canada. (2006a). *Canadian Community Health Survey Cycle 2.2, Nutrition (2004): A guide to accessing and interpreting the data*. Ottawa, Ontario.

Health Canada. (2006b). *Dietary Reference Intakes. Health Canada.* Retrieved from http://www.hc-sc.gc.ca/fn-an/nutrition/reference/dri_ques-ques_anref-eng.php#a2a

Health Canada. (2010). Dietary Reference Intakes Tables. Retrieved from http://www.hc-sc.gc.ca/fn-an/nutrition/reference/table/index-eng.php

Helen Keller International. (2010). Homestead food production model contributes to improved household food security, nutrition and female empowerment - experience from scaling-up programs in Asia (Bangladesh, Cambodia, Nepal and Philippines). *Nutrition Bulletin, 8*(1), 1–8.

Helen Keller International. (2014). *Homestead Food Production.* Retrieved from http://www.hki.org/reducing-malnutrition/homestead-food-production/

Hong, R., & Hong, R. (2007). Economic inequality and undernutrition in women: multilevel analysis of individual, household, and community levels in Cambodia. *Food and Nutrition Bulletin, 28*(1), 59–66. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/17718013

Hop, L. T. (2003). Animal source foods to improve micronutrient nutrition in developing countries. *The Journal of Nutrition, 133*(11, S2), 4006–4009. Retrieved from http://jn.nutrition.org/content/133/11/4048S.short

Hotz, C., Loechl, C., de Brauw, A., Eozenou, P., Gilligan, D., Moursi, M., … Meenakshi, J. V. (2012). A large-scale intervention to introduce orange sweet potato in rural Mozambique increases vitamin A intakes among children and women. *British Journal of Nutrition, 108*(1), 163–176. doi:10.1017/S0007114511005174

Institute of Medicine. (2000a). *Dietary Reference Intakes for vitamin A, vitamin K, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium, and zinc*. Washington, D.C. Retrieved from http://www.nap.edu/catalog/10026.html

Institute of Medicine. (2000b). *Dietary Reference Intakes: applications in dietary assessment*. Washington, D.C.

Institute of Medicine. (2005). *Dietary Reference Intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein, and amino acids*. Washington, D.C.

Institute of Nutrition. (2007). *Vietnamese food composition table*. *Medical Publishing House*. Hanoi, Vietnam. Retrieved from http://www.fao.org/fileadmin/templates/food_composition/documents/pdf/VTN_FCT_2007.pdf

Institute of Nutrition. (2014). *ASEAN food composition database: electronic version 1*. Salaya, Thailand. Retrieved from http://www.inmu.mahidol.ac.th/aseanfoods/composition_data.html

International Life Sciences Institute. (2005). *Recommended Dietary Allowances: harmonization in Southeast Asia*. Singapore.

Iowa State University. (2015). *PC-SIDE: Software for Intake Distribution.* Retrieved from http://www.side.stat.iastate.edu/pc-side.php

Jacobs, B., & Roberts, E. (2004). Baseline assessment for addressing acute malnutrition by public-health staff in Cambodia. *Journal of Health and Population Nutrition*, *22*(2), 212–219.

Kawarazuka, N., & Béné, C. (2011). The potential role of small fish species in improving micronutrient deficiencies in developing countries: building evidence. *Public Health Nutrition*, *14*(11), 1927–1938. doi:10.1017/S1368980011000814

Lee, R. D., & Nieman, D. C. (2013). *Nutritional Assessment*. New York, N.Y.: McGraw-Hill. Retrieved from http://webcat2.library.ubc.ca/vwebv/holdingsInfo?searchId=95722&recCount=10&recPointer=0&bibId=6684924

Martorell, R., & Zongrone, A. (2012). Intergenerational influences on child growth and undernutrition. *Paediatric and Perinatal Epidemiology*, *26*(S1), 302–314. doi:10.1111/j.1365-3016.2012.01298.x

Ministry of Planning & UN World Food Programme. (2012). *Identification of poor households: Cambodia*. Phnom Penh, Cambodia.

Ministry of Tourism of Cambodia. (2015). *Weather in Cambodia.* Retrieved from http://www.tourismcambodia.org/contents/about_cambodia/index.php?view=weather

Moshfegh, A. J., Rhodes, D. G., Baer, D. J., Murayi, T., Clemens, J. C., Rumpler, W. V, … Cleveland, L. E. (2008). The US Department of Agriculture Automated Multiple-Pass Method reduces bias in the collection of energy intakes. *American Journal of Clinical Nutrition*, *88*, 324–332.

National Institute of Statistics, Directorate General for Health, & Measure DHS. (2011). *Cambodia Demographic and Health Survey 2010*. Phnom Penh, Cambodia and Calverton, Maryland, USA.

National Institute of Statistics, & Ministry of Planning. (2008). *General population census of Cambodia 2008: provisional population totals*. Phnom Penh, Cambodia.

National Research Council. (1986). *Nutrient adequacy: assessment using food consumption surveys*. Washington, D.C.: National Academies Press. Retrieved from http://site.ebrary.com/lib/ubc/reader.action?docID=10056799

Ogello, E. O. (2013). Can integrated livestock-fish culture be a solution to East Africa's food insecurity? A review. *African Journal of Food, Agriculture, Nutrition and Development*, *13*(4), 8058–8076.

Olney, D. K., Talukder, A., Iannotti, L. L., Ruel, M. T., & Quinn, V. (2009). Assessing impact and impact pathways of a homestead food production program on household and child nutrition in Cambodia. *Food and Nutrition Bulletin*, *30*(4), 355–369.

Olney, D. K., Vicheka, S., Kro, M., Chakriya, C., Kroeun, H., Hoing, L. S., … Roopnaraine, T. (2013). Using program impact pathways to understand and improve program delivery, utilization, and potential for impact of Helen Keller International's Homestead Food Production Program in Cambodia. *Food and Nutrition Bulletin*, *34*(2), 169–184.

Pries, A., Feeley, A., Mengkheang, K., Adhikary, I., Ndiaye, A., & Huffman, S. (2015). Commercially produced snack food consumption among children 6-23 months in urban Cambodia, Nepal, and Senegal (abstract). *The Journal of the Federation of American Societies of Experiemental Biology*, *29*(S1), 898. Retrieved from http://www.fasebj.org/content/29/1_Supplement/898.1.short

Reurings, M., Vossenaar, M., Doak, C. M., & Solomons, N. W. (2013). Stunting rates in infants and toddlers born in metropolitan Quetzaltenango, Guatemala. *Nutrition*, *29*(4), 655–60. doi:10.1016/j.nut.2012.12.012

Roos, N., Chamnan, C., Loeung, D., Jakobsen, J., & Thilsted, S. H. (2007). Freshwater fish as a dietary source of vitamin A in Cambodia. *Food Chemistry*, *103*(4), 1104–1111. doi:10.1016/j.foodchem.2006.10.007

Roos, N., Islam, M., & Thilsted, S. H. (2003). Small fish is an important dietary source of vitamin A and calcium in rural Bangladesh. *International Journal of Food Sciences and Nutrition*, *54*(5), 329–339. doi:10.1080/09637480120092125

Roos, N., Thorseng, H., Chamnan, C., Larsen, T., Gondolf, U. H., Bukhave, K., & Thilsted, S. H. (2007). Iron content in common Cambodian fish species: perspectives for dietary iron intake in poor, rural households. *Food Chemistry*, *104*(3), 1226–1235. doi:10.1016/j.foodchem.2007.01.038

Semba, R. D., de Pee, S., Panagides, D., Poly, O., & Bloem, M. W. (2003). Risk factors for nightblindness among women of childbearing age in Cambodia. *European Journal of Clinical Nutrition*, *57*, 1627–1632. doi:10.1038/sj.ejcn.1601734

Senbanjo, I. O., Olayiwola, I. O., Afolabi, W. A., & Senbanjo, O. C. (2013). Maternal and child under-nutrition in rural and urban communities of Lagos state, Nigeria: the relationship and risk factors. *BMC Research Notes*, *6*(1), 286. doi:10.1186/1756-0500-6-286

Shoham, J., & Duffield, A. (2009). Proceedings of the World Health Organization/ UNICEF/World Food Programme/United Nations High Commissioner for Refugees Consultation on the management of moderate malnutrition in children under 5 years of age. *Food and Nutrition Bulletin*, *30*(S3), 464–474. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/19998867

Smitasiri, S., & Chotiboriboon, S. (2003). Animal source foods to improve micronutrient nutrition and human function in developing countries: experience with programs to increase animal source food intake in Thailand. *The Journal of Nutrition, S1*, 4000–4005.

Subar, A. F., Kipnis, V., Troiano, R. P., Midthune, D., Schoeller, D. A., Bingham, S., … Schatzkin, A. (2003). Using intake biomarkers to evaluate the extent of dietary misreporting in a large sample of adults: The OPEN Study. *American Journal of Epidemiology*, *158*(1), 1–13.

Talukder, A., & Green, T. (2011). *CIFSRF Proposal: Integration of small-scale aquaculture with homestead food production for improved household food security and nutrition in rural Cambodia*. Vancouver, BC.

Thakwalakwa, C. M., Kuusipalo, H. M., Maleta, K. M., Phuka, J. C., Ashorn, P., & Cheung, Y. B. (2012). The validity of a structured interactive 24-hour recall in estimating energy and nutrient intakes in 15-month-old rural Malawian children. *Maternal & Child Nutrition*, *8*(3), 380–389. doi:10.1111/j.1740-8709.2010.00283.x

Tontisirin, K., & Gillespie, S. (1999). Linking community-based programs and service delivery for improving maternal and child nutrition. *Asian Development Review*, *17*(1-2), 33–65.

UNICEF. (2008). *Lesson 2.5: Causes and most vulnerable to undernutrition: UNICEF Conceptual Framework.* Retrieved from http://www.unicef.org/nutrition/training/2.5/4.html

USDA. (2014). *USDA Automated Multiple-Pass Method*. Retrieved from http://www.ars.usda.gov/News/docs.htm?docid=7710

Wallace, L. J., Summerlee, A. J., Dewey, C. E., Hak, C., Hall, A., & Charles, C. V. (2014). Women's nutrient intakes and food-related knowledge in rural Kandal province, Cambodia. *Asia Pacific Journal of Clinical Nutrition*, *23*(2), 263–271. doi:10.6133/apjcn.2014.23.2.02

WHO. (1995). *Physical status: the use and interpretation of anthropometry.* Retrieved from http://whqlibdoc.who.int/trs/WHO_TRS_854.pdf?ua=1

WHO. (2006a). *Child growth standards: length/height-for-age.* Retrieved from http://www.who.int/childgrowth/standards/chts_lhfa_girls_z/en/

WHO. (2006b). *Global database on body mass index.* Retrieved from http://apps.who.int/bmi/index.jsp?introPage=intro_3.html

WHO. (2011a). *Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity*. *Vitamin and Mineral Nutrition Information System*. Geneva, Switzerland. Retrieved from http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Haemoglobin+concentrations+for+the+diagnosis+of+anaemia+and+assessment+of+severity#1

WHO. (2011b). *WHO Anthro (version 3.2.2, January 2011) and macros.* Retrieved from http://www.who.int/childgrowth/software/en/

WHO. (2014). *Country Statistics: Cambodia: health profile.* Retrieved from http://www.who.int/gho/countries/khm.pdf?ua=1

WorldAtlas. (2015). *Cambodia.* Retrieved from http://www.worldatlas.com/webimage/countrys/asia/kh.htm#page

Yeudall, F., Gibson, R. S., Cullinan, T. R., & Mtimuni, B. (2005). Efficacy of a community-based dietary intervention to enhance micronutrient adequacy of high-phytate maize-based diets of rural Malawian children. *Public Health Nutrition*, *8*(7), 826–836. doi:10.1079/PHN2005744

Zeger, S. L., & Liang, K. Y. (1986). Longitudinal data analysis for discrete and continuous outcomes. *Biometrics*, *42*(1), 121–130. doi:10.2307/2531248

Appendix 1: Forms

24-hour recall form - mother

Mother's ID #:

Interviewer name:

Interview date:

Time	Food or drink (or recipe name)	Detailed description	Cooking method	Amount eaten
Rows continued on a second page				

1. Which of these options best describes your intake yesterday ☐

1= My intake was usual (if usual, skip to question 2).

2= My intake was less than usual

3= My intake was more than usual

1(a). If your intake was less than usual or more than usual, why? ☐

1 = Suffering from a cough

2 = Suffering from diarrhea

3 = Suffering from fever

4 = It was a feast day (holiday)

5 = Other

2. Are you currently in the following states?

2(a). Pregnant ☐

0= No

1= Yes

2(b). Breast feeding ☐

0= No

1= Yes

3. Do you have a fish pond? ☐

0=No

1=Yes

3(a). If yes, have all the fish been harvested? ☐

0=No

1=Yes

Codes:

Time	Food or drink (or recipe name)	Detailed description	Cooking method	Amount eaten
1=daybreak-10am 2=10am-3pm 3=3pm-7pm 4=7pm-daybreak			1=raw 2=boiled 3=steamed 4=roasted 5=fried 6=other (describe)	Water bowl #1, 2, 3 Plate #1, 2, 3 Soup bowl #1, 2, 3 Bowl #1, 2, 3 Mug #1, 2, 3 Glass #1, 2, 3 Ladle #1, 2, 3 Serving spoon #1, 2, 3 Spoon #1, 2, 3 Slice #1, 2 Piece #1, 2 Small, Medium, Large

24-hour recall form – mother (Khmer translation)

ទម្រង់អាហារ ២៤ម៉ោង - សម្រាប់ម្តាយ

លេខសម្គាល់ម្តាយ៖ ……………………………………………..
ឈ្មោះអ្នកសម្ភាសន៍៖ ……………………………………………
កាលបរិច្ឆេទសម្ភាសន៍៖ ថ្ងៃទី.......... ខែ.......... ឆ្នាំ...........

ពេលវេលា	អាហារ ឬភេសជ្ជៈ (ឬឈ្មោះមុខម្ហូប)	ពិពណ៌នាលម្អិត	វិធីសាស្ត្រចម្អិន	បរិមាណដែលបាន
	Rows continued on a second page			

១. តើជម្រើសខាងក្រោមមួយណាដែលពិពណ៌នាពីការហូបចុករបស់អ្នកកាលពីម្សិលមិញ?
1= ធម្មតា *ទៅសំណួរទី៣*
2= តិចជាងធម្មតា
3= ច្រើនជាងធម្មតា

២. ប្រសិនបើអ្នកហូបតិចជាង ឬច្រើនជាងធម្មតា តើមកពីមូលហេតុអ្វី?
1 = ក្អក
2 = រាគ
3 = ក្តៅខ្លួន
4 = មានបុណ្យ ឬពិធី
5 = ផ្សេងៗ**...............................**

៣. តើអ្នកកំពុងតែមានផ្ទៃពោះមែនដែរឬទេ?
0 = ទេ
1 = ចាស
2 = មិនច្បាស់/មិនដឹង

៤. តើអ្នកកំពុងតែបំបៅដោះកូនមែនដែរឬទេ?
0 = ទេ
1 = ចាស

៥. តើអ្នកមានស្រះចិញ្ចឹមត្រីដែរឬទេ?
0 = ទេ
1 = ចាស (ស្រះដែលដាក់ចិញ្ចឹមត្រី)
2 = ចាស (បុង បៀរដែលមិនចិញ្ចឹមត្រី តែមានត្រីស្រែ)

៦.ប្រសិនបើមានស្រះដែលដាក់ចិញ្ចឹមត្រី តើអ្នកបានប្រមូលផលត្រីទាំងអស់ហើយមែនទេ?
0 = ទេ 1 = ចាស

លេខកូដពេលវេលា			លេខកូដ វិធីសាស្ត្រចម្អិន	លេខកូដ បរិមាណដែលបានបរិ
1 = ក្រោក-10ព្រឹក 2 = 10ព្រឹក-3ល្ងាច 3= 3ល្ងាច-7យប់			1 = ឆៅ 2 = ស្ងោរ/ស្ល/ដាំ (បាយ/បបរ)	ស្លាបព្រា #1, #2, #3 វែកបាយ #1, #2, #3 វែកសម្ល #1, #2, #3

4 = 7យប់-ចូលគេង			3= ចំហុយ 4 = អាំង 5= ចៀន 6 = ផ្សេងៗ.............	កែវ #1, #2, #3 កា #1, #2, #3 ចានចង្កឹះ #1, #2, #3 ចានគោម #1, #2, #3 ចានបាយ #1, #2, #3 ផ្តិល #1, #2, #3 ចំណិត #1, #2 ដុំ #1, #2 តូច មធ្យម ធំ

24-hour recall form - child

Mother's ID #:

Interviewer name:

Interview date:

Time	Food or drink (or recipe name)	Detailed description	Cooking method	Amount eaten
Rows continued on a second page				

1. Which of these options best describes (CHILD'S NAME) intake yesterday ☐

1= Intake was usual for my child

2= Intake was less than usual for my child

3= Intake was more than usual for my child

1(a). If (CHILD'S NAME) was less than usual or more than usual, why? ☐

1 = Suffering from a cough

2 = Suffering from diarrhea

3 = Suffering from fever

4 = It was a feast day (holiday)

5 = Other

3. Was this child breastfed yesterday? ☐

0=No

1=Yes

88=NA – child off breast milk

3(a). If yes, how many times? ______________ What was the average time per feeding? _________________

Codes:

Time	Food or drink (or recipe name)	Detailed description	Cooking method	Amount eaten
1=daybreak-10am 2=10am-3pm 3=3pm-7pm 4=7pm-daybreak			1=raw 2=boiled 3=steamed 4=roasted 5=fried 6=other (describe)	Water bowl #1, 2, 3 Plate #1, 2, 3 Soup bowl #1, 2, 3 Bowl #1, 2, 3 Mug #1, 2, 3 Glass Ladle #1, 2, 3 Serving spoon #1, 2, 3 Spoon #1, 2, 3 Slice #1, 2 Piece #1, 2 Small, Medium, Large

24-hour recall form – child (Khmer translation)

ទម្រង់អាហារ ២៤ម៉ោង - សម្រាប់កុមារ

លេខសម្គាល់ម្តាយ៖ ……………………………………………..
ឈ្មោះអ្នកសម្ភាសន៍៖ ……………………………………………
កាលបរិច្ឆេទសម្ភាសន៍៖ ថ្ងៃទី………. ខែ………. ឆ្នាំ………..

ពេលវេលា	អាហារ ឬភេសជ្ជៈ (ឬឈ្មោះមុខម្ហូប)	ពិពណ៌នាលម្អិត	វិធីសាស្រ្តចម្អិន	បរិមាណដែលបានបរិភោគ
	Rows continued on a second page			

១. តើជម្រើសខាងក្រោមមួយណាដែលពិពណ៌នាពីការហូបចុករបស់កូនអ្នកកាលពីម្សិលមិញ?
1= ធម្មតា
2= តិចជាងធម្មតា

3= ច្រើនជាងធម្មតា

២. ប្រសិនបើកូនរបស់អ្នកហូបតិចជាង ឬច្រើនជាងធម្មតា តើមកពីមូលហេតុអ្វី?
1 = ក្អក
2 = រាគ
3 = ក្តៅខ្លួន
4 = មានបុណ្យ ឬពិធី
5 = ផ្សេងៗ**...............................**

៣. តើអ្នកបានបំបៅដោះកូនដែរឬទេកាលពីម្សិលមិញ?
0 = ទេ
1 = ចាស
88**=**កុមារបានផ្តាច់ដោះ

៤. ប្រសិនបើចាស តើអ្នកបានបំបៅដោះកូនអ្នកប៉ុន្មានដងកាលពីម្សិលមិញ? ....**....**ដង
តើជាមធ្យមអ្នកបំបៅកូនប៉ុន្មាននាទីក្នុងមួយលើក?......................នាទី

លេខកូដពេលវេលា			លេខកូដ វិធីសាស្រ្តចម្អិន	លេខកូដ បរិមាណដែលបានបរិភោគ
1 = ព្រោក-10ព្រឹក 2 = 10ព្រឹក-3ល្ងាច 3= 3ល្ងាច-7យប់ 4 = 7យប់-ចូលគេង			1 = ឆៅ 2 = ស្ងោរ/ស្លរ/ដាំ (បាយ/បបរ) 3= ចំហុយ 4 = អាំង 5= ចៀន 6 = ផ្សេងៗ............	ស្លាបព្រា #1, #2, #3 វែកបាយ #1, #2, #3 វែកសម្ល #1, #2, #3 កែវ #1, #2, #3 កា #1, #2, #3 ចានចង្កឹះ #1, #2, #3 ចានគោម #1, #2, #3 ចានបាយ #1, #2, #3 ផ្តិល #1, #2, #3

				ចំណិត #1, #2 ដុំ #1, #2 តូច មធ្យម ធំ

Recipe form

Mother's ID #:

Interviewer name:

Interview date:

Recipe name:

Description of recipe (e.g. soup, paste, sauce, stir fry, etc.):

Total amount of recipe:

Proportion of recipe consumed by participant:

Ingredient	Detailed description of ingredient	Amount of raw ingredient in recipe
Rows continued on a second page		
Notes:		

*** Don't forget to get total volume of recipe & amount consumed ***

Recipe form (Khmer translation)

ទម្រង់គ្រឿងផ្សំអាហារ

លេខសំគាល់ម្តាយ៖ ………………………………………………………………

ឈ្មោះអ្នកសម្ភាសន៍៖ ………………………………………………………………..

កាលបរិច្ឆេទសម្ភាសន៍៖ ……………………………………………………………

ឈ្មោះមុខម្ហូប៖ ………………………………………………………………….…..

ពិពណ៌នាពីប្រភេទមុខម្ហូប៖ ………………………………………………………..

បរិមាណមុខម្ហូបសរុប៖ …………………………………………………………........

បរិមាណមុខម្ហូបដែលអ្នកផ្តល់ចម្លើយបរិភោគ៖ ……………………………...

គ្រឿងផ្សំ	ពិពណ៌នាលំអិតពីគ្រឿងផ្សំ	បរិមាណគ្រឿងផ្សំមុនចម្អិនម្ហូប
Rows continued on a second page		
កំណត់ចំណាំ៖		

* សូមកុំភ្លេចសួរពីបរិមាណដែលបានធ្វើ និងបរិភោគ *

Appendix 2: Protocols

24-hour dietary recall data collection protocol - for interviewers

Greet Participant:
- Build rapport – introduce yourself
- Explain purpose of 24-hour recalls: "*we are interested in finding out about everything you ate and drank from when you woke up yesterday until you went to bed last night (or until midnight)*"
- Explain that you will conduct a 24-hour recall for the woman first and for her youngest child (over 6 months of age) second.

Multiple-pass interviewing technique (this yields the most accurate data):
Start the interview by saying "*I would like you to tell me everything you ate and drank after you woke up yesterday morning*."

Pass 1: ask respondents for a list of all foods and drinks consumed during the previous 24-hours
- Keep questions neutral.
  (e.g.) *"When did you get up in the morning?" "Did you eat or drink anything then?"*
- Proceed to ask questions about the rest of the day
  (e.g.) *"What did you have next?"*
- Avoid asking about specific meals or snacks (avoid asking "what did you have for a snack"). Instead, help participants remember the day's events and what they ate or drank. (e.g.) You could ask: *"Did you have anything else to eat or drink before you went to bed?"*
- Record the time when food and drinks were consumed
- If a recipe (or mixed dish) is mentioned, use the recipe form

Pass 2: Review the list of foods and drinks in chronological order, probing for more specific descriptions
- Probe for cooking methods, brand names, or additional food details
  (e.g.) *"Did you eat it whole (with the head and bones) or just the flesh?"*
  (see examples of probing questions on next page)
- Ask if the participant remembers any other additional items that were consumed but forgotten in the first pass
  (e.g.) "*Did you eat anything else with your rice?*"

Pass 3: Estimate portion sizes
- Show tools for estimating portion sizes (bowls, cups, spoons)
- Use household measures and clay models to estimate portion sizes of all food, drinks, and additions (e.g. oil used for cooking, salt, etc.)
- Avoid using other measures, such as "piece" or "slice" or "pinch"

Pass 4: Read the information back to the participant to verify that the food record is complete. Tell the participant "I will read back to you what I have recorded to make sure that I have not made any mistakes."

- Read back all foods and beverages consumed throughout the day
- Ask participant if what was read is correct
- Make any corrections or add any foods that were forgotten
- Probe for forgotten foods
  (e.g.) *"Did you have anything else to drink (juice or alcohol)?"*

Examples of probing questions (to obtain detailed descriptions of specified foods)

Food type	Required Detailed Information
Meat	What kind of meat? What cut of meat? Raw or cooked portion size? How was it cooked? Was it lean meat or lean meat plus fat? Was the bone in or not?
Fish & seafood	What kind of fish or seafood? Raw or cooked portion size? How was it cooked? What part of the fish/seafood was eaten? Amount of bones eaten or not eaten?
Poultry	What kind of poultry? What parts eaten (e.g. breast, thigh)? Raw or cooked portion size? How was it cooked? White or dark meat? Meat plus skin or meat only? Was the bone in or not?
Eggs	Chicken or duck? Fertilized (and if so, how many weeks)? How was it cooked? Was anything added (e.g. salt, fish sauce, etc.)
Insects	What kind of insect? Larvae or adult insect? How was it cooked? Fresh or dried? What was added (e.g. salt, oil, bullion cubes).
Beans or nuts	What type of bean or nut? Fresh or dried? Eaten whole or as a paste? How was it cooked?
Fats	What kind of fat (e.g. oil or lard, vegetable or animal)? How much? What brand name?
Rice	Was the rice milled or polished (white) or unpolished (brown)?
Grains	What type of grain? Was the grain whole or refined? If flour, was it refined or unrefined? Raw or cooked portion size? Enriched or not? How was it cooked?
Milk products	What kind of dairy product? What was the brand name (if commercial product)? Was it liquid or made from powdered milk? What percentage of fat (butter fat or milk fat)?
Vegetables	Fresh or cooked? How was it cooked? Was it peeled or unpeeled? Was there a topping or anything added (e.g. oil, salt, etc.)?
Fruits	Fresh, canned, dried, or cooked? Peeled or unpeeled? Young or ripe? Was it eaten fresh or mashed?
Beverages	Fresh or in a can/bottle? Was water added (if so, how much)? Juice: what kind of fruit juice? If mixed fruits, what fruits? Sweetened or unsweetened? Added vitamins or minerals? Carbonated? Coffee: Brewed or instant? Decaffeinated or regular? Anything added to coffee or tea (e.g. milk or sugar)? Any alcoholic beverages consumed? What kind of alcohol (e.g. beer, gin, or

	wine)? Any water?
Food from vendors	What kind of food? Anything added? Method of cooking?
Mixed dishes (e.g. soup)	*(Use recipe form)* What are the recipe ingredients and amounts? What was the cooking method? How much did the recipe make in total? How much of the recipe was eaten by participant?
Herbs	What kind of herb? Fresh or dried?
Sauces or pastes	Homemade or commercial? If commercial: Fortified or not? If homemade, *use recipe form*.
Packaged snacks	Package size? Brand name? How much of package eaten?
Cake & sweets	Homemade or commercial? If homemade, *use recipe form*.

24-hour dietary recall data collection protocol - for interviewers (Khmer translation)

ពិធីសារប្រមូលពត៌មានអាហារ ២៤ម៉ោងសម្រាប់អ្នកសម្ភាសន៍

ធ្វើកិច្ចគោរពដល់អ្នកផ្តល់ចម្លើយ
- ការកសាងទំនាក់ទំនង - ណែនាំខ្លួន
- ពន្យល់ពីគោលបំណងនៃការប្រមូលពត៌មានអាហារ ២៤ម៉ោង "ខ្ញុំចាប់អារម្មណ៍រាល់អ្វីដែលអ្នកបានបរិភោគ និងផឹកចាប់តាំងពីពេលដែលអ្នកក្រោកពីគេង រហូតដល់ពេលអ្នកចូលគេងវិញកាលពីម្សិលមិញ"
- ពន្យល់ថាអ្នកនិងសួរអំពីអាហារ ២៤ម៉ោងរបស់ម្តាយមុននឹងអ្នកសួរអំពីអាហារ ២៤ម៉ោងរបស់កូនពៅគេបង្អស់របស់គាត់ ដែលមានអាយុលើសពី ៦ខែ

វិធីសាស្ត្រសួរដែលមានច្រើនជំហាន (អាចជួយអោយទទួលបានទិន្នន័យសុក្រិត)
ចាប់ផ្តើមការសម្ភាសន៍ដោយនិយាយថា "ខ្ញុំចង់អោយអ្នកប្រាប់ខ្ញុំរាល់អ្វីដែលអ្នកបានបរិភោគ និងផឹកបន្ទាប់ពី អ្នកក្រោកពីដំណេកកាលពីព្រឹកម្សិលមិញ"

ជំហានទី ១៖ សួរអ្នកផ្តល់ចម្លើយរាល់អាហារ និងភេសជ្ជៈដែលគាត់បានបរិភោគ និងផឹកក្នុងរយៈពេល ២៤ម៉ោងកន្លងមក
- រក្សាសំណួរអព្យាក្រឹត ឧ. តើអ្នកក្រោកពីដំណេកនៅម៉ោងប៉ុន្មានកាលពីព្រឹកម្សិលមិញ? តើអ្នកមានបរិភោគ ឬផឹកអ្វីដែរឬទេបន្ទាប់ពីនោះ?
- បន្តសួរពីអ្វីដែលគាត់បានបរិភោគ ឬផឹក ឧ. តើអ្នកហូប ឬផឹកអ្វីទៀត?
- ចៀសវាងសួរពីអាហារពេល និងអាហារក្រៅពេលចំៗ (ចៀសវាងសួរថា"តើអ្នកមានហូបអាហារក្រៅពេលដែរឬទេ?") អ្នកអាចជួយអោយអ្នកផ្តល់ចម្លើយចាំនូវព្រឹត្តិការណ៍ក្នុងថ្ងៃនោះ និងសួរថាគាត់បានហូប និងផឹកអ្វី? ឧ. អ្នកអាចសួរថា តើអ្នកបានហូប ឬផឹកអ្វីដែលឬទេមុនពេលចូលដំណេក?
- កត់ត្រាពេលវេលាដែលគាត់បរិភោគអាហារ និងផឹកភេសជ្ជៈ
- ប្រសិនបើមុខម្ហូបមានផ្សំគ្រឿងច្រើនមុខ សូមប្រើទម្រង់គ្រឿងផ្សំអាហារ

ជំហានទី ២៖ មើលឡើងវិញនូវបញ្ជីអាហារ និងភេសជ្ជៈតាមលំដាប់លំដោយ សួរដេញរហូតបានការពិពណ៌នាជាក់លាក់
- សួរដេញពីវិធីសាស្ត្រចម្អិនម្ហូប ឈ្មោះផលិតផល ឬពត៌មានបន្ថែមពីអាហារ ឧ. តើអ្នកហូបទាំងមូល (ទាំងក្បាល និងឆ្អឹង) ឬតែសាច់ទេ? (មើលឧទាហរណ៍នៃការសួរដេញនៅទំព័របន្ទាប់)
- សួរអ្នកផ្តល់ចម្លើយថាមានចាំអាហារ ឬភេសជ្ជៈណាផ្សេងទៀត ដែលគាត់បានបរិភោគ តែភ្លេចប្រាប់យើងក្នុងជំហានទី១ ឧ. តើអ្នកមានហូបបាយជាមួយអ្វីផ្សេងទៀតទេ?

ជំហានទី៣៖ ការប៉ាន់ប្រមាណនូវបរិមាណ/ទំហំ
- បង្ហាញសម្ភារៈសម្រាប់ការប៉ាន់ប្រមាណនូវបរិមាណ/ទំហំ (ចានគោម ពែង ស្លាបព្រា)
- ប្រើប្រាស់រង្វាស់រង្វាល់គ្រួសារ និងគំរូដីឥដ្ឋ ដើម្បីប៉ាន់ប្រមាណនូវបរិមាណ/ទំហំ របស់អាហារ ភេសជ្ជៈ និងគ្រឿងផ្សំបន្ថែមទាំងអស់ (ឧ. បរិមាណប្រេងឆា អំបិល...)
- ចៀសវាងសួរពីរង្វាស់រង្វាល់ផ្សេងទៀត ដូចជា ដុំ ចំណិត...

ជំហានទី៤៖ អានរាល់ព័ត៌មានដែលអ្នកទទួលបានអោយអ្នកផ្តល់ចម្លើយស្តាប់ ដើម្បីផ្ទៀងផ្ទាត់ការកត់ត្រារបស់អ្នក ។ ប្រាប់អ្នកផ្តល់ចម្លើយថា "ខ្ញុំនឹងអានរាល់ព័ត៌មាន ដែលខ្ញុំបានកត់ត្រាអោយអ្នកស្តាប់ ដើម្បីប្រាកដថា ខ្ញុំមិនមានភ្លេចកត់ត្រាចំណុចណាមួយនោះឡើយ" ។

- អានរាល់អាហារ និងភេសជ្ជៈ ដែលគាត់បានបរិភោគពេញមួយថ្ងៃ
- សួរអ្នកផ្តល់ចម្លើយថា រាល់អ្វីដែលបានអានត្រឹមត្រូវដែរឬទេ?
- ធ្វើការកែសម្រួល ឬបន្ថែមអាហារផ្សេងទៀតដែលអ្នកភ្លេចកត់ត្រា
- សួរពីអាហារដែលអ្នកភ្លេចកត់ត្រា ឧ. តើអ្នកមានផឹកទឹកផ្លែឈើ ស្រា....ទេ?

ឧទាហរណ៍សម្រាប់សំណួរដេញ (ដើម្បីទទួលបាននូវព័ត៌មានលម្អិតអំពីអាហារ ដែលបានបរិភោគ)

ប្រភេទអាហារ	ព័ត៌មានលម្អិតដែលចង់បាន
សាច់	តើប្រភេទសាច់អ្វី? តើសាច់នោះកាត់របៀបម៉េច? ឆៅ ឬឆ្អិន? ប៉ុណ្ណា? តើចម្អិនរបៀបម៉េច? តើសាច់សុទ្ធ ឬសាច់ជាប់ខ្លាញ់? តើមានជាប់ឆ្អឹងដែរឬទេ?
ត្រី និងអាហារសមុទ្រ	តើប្រភេទត្រី ឬអាហារសមុទ្រអ្វី? ឆៅ ឬឆ្អិន? ប៉ុណ្ណា? តើចម្អិនរបៀបម៉េច? តើអ្នកហូបផ្នែកណាមួយនៃត្រី ឬអាហារសមុទ្រ? បរិមាណឆ្អឹងដែលបានហូប ឬមិនបានហូប?
សាច់បក្សី	តើប្រភេទសាច់បក្សីអ្វី? តើអ្នកហូបផ្នែកណាមួយនៃសាច់បក្សី (ទ្រូង ភ្លៅ)? ឆៅ ឬឆ្អិន? ប៉ុណ្ណា? តើចម្អិនរបៀបម៉េច? តើសាច់ស ឬខ្មៅ? សាច់ជាមួយស្បែក ឬសាច់សុទ្ធ? ជាមួយឆ្អឹង ឬគ្មានឆ្អឹង?
ស៊ុត	ស៊ុតមាន់ ឬស៊ុតទា? ស៊ុតមានកូន ឬមិនមាន (ប្រសិនបើមាន តើកូនមានអាយុប៉ុន្មាន សប្តាហ៍?) តើចម្អិនរបៀបម៉េច? មានថែមអ្វីផ្សេងទៀតទេ? ដូចជា អំបិល ទឹកត្រី....
សត្វល្អិត	តើសត្វល្អិតប្រភេទអ្វី? កូនសត្វល្អិត ឬសត្វល្អិតធំៗ? តើចម្អិនរបៀបម៉េច? ស្រស់ ឬក្រៀម? មានថែមអ្វីផ្សេងទៀតទេ? ដូចជា អំបិល ខ្លាញ់ ដុំម្សៅស៊ុប…
សណ្តែក ឬគ្រាប់សណ្តែក	តើសណ្តែក ឬគ្រាប់សណ្តែកប្រភេទអ្វី? ស្រស់ ឬស្ងួត? ញ៉ាំទាំងមូល ឬកំទេច? តើចម្អិនរបៀបម៉េច?
ខ្លាញ់	តើខ្លាញ់ប្រភេទអ្វី? (ឧ. ប្រេងឆា ឬខ្លាញ់)? ប៉ុន្មាន? តើម៉ាកអ្វី?
បាយ	តើបាយអង្ករសម្រូប ឬសម្រិត?
ធញ្ញជាតិ	តើធញ្ញជាតិប្រភេទអ្វី? តើធញ្ញជាតិទាំងមូល ឬលីង? ឆៅ ឬឆ្អិន? ប៉ុណ្ណា? តើចម្អិនរបៀបម៉េច?
ផលិតផលទឹកដោះគោ	តើប្រភេទផលិតផលទឹកដោះគោអ្វី? តើម៉ាកអ្វី (ប្រសិនបើទិញ)? រាវ ឬម្សៅ? ភាគរយខ្លាញ់ប៉ុន្មាន?
បន្លែ	ស្រស់ ឬឆ្អិន? តើចម្អិនរបៀបម៉េច? ចិត ឬមិនចិតសំបក? មានបន្ថែមអ្វីផ្សេងទៀត ទេ? ដូចជា ខ្លាញ់ អំបិល...
ផ្លែឈើ	ស្រស់ កំប៉ុង ក្រៀម ឬឆ្អិន? ចិត ឬមិនចិតសំបក? ខ្ចី ឬទុំ? ហូបទាំងមូល ឬពាតអោយម៉ត់?
ភេសជ្ជៈ	ស្រស់ កំប៉ុង ឬដប? មានបន្ថែមទឹកដែរឬទេ (បើថែម តើប៉ុន្មាន?) ទឹកផ្លែឈើ ៖ ទឹកផ្លែឈើប្រភេទអ្វី? បើលាយ លាយផ្លែឈើអ្វីខ្លះ? ផ្អែម ឬមិនផ្អែម? មានបន្ថែមវីតាមីន ឬជាតិរ៉ែដែរឬទេ? មានហ្គាសដែរឬទេ? កាហ្វេ៖ កាហ្វេឆុង ឬកញ្ចប់? មានជាតិកាហ្វេអ៊ីន ឬគ្មាន? មានបន្ថែមអ្វីផ្សេងទៀតក្នុងកាហ្វេ ឬតែទេ (ដូចជាទឹកដោះគោ ឬស្ករ)? មានហូបគ្រឿងស្រវឹងទេ? គ្រឿងស្រវឹងប្រភេទអ្វី (ស្រាបៀរ ស្រា ទឹកត្នោតជូរ)?

	មានហូបទឹកទេ?
អាហារដែលគេធ្វើសម្រាប់លក់	អាហារប្រភេទអ្វី? មានបន្ថែមអ្វីផ្សេងទៀតទេ? តើចម្អិនរបៀបម៉េច?
សម្លលាយគ្នា ឧ. ស៊ុប	ប្រើទម្រង់គ្រឿងផ្សំអាហារ តើមានគ្រឿងផ្សំអ្វីខ្លះ? ហើយបរិមាណប៉ុន្មាន? តើចម្អិនរបៀបម៉េច? តើសរុបមានបរិមាណប៉ុន្មាន? តើអ្នកបរិភោគប៉ុន្មាន?
ជី	តើជីប្រភេទអ្វី? ស្រស់ ឬក្រៀម?
ទឹកជ្រលក់ ឬរបស់ផ្អាប់	ធ្វើខ្លួនឯង ឬទិញគេ? ប្រសិនបើទិញ មានបញ្ចូលជីវជាតិផ្សេងៗដែរឬទេ? ប្រសិនបើធ្វើខ្លួនឯង សូមប្រើទម្រង់គ្រឿងផ្សំអាហារ
នំកញ្ចប់	ទំហំប៉ុណ្ណា? ម៉ាកអ្វី? ថ្លៃប៉ុន្មាន?
នំ ឬបង្អែម	ធ្វើខ្លួនឯង ឬទិញគេ? ប្រសិនបើធ្វើខ្លួនឯង សូមប្រើទម្រង់គ្រឿងផ្សំអាហារ

24-hour dietary recall data collection protocol - for field supervisors

Goals of review by field supervisor

- Prevent underestimation
- Make sure the data collected is accurate
- Improve ease of coding and analysis

Role of field supervisor

(1) Check for errors
(2) Make sure protocol is followed
(3) Make sure interviewers have been thorough

(1) Checking for errors

- Is the writing neat and legible?
- Are all the necessary columns filled out?
- Check portion sizes - do the portion sizes listed make sense?
- Does the overall day's consumption make sense?

(2) Making sure protocol is followed

- Food and beverage items listed clearly (e.g.):
  - If a food is "fried," oil should be included in the list
  - If a mixed dish is included in the food list, check for a recipe form
- Detailed description (e.g.):
  - Is fish eaten whole or flesh only?
  - Is fish or poultry eaten with skin or without?
  - Is the meat lean (no fat) or lean plus fat (fatty meat)?
  - Are vegetables raw or cooked?
  - Is juice fresh or canned?
  - Is milk fresh or made from powder?
  - What is the brand name of packaged foods (e.g. biscuits, fish sauce)?
- Cooking method (e.g.):
  - Is the cooking method listed or coded properly?
- Amount eaten
  - Standard household measures or clay models should be used

(3) Making sure the interviewer has been thorough

- Look for beverages (e.g. water, juice, alcohol)
- Look for common additions to food (e.g. oil/fat, fish sauce)
- Check that recipe forms have been used when needed

Appendix 3: Food measurement data

Ingredient:	Bowl #1	Bowl #2	Bowl #3	Soup bowl #1	Soup bowl #2	Soup bowl #3	Water bowl #1	Water bowl #2	Water bowl #3	Mug #1	Mug #2	Mug #3	Glass #1	Glass #2	Glass #3	Plate #1	Plate #2	Plate #3
Kang kong, leaves and stems (raw)	46	25	15	195	119	67	148	96	61	42	38	26	47	26	17	122	80	56
Kang kong, leaves and stems (cooked)	135	78	35	438	245	161				129	92	67	121	50	33	241	147	97
Amaranth leaves (raw)	34	29	12	158	103	61	160	90	54	42	26	22	39	19	13	78	63	32
Sweet potato leaves (raw)*	45	30	10	206	113	84	163	96	53	45	36	25	30	13	12	72	54	42
Cabbage, Chinese (raw)	38	32	13	145	92	61	140	121	59	57	43	30	47	21	13	89	74	57
Cabbage, Chinese (cooked)	124	76	39	507	241	160				148	100	74	113	58	41	247	149	115
Bamboo (raw)	124	68	30	458	247	130	420	248	133	120	66	53	91	41	33	254	150	94
Bamboo (cooked)	127	68	36	578	300	193				139	97	75	125	43	31	299	159	106
Sponge gourd (raw)	154	89	54	648	401	235	509	351	226	164	115	83	115	59	50	331	229	173
Sponge gourd (cooked)	228	135	72	880	475	339				244	171	152	224	89	63	410	258	193
Taro stem (raw)*	103	60	28	350	175	119	348	209	128	97	73	51	82	41	27	144	111	85
Taro stem (cooked)*	141	73	44	475	289	210				162	105	95	131	57	38	268	177	116
Tomato (raw)*																		
Onions (raw)*																		
Eggplant (raw)	127	69	40	571	317	215	439	297	194	140	106	81	109	52	38	299	201	127
Eggplant (cooked)	206	107	51	753	383	283				212	155	128	179	77	48	420	246	156
Pumpkin (raw)	177	102	55	754	432	307	605	420	268	192	146	104	140	58	48	422	269	193
Pumpkin (cooked)	197	115	59	760	459	326				221	155	123	184	86	57	433	283	186
Tamarind, fruit (raw)																		
Mango (raw) (green)	150	83	39	692	391	215				163	91	80	120	43	37	277	191	139

Ingredient:	Bowl #1	Bowl #2	Bowl #3	Soup bowl #1	Soup bowl #2	Soup bowl #3	Water bowl #1	Water bowl #2	Water bowl #3	Mug #1	Mug #2	Mug #3	Glass #1	Glass #2	Glass #3	Plate #1	Plate #2	Plate #3
Mango (raw) (ripe)	192	114	64	910	430	258				211	176	130	196	88	63	392	289	235
Banana (raw) (ripe)	191	128	61													527	470	293
Young native melon (raw)	178	103	49	666	375	268				191	132	109	158	66	44	360	239	177
Cucumber (raw)	202	111	58	733	414	279				206	145	107	168	78	44	395	341	212
Oil																		
Sugar																		
MSG																		
Bread	44	28	16															
Khmer noodle	251	138	74	1022	534	330				287	177	160	270	101	68	335	231	182
Sticky rice cake, Koum cake*	263	157	86	853	568	330				278	210	164	243	102	71	386	292	159
Mung bean dessert*	233	130	65	838	504	309				310	240	182				295	279	182
Pa ork																		
Pra hok (fish paste)																		
Small fish, any kind (cooked)	163	84	38													218	168	112
Large fish, any kind (cooked)	172	93	47													357	214	136
Dried fish																		
Dried beef																		
Pork meat with fat (cooked)	189	91	42															
Water (volume measurement) on scale	312	184	73	1226	621	421	1119	742	457	352	269	212	315	124	81	527	347	261
Uncooked rice (Ang Kor)																		
Fried uncooked rice (Ang Kor Ling)	264	142	57															

Ingredient:	Slice #1	Slice #2	Piece #1	Piece #2	Ladle #1	Ladle #2	Ladle #3	Serving spoon #1	Serving spoon #2	Serving spoon #3	Spoon #1	Spoon #2	Spoon #3	"Can"
Kang kong, leaves and stems (raw)					21	17	8	23	14	9	6	4	1	
Kang kong, leaves and stems (cooked)					35	30	18	40	32	23	9	4	3	
Amaranth leaves (raw)					17	11	8	17	14	10	6	3	1	
Sweet potato leaves (raw)*					11	8	5	18	13	7	4	1	0	
Cabbage, Chinese (raw)					19	17	12	22	17	14	7	4	1	
Cabbage, Chinese (cooked)					35	26	17	45	37	30	11	7	4	
Bamboo (raw)					35	24	13	40	34	20	10	4	3	
Bamboo (cooked)					35	27	19	37	34	19	11	5	3	
Sponge gourd (raw)					52	40	20	47	45	31	14	6	3	
Sponge gourd (cooked)					75	56	31	74	69	44	21	5	2	
Taro stem (raw)*					32	25	16	30	26	15	9	5	3	
Taro stem (cooked)*					33	25	21	35	32	22	11	7	4	
Tomato (raw)*					53	38	25	50	36	24	15	7	3	
Onions (raw)*					38	32	17	47	30	26	11	5	2	
Eggplant (raw)					40	32	22	43	34	26	11	6	3	
Eggplant (cooked)					58	43	29	63	58	47	21	7	3	
Pumpkin (raw)					49	33	26	56	46	31	14	5	2	
Pumpkin (cooked)					76	55	36	79	68	50	23	9	4	
Tamarind, fruit (raw)					70	54	42	47	45	36	16	8	4	
Mango (raw) (green)					47	34	22	47	42	24	9	4	1	
Mango (raw) (ripe)					67	53	41	71	57	40	21	15	10	

Ingredient:	Slice #1	Slice #2	Piece #1	Piece #2	Ladle #1	Ladle #2	Ladle #3	Serving spoon #1	Serving spoon #2	Serving spoon #3	Spoon #1	Spoon #2	Spoon #3	"Can"
Banana (raw) (ripe)	30	9	48	19	64	49	31	118	95	67	15	7	4	
Young native melon (raw)					53	42	26	55	50	37	13	5	3	
Cucumber (raw)					60	40	34	68	46	32	15	6	3	
Oil					24	18	13	23	19	13	5	2	0	
Sugar					35	30	16	41	39	23				
MSG											9	3	2	
Bread											4	1	0	
Khmer noodle					47	44	27	54	50	30	11	3	2	
Sticky rice cake, Koum cake*					70	47	36	90	79	51	23	10	5	
Mung bean dessert*					52	49	28	60	56	28	12	7	4	
Pa ork					48	34	26	51	35	29	12	5	2	
Pra hok (fish paste)					39	31	22	54	39	29	15	5	3	
Small fish, any kind (cooked)					38	27	21	47	36	21	11	5	2	
Large fish, any kind (cooked)	28	4	40	14	66	51	24	67	54	50	24	5	3	
Dried fish											9	4	1	
Dried beef											6	3	1	
Pork meat with fat (cooked)	19	4	27	12	47	36	24	49	43	32	9	5	2	
Water (volume measurement) on scale					52	45	32	45	56	26	9	3	2	314
Uncooked rice (Ang Kor)					44.72	38.7	27.52	38.7	48.16	22.36	7.74	2.58	1.72	264
Fried uncooked rice (Ang Kor Ling)					53	44	30	50	44	27	10	4	3	

Appendix 4: Training schedule and lesson plans

Training Schedule for Endline Survey 24-hour Recalls

Fish on Farms Project

Venue: HKI Office
Duration: 3 days (2 days in class, and 1 day field test/pre-test)
Date: May 20-22, 2014
Participants: 9 interviewer trainees
Facilitator: Vashti and Kroeun/Vanak

Time	Topic
Day 1: 20/05/2014	
8:00-10:00 (2 hours)	- Group Training
10:00-10:15 (15 min)	- **Coffee Break**
10:15-11:15 (60 min)	- Review of new 24-hour recall form for endline
11:15-12:00 (45 min)	- Interviewing techniques
12:00-13:30 (90 min)	- **Lunch Break**
13:30-14:00 (30 min)	- Description of multiple-pass 24-hour recall with a focus on Pass 1 and Pass 2
14:00-15:00 (60 min)	- How to generate a list of foods (Pass 1) and a description of foods (Pass 2)
15:00 - 15:15 (15 min)	- **Coffee Break**
15:15-15:45 (30 min)	- Activity debrief (Pass 1 and 2)
15:45-16:45 (60 min)	- Estimating portion sizes (Pass 3) and completing final review (Pass 4)
16:45-17:00 (15 min)	- **Questions and Answers for day one**
Day 2: 21/05/2014	
08:00-08:30 (30 min)	- Review day one session (Pass 1, Pass 2, Pass 3, Pass 4)
8:30-9:00 (30 min)	- Do demo (showing the first 4 passes of 24 hour recall)
09:00 – 09:45 (45 min)	- In partners, practice all 4 passes (**first partner**), generating a list of foods (Pass 1), a description of foods (Pass 2), and estimated portion sizes (Pass 3), and a final review, probing for forgotten foods (Pass 4), using 24-hour recall form
9:45-10:00 (15 min)	- **Coffee Break**
010:00-10:45 (45 min)	- In partners, practice all 4 passes (**second partner**)

10:45-11:30 (45 min)	- Debrief process of conducting 24-hour recall - Discuss challenges
11:30--12:00 (30 min)	- Review recipe form
12:00-13:30 (90 min)	- **Lunch break**
13:30-14:30 (60 min)	- In partners, practice completing recipe form (**both partners**)
14:30-15:30	- Discuss how to handle difficult scenarios
15:00-15:15	- **Coffee break**
15:15 - 16:00 (45 min)	- Debrief activity (difficult scenarios)
16:00-16:30 (30 min)	- Review schedule and protocol for work in the field - **Questions and Answers for day two**
16:30-17:00 (30 min)	- **Whole group meets to review plan for field exercise tomorrow**

Lesson plans for 24-hour recall interviewers

Supplies needed for both days:

- Flipchart paper (3x flipcharts, standing)
- Tape
- Markers
- 24-hour recall form (x10 copies)
- Protocol for interviewers (x10 copies)
- Household measures and clay models

Day 1

10:15-11:15 (60 min) - Review of new 24-hour recall form for endline

GROUP DISCUSSION (30 minutes):

- Introductions
- Ask the group who has conducted 24-hour recalls.
- "What were some challenges collecting 24-hour recalls" (during baseline, or other research)?

Explain purpose of study and introduce new form (30 min):

- Will interview same participants (from baseline)
- Explain purpose of 24-hour recalls
  - To analyze all nutrients: e.g. energy (stunting), iron (anemia)
  - (e.g.) oils, snacks, and beverages are important (for kcal & iron in water)
- Show how the analysis is done
  - Show difficulties with analysis
- Provide 24-hour recall forms
  - Highlight sections of form
- Provide "cheat sheet" for interviewers
- Explain multiple passes
  - Pass 1 (list), Pass 2 (additional detail), Pass 3 (portions), Pass 4 (review)
  - Rationale for multiple passes: to improve accuracy, help with recall

11:15-12:00 (45 min) - Interviewing techniques

GROUP DISCUSSION (30 minutes):

- Ask for someone to volunteer as a note-taker on flipchart paper:
- Ask the group: "What are important things to consider when greeting participants?"
  - Be prepared
  - Try to find the best situation for the interview: quiet and not too many distractions
  - Gain confidence of participant
  - Be warm and kind, but not too personal
  - Have a professional attitude
  - Be respectful and listen
  - Be non-judgmental
  - Avoid showing signs of surprise, approval, or disapproval
  - Pay attention to "body language" – do not "look down" on respondents nor convey disrespect through posture or gestures
  - Dress appropriately; do not offend local standards of modesty
- Discuss how to be a skilled listener as awell as a questioner
- Focus on and empathize with the participant

DEMO ROLE PLAY (15 min): (Kang/Vashti and volunteer 'participant')
- Explain that this is not going to be "perfect" and we will talk about it afterwards (during demo, include a sign of surprise when "participant" talking, to see if the group notices the "mistakes")
- Demonstrate introductions & recall of first meal (completing all 4 passes)
    o Establish a pattern of questioning
    o Stimulate memory by retracing the activities of the participant
    o Fix time frame as the day before the recall interview
    o Focus on detail to describe the food and how much was eaten
    o Probe without bias
    o Avoid quick assumptions and conclusions… use silence and waiting
    o Avoid providing participant with information
    o Demonstrate probes used to elicit detailed descriptions of food and beverages
 	
GROUP DISCUSSION (15 min)
- What went well?
- What can be improved?

12:00-13:30 (90 min) – Lunch break
13:30-14:00 (30 min) - Describe multiple-pass 24-hour recall, focus on Pass 1 & 2 Explain Pass 1 (15 min): - First establish rapport, do introductions, & explain purpose of study - Remind participants that questions will cover all the food and beverages, including snacks consumed during previous day - Ask participant to list of all foods and drinks (including H2O) - Use NEUTRAL questions - Probe for snacks and drinks consumed between meals Explain Pass 2 (15 min): - Review list in chronological order, probing for more specific descriptions (cooking methods, brand names, state of food, see "cheat sheet") - Ask if participant has remembered any additional items consumed but forgotten (e.g. beverages, snacks) - For mixed dishes, use the recipe form (to be discussed tomorrow)

14:00-15:00 (60 min) - Generating a list of foods (Pass 1) & food descriptions (Pass 2)
ACTIVITY (with 3x flipchart paper):
- Brainstorm what kind of <u>probing questions</u> to ask to generate a list of foods (Pass 1) and additional details (Pass 2); each station with different "topic"
    o Station 1: Generating list of foods, including beverages & snacks (Pass 1)
    o Station 2: Probing for beverages and snacks (Pass 1)
    o Station 3: Probing questions about cooking methods & processing (Pass 2)
- Each group rotates through each station and brainstorms new questions
- During final rotation, choose one person to report back to the group

15:00 - 15:15 (15 min) - Coffee Break
15:15-15:45 (30 min) – Pass 1 and 2 debrief Report each flipchart topic back to group (30 min) - One representative from each group will summarize useful probing questions (10 minutes for each representative)
15:45-16:45 (60 min) – Review of Pass 3 and Pass 4 Explain Pass 3 (how to estimate portion sizes) (15min)

- Pass 3: show household measures and clay models to use in the field

Explain Pass 4 (final review) (15 min)

- Pass 4 is a chance to probe for forgotten foods

ACTIVITY (30min) (15 min for each partner)

- In partners, practice Pass 1-4 use 24-hour recall form
- Practice getting a list (Pass 1), getting additional details (Pass 2), estimating portion sizes using household measures and clay models (Pass 3) and doing a final review (Pass 4)

GROUP DISCUSSION (if there's time)

- What went well?
- What can be improved?

16:45-17:00 (15 min) - Questions and Answers for day one

- Overview for day 2

Day 2

08:00-08:30 (30 min) - Review day one (Pass 1, Pass 2, Pass 3, Pass 4)

GROUP DISCUSSION (if there was not enough time yesterday to discuss practice 24HR)

- What went well? What can be improved?
- Discuss challenges
    - "Any problems estimating portion sizes?"
    - "Any difficulty getting additional details?"
- Discuss epiphanies
    - "Did the 'participant' remember additional food items in the 2nd, 3rd, or 4th pass?"

Recap (if needed)

Ask group: "Explain why each pass is important" (go through all 4 Passes)

- 1: to give participant opportunity to share
- 2: to collect additional details
- 3: to enhance accuracy
- 4: to improve recall of forgotten foods

8:30-9:15 (45 min) – review/demo all 4 passes of 24-hour recall

RECIPE FORM (30min)

- Review recipe form
    - Name of mixed dish (local and general)
    - Descriptive list of all ingredients in descending order of quantity
    - Amount of each raw ingredient (excluding water)
    - Method of preparation and cooking
    - Total amount of cooked dish (in grams or mL or household measure)
    - Amount of mixed dish consumed by the respondent in the same units
- Ask: "what are some examples of when to use the recipe form" (examples could be from previous activity or other ideas)Q&A

DEMO RECIPE FORM (15 min) e.g. pickled cucumber recipe

- What went well?
- What can be improved?
- Highlight that all 4 Passes are used for the recipe form also

09:15 – 10:00 (45 min) – Practice using recipe form

ACTIVITY – 1st partner

- In partners, practice using the recipe form (1st partner)
10:00-10:15 - Coffee Break
10:15-11:00 (45 min) - Practice using recipe form (continued) ACTIVITY – 2nd partner - In partners, practice using the recipe form (2nd partner)
11:00-11:45 (45 min) – Review ACTIVITY & GROUP DISCUSSION - Step #1: In partners, trade recipes and look for mistakes or unclear entries - Step #2: Discuss as a group what went well and where errors were made
11:45-12:00 (30 min) Q&A OF YESTERDAY AND TODAY'S MORNING SESSION
12:00-13:30 (90 min) - Lunch break
13:30-15:30 (120 min) – Practice 24-hour recall ACTIVITY - In partners, practice full 24-hour recall (60 min each partner) - Explain that this is practice for the pretest tomorrow
15:30-15:45 (15 min) - Coffee break
15:45 - 16:30 (45 min) – Debrief activity GROUP DISSCUSION (Or use flip charts if there's more time) What are some ways to manage these situations: - Dealing with distractions (e.g. too many neighbors or children want to see what is going on) - The respondent gives socially desirable answers - A mother giving a 24-hour recall on her child, insists on asking whether what her child ate is satisfactory - Participant has difficulty adhering to the format of the recall interview - Another family member responds or corrects the respondent - Children needing more than minimal attention - The participant insists on asking the interviewer how her neighbor answered - Very dirty home, but participant insists on offering you some of the family meal - A mother is ill on the recording day
16:30-16:45 (15 min) - Review schedule and protocol for work in the field Explain repeat recalls - Explain purpose of repeat 24 hour recalls - To estimate "within person variation in the diet" as a way to estimate prevalence of inadequacy among individuals Explain Pre-test - Objectives of pre-test is to identify potential problems and check that: o Participants recognize the staple foods o Willing and able to answer the questions in the way they are asked o No questions are difficult to answer o Address sensitive issues appropriately o Questions are well understood by the participants o Participants have the same understanding of the questions that the interviewers and researchers have o The questionnaire and recall form are designed with adequate space for responses

○ The interview will not interfere with the participants ability to perform their necessary daily tasks ○ The interview does not take too long (but interviewer will get faster)
16:45-17:00 (15 min) - Questions and Answers for day two
17:00-17:30 (30 min) – Whole group meets to review plan for field exercise tomorrow

Day 3
Field testing (AM) & debriefing (PM)

Appendix 5: Nutrient values imputed

Food item added to ESHA database	Energy (kcal)	Prot (g)	Carb (g)	Fat (g)	H2O (g)	Vit A (RAE)	B1 (mg)	B2 (mg)	B3 (mg)	B6 (mg)	B12 (mcg)	Ca++ (mg)	Fe++ (mg)	Zn++ (mg)	Imputing notes (when food differed)
FOF, (star) gooseberry (fruit), Indian, ASEAN, TH, 100g EP (sauropus)										USDA	USDA			USDA	/
FOF, Acacia leaves, Cha Om, ASEAN, EP, 100g										USDA	USDA				Used kangkong values
FOF, Amaranth, spineless, fres, raw, ASEAN, TH, 100g EP, eUSDA										USDA	USDA				/
FOF, Anabas, climbing perch, ASEAN, PH, MY, TH, 100g EP, eUSDA										USDA	USDA				/
FOF, anchovy, fresh, whole, ASEAN, MY, TH, 100g, eUSDA										USDA	USDA				/
FOF, angled loofah, ASEAN, TH, MY, PH, 100g EP										/	/				No imputed values
FOF, apple, green, ASEAN, PH, TH, NE, MY, 100g EP, eUSDA										USDA	USDA				/
FOF, ASEAN, TH, ricebean, seed, dried, red, ckd conv 1:157.5						USDA				USDA	USDA				/
FOF, ASEAN, TH, ricebean, seed, dried, red, raw, 100g						USDA				USDA	USDA				/
FOF, bamboo shoots, spring variety, fresh, raw, ASEAN, 100g EP										USDA	USDA				/
FOF, banana shoot, stem, fresh, raw, ASEAN-THD, 100g										USDA	USDA				Used bamboo shoots
FOF, Banana, cavendish, ripe, ASEAN, PH, ID, TH, MY, 100g EP										USDA	USDA				/
FOF, banana, flowers and buds, fresh, raw, ASEAN, MY..., 100g EP										/	USDA				No imputed value for B6
FOF, Banana, unripe, pg. 101, VW, EP, 100g					USDA	USDA									Used INTL banana
FOF, beef meat ball, ASEAN, TH, 100g						USDA	USDA	UDSA	USDA	USDA	USDA			USDA	/
FOF, beef stomach, intestine, VW, 100g EP						USDA									/
FOF, Beef, blood, ASEAN, PH, VN, HF, 100g EP							USDA			USDA	USDA			USDA	Used ox blood for B1 & Zn; blood sausage for B6 & B12
FOF, beef, dried, pg. 353, VW, EP, 100g					USDA	USDA				USDA	USDA			USDA	/
FOF, beef, top loin, lean only, trim to 1/8" fat, prime, raw						USDA									/
FOF, Bell peppers, green, capsicum, fresh, raw, ASEAN, VN..., 100g EP										VW	VW				/
FOF, Bird chilli (chili pepper), small, dried, ASEAN, TH, 100g EP										USDA	USDA			USDA	/

Food item added to ESHA database	Energy (kcal)	Prot (g)	Carb (g)	Fat (g)	H2O (g)	Vit A (RAE)	B1 (mg)	B2 (mg)	B3 (mg)	B6 (mg)	B12 (mcg)	Ca++ (mg)	Fe++ (mg)	Zn++ (mg)	Imputing notes (when food differed)
FOF, bird nest, in sealed bottle, ASEAN, TH, 100g EP						/			/	/	/			/	No imputed values
FOF, biscuit, VM, p. 462, EP, 100g					USDA	USDA				USDA	USDA			USDA	/
FOF, bitter gourd, leaf and top, raw, ASEAN, PH, 100g EP										USDA	USDA			USDA	/
FOF, bitter gourd, mixed variety, raw, ASEAN, PH..., 100g EP, melon										USDA	USDA				/
FOF, breast milk, human, 6 months lactation, ASEAN, TH, per 100g						USDA				USDA	USDA			USDA	/
FOF, Buffalo, meat, pg. 301, VW, EP, 100g					USDA	USDA					USDA				/
FOF, Cabbage Chinese, salted, ASEAN, ID..., 100g EP, pickled										USDA	USDA			USDA	/
FOF, Cabbage, Chinese, fresh, raw, ASEAN, ID, 100g EP										USDA	USDA				/
FOF, cabbage, common, fresh, raw, ASEAN, ID..., 100g EP										USDA	USDA				/
FOF, carabao energy drink, 250mL can = 250g		USDA		USDA	USDA	USDA	USDA	USDA				USDA	USDA	USDA	Used redbull
FOF, Carp, common, ASEAN, PH..., 100g EP, fish										USDA	USDA			USDA	/
FOF, carrot, raw, ASEAN, VN..., 100g EP										USDA	USDA				/
FOF, cassava, young leaf and top, ASEAN, VN..., 100g EP										USDA	USDA			USDA	/
FOF, cassia, leaf, raw, ASEAN, TH										USDA	USDA			USDA	Used bay leaf, dried x 0.33 for raw
FOF, Catfish, w/ skin, steamed, ASEAN, 100g (Pangasius, Clarias, fish)						USDA				USDA	USDA				/
FOF, chicken blood, cooked, ASEAN, TH, 100g EP						USDA	USDA	USDA	USDA	USDA	USDA			USDA	Used ox blood for B1 & Zn; blood sausage for B6 & B12
FOF, Chicken, breast, w/ skin, raw, ASEAN, TH..., 100g EP										USDA	USDA				/
FOF, Chicken, liver, raw, ASEAN, VN..., 100g EP										USDA	USDA				/
FOF, chili, red, hot, fresh, ASEAN, TH, 100g EP										USDA	USDA			USDA	/
FOF, chilli, leaves, all varieties, EA, EP, 100g					USDA	USDA				USDA	USDA			USDA	Used basil leaves
FOF, clam, undulated, ASEAN, TH, 100g EP						USDA	USDA		USDA	USDA	USDA			USDA	/
FOF, Coconut (meat), mature kernel, ASEAN, PH..., 100g EP										USDA	USDA			USDA	/
FOF, Coconut (meat), very immature, ASEAN, PH..., 100g EP										USDA	USDA			USDA	Used raw, shredded x 0.116

Food item added to ESHA database	Energy (kcal)	Prot (g)	Carb (g)	Fat (g)	H2O (g)	Vit A (RAE)	B1 (mg)	B2 (mg)	B3 (mg)	B6 (mg)	B12 (mcg)	Ca++ (mg)	Fe++ (mg)	Zn++ (mg)	Imputing notes (when food differed)
FOF, Coconut cream, ASEAN, PH, MY, 100g EP										USDA	USDA			USDA	/
FOF, coconut juice, ASEAN, TH, 100mL = 100g EP						USDA	USDA	UDSA	USDA	USDA	USDA			USDA	/
FOF, Coconut milk, canned, ASEAN, TH, per 100mL, 100g										USDA	USDA			USDA	/
FOF, coriander seed, ASEAN, TH, 100g EP										USDA	USDA			USDA	/
FOF, coriander, leaf, raw, ASEAN, VN..., 100g EP										VW	USDA				/
FOF, Corn, baby (immature), ASEAN, TH, 100g EP						USDA				USDA	USDA			USDA	/
FOF, Corn, white, EA, EP, 100g					USDA	USDA				USDA	USDA			USDA	/
FOF, Corn, yellow, on the cob, boiled, ASEAN, PH, TH, 100g EP										USDA	USDA			USDA	/
FOF, Crabmeat, mud (fresh water, boiled, ASEAN, TH..., 100g EP										USDA	USDA				/
FOF, cricket, bug, insect, ASEAN, TH, 100g EP						ASEAN				/	/			/	Used hornet for VitA; none imputed for B6, B12, & zinc
FOF, Cucumber, pickled, pg. 196, VW, EP, 100g				USDA	USDA	USDA									/
FOF, cucumber, small, ASEAN, TH, 100g EP										USDA	USDA				/
FOF, dog, meat, pg. 286, VW, EP, 100g			USDA		USDA	USDA				USDA	USDA			USDA	Used beef, back ribs, w/ bone, braised, select, 0" trim
FOF, dried fish, miscellaneous, VW, 100g					USDA	USDA				USDA	USDA			USDA	/
FOF, dried lotus seed, VW, 100g EP						USDA				USDA	USDA				/
FOF, Duck egg, embryonated, pg. 429, VW, EP, 100g (same as other)					USDA	RG				RG	RG			RG	/
FOF, Duck, egg, embryonated (fertilized), VW, 100g					USDA	RG				RG	RG			RG	/
FOF, Duck, liver, raw, ASEAN, VN, PH, 100g EP										USDA	USDA			USDA	/
FOF, duck, meat, raw, ASEAN, VN, TH, 100g EP						USDA				VW	VW			VW	/
FOF, durian, assorted, ASEAN, PH..., 100g EP (civet)										USDA	USDA				/
FOF, eel, silver pike, sea water, raw, ASEAN, PH, VN, 100g EP										USDA	USDA			USDA	/
FOF, egg, duck, whole, ASEAN, TH..., 100g EP										USDA	USDA				/
FOF, egg, duck, yolk, ASEAN, PH..., 100g EP										USDA	USDA				/
FOF, eggplant, brinjal, raw, ASEAN, TH, 100g EP (big, aubergine)										VW	VW				/

Food item added to ESHA database	Energy (kcal)	Prot (g)	Carb (g)	Fat (g)	H2O (g)	Vit A (RAE)	B1 (mg)	B2 (mg)	B3 (mg)	B6 (mg)	B12 (mcg)	Ca++ (mg)	Fe++ (mg)	Zn++ (mg)	Imputing notes (when food differed)
FOF, eggplant, small, round, pg. 88, VW, EP, 100g				USDA	USDA	USDA				USDA	USDA				/
FOF, fish ball, uncooked, ASEAN, PH, MY, 100g										USDA	USDA			USDA	/
FOF, Fish sauce (tuk try), 100g (same as ASEAN)										USDA	USDA			USDA	/
FOF, fish sauce, ASEAN, MYG, VNN, 100g										USDA	USDA			USDA	/
FOF, Fish, Catfish, VW, EP, 100g (same as ASEAN)						USDA	USDA			USDA	USDA				/
FOF, fish, mackerel, canned, VW, 100g			USDA			USDA				USDA	USDA			USDA	/
FOF, Fish, Snakehead, pg. 382, VW, EP. 100 g						USDA				USDA	USDA		USDA	USDA	/
FOF, Fish, snakehead, VW, (Channastriata, was sergeant, x1.3 for ckd)						USDA				USDA	USDA		USDA	USDA	/
FOF, Fish, Snakehead, VW, EP. 100 g, same as other						USDA				USDA	USDA		USDA	USDA	/
FOF, Frog (meat), small, ASEAN, TH, 100g EP						USDA				USDA	USDA	USDA		USDA	/
FOF, galangal, likely raw/fresh, ASEAN, TH, 100g										USDA	USDA				Used ginger
FOF, ginger, root, fresh, ASEAN, VN..., 100g EP										USDA	USDA			USDA	/
FOF, glutinous rice flour, white, ASEAN, MY, VN, 100g EP										VW	VW			USDA	/
FOF, Glutinous Rice, white, polished, ASEAN, ckd eqiv 1:1.575										USDA	USDA			USDA	/
FOF, Glutinous Rice, white, polished, raw, ASEAN, PH..., 100g EP										USDA	USDA			USDA	/
FOF, Gourami, snake skin, raw, ASEAN, EP, 100g										/	/			RG	No imputed values for B6 and B12
FOF, Gourd, bitter, young leaves, 100g (same as ASEAN)										USDA	USDA			USDA	/
FOF, gourd, bottle, raw, ASEAN, PH..., 100g EP, Calabash										USDA	USDA				/
FOF, Gourd, Sponge, raw, ASEAN, TH..., 100g EP										USDA	USDA			VW	Used bottle gourd
FOF, gourd, wax, mixed variety, ASEAN, 100g EP, asgourd, winter melon										USDA	USDA				/
FOF, grape, assorted, ASEAN, TH, NE, MY										USDA	USDA				/
FOF, grapefruit, sour, VW, 100g				USDA		USDA				USDA	USDA				/
FOF, Guava, white flesh, ASEAN, PH..., 100g EP										USDA	USDA				/
FOF, hen egg, whole, ASEAN, VN..., 100g EP										VW	VW				/

Food item added to ESHA database	Energy (kcal)	Prot (g)	Carb (g)	Fat (g)	H2O (g)	Vit A (RAE)	B1 (mg)	B2 (mg)	B3 (mg)	B6 (mg)	B12 (mcg)	Ca++ (mg)	Fe++ (mg)	Zn++ (mg)	Imputing notes (when food differed)
FOF, HKI, skin tiger cake, per 100g, Nutrition Facts Table				USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	Used snack mix, oriental, rice
FOF, Hog (pork), intestine, large, raw, pg. 324, VW, 100g EP						USDA				USDA	USDA			USDA	/
FOF, Hog (pork), intestine, VW, pg. 324, 100g EP (same as other)						USDA				USDA	USDA			USDA	/
FOF, holy basil, leaf, fresh, ASEAN, TH, 100g EP										USDA	USDA				/
FOF, holy basil, leaf, fresh, ASEAN, TH, 100g EP, original item										USDA	USDA				/
FOF, horseradish-tree, leaf, raw, ASEAN, TH, 100g EP (drumstick tree)										USDA	USDA			USDA	/
FOF, Indian pennywort, leaf, raw, ASEAN, MY..., 100g EP										USDA	USDA			USDA	Used vinespinach, raw
FOF, ivygourd, fresh, raw, ASEAN, THD, 100g										/	USDA				No imputed value for B6
FOF, jackfruit, fresh (mature, ripe), ASEAN, PH..., 100g EP										USDA	USDA			USDA	/
FOF, Jackfruit, mature (khno tum), 100g (same as ASEAN)										USDA	USDA			USDA	/
FOF, jackfruit, unripe, ASEAN, EP, 100g										USDA	USDA			USDA	/
FOF, jelly with coconut cream, ASEAN, THT, 100g							USDA	USDA	USDA	USDA	USDA		USDA	USDA	Used dessert, gelatin
FOF, juice, coconut (water), immature (young) kernel, ASEAN, 100g EP						USDA	USDA	USDA	USDA	USDA	USDA			USDA	/
FOF, juice, winter melon, KaKa brand, 55g/srvg, but assume = 270g						USDA	USDA	USDA	USDA	USDA	USDA			USDA	Used pineapple juice
FOF, Jujube, ASEAN, PH..., 100g EP (Chinese date)										USDA	USDA			USDA	/
FOF, jujube, common or Chinese date, VW, 100g EP (same as ASEAN)										USDA	USDA			USDA	/
FOF, Kale, Chinese, raw, ASEAN, MY, TH, 100g EP (leaves and stems)										USDA	USDA			USDA	/
FOF, knifefish, featherback, ASEAN, TH, 100g (raw)										USDA	USDA			USDA	Used perch for B12
FOF, lancet/langsium/langsat, ASEAN, 100g (long kong fruit, duku)						USDA				USDA	USDA				Used lychee, raw for VitA & B6
FOF, leaves Amaranth spinosus (ge), 100g (same as ASEAN)										USDA	USDA			USDA	/
FOF, leaves, Holy basil, 100g (same as ASEAN)										USDA	USDA				/
FOF, leaves, Ivy gourd, coccinia, 100g (same as ASEAN)										/	USDA				No imputed value for B6

Food item added to ESHA database	Energy (kcal)	Prot (g)	Carb (g)	Fat (g)	H2O (g)	Vit A (RAE)	B1 (mg)	B2 (mg)	B3 (mg)	B6 (mg)	B12 (mcg)	Ca++ (mg)	Fe++ (mg)	Zn++ (mg)	Imputing notes (when food differed)
FOF, Leaves, pumpkin, raw, 100g (same as ASEAN)										VW	VW			VW	/
FOF, Leek, Chiniese, onion, fragant, ASEAN, MY, VN, 100g EP						USDA				USDA	USDA				/
FOF, lemon, VW, EP, 100g						USDA					USDA				/
FOF, Lemongrass, 100g (same as ASEAN)										USDA	USDA				/
FOF, lemongrass, ASEAN, THN, 100g										USDA	USDA				/
FOF, Lettuce, garden, leaf and petiole, ASEAN, PH..., 100g EP										USDA	USDA			USDA	/
FOF, Litchi (Lychee), ASEAN, PH..., 100g EP										USDA	USDA				/
FOF, lolot (piper leaves, pepper), VW, 100g EP						USDA	USDA	USDA	USDA	USDA	USDA			USDA	Used grape leaf, fresh
FOF, Longan, fresh, ASEAN, ID..., 100g EP										USDA	USDA				Used lychee, raw for B6
FOF, Longkong, Langsat, Lancet, fruit, ASEAN, 100g EP						USDA				USDA	USDA				Used lychee, raw for VitA & B6
FOF, lotus seed, raw, VW, 100g EP						USDA					USDA				/
FOF, lotus, stem underground, VW, 100g EP						USDA					USDA				/
FOF, Mandarin/tangerine, ASEAN, TH, VN, MY, 100g EP (orange)										VW	USDA				/
FOF, Mango, kaew variety, magure, unripe, ASEAN, TH, 100g EP										USDA	USDA				/
FOF, mango, num-dok-mai variety, ripe, ASEAN, TH, 100g EP										VW	USDA				/
FOF, mangosteen, ASEAN, PH, TH, MY, 100g						USDA				USDA	USDA				/
FOF, milk, condensed, sweetened, ASEAN, TH..., 100g EP										USDA	USDA			USDA	/
FOF, milk, pasteurised, natural, ASEAN, TH, per 100mL (100g)									USDA	USDA	USDA			USDA	/
FOF, Milklo powder, B-vitamins, 1 package = 15g	/	/	/	/	/	/						/	/	/	No imputed values
FOF, Mint, leaf, ASEAN, MY..., 100g EP										USDA	USDA			USDA	/
FOF, Mungbean, Sprouts, Pickled, pg. 197, VW, EP, 100g						USDA	USDA	USDA	USDA	USDA	USDA			USDA	/
FOF, Mungbean, Sprouts, Pickled, VW, EP, 100g (same as other)						USDA	USDA	USDA	USDA	USDA	USDA			USDA	/
FOF, mungo (mung) bean, flour, VW, pg. 72, 100g EP						USDA									/
FOF, Mungobean (mungbean), sprouts, green gram, VW, pg. 118, 100g						USDA									/

Food item added to ESHA database	Energy (kcal)	Prot (g)	Carb (g)	Fat (g)	H2O (g)	Vit A (RAE)	B1 (mg)	B2 (mg)	B3 (mg)	B6 (mg)	B12 (mcg)	Ca++ (mg)	Fe++ (mg)	Zn++ (mg)	Imputing notes (when food differed)
FOF, mushroom, grey, oyster, fresh, raw, ASEAN, MY, TH, 100g EP										USDA	USDA				/
FOF, mussel, green, raw, ASEAN, TH, 100g EP						USDA				USDA	USDA				/
FOF, Mustard (green), Chinese, leaf, pickled, ASEAN, VN..., 100g EP										VW	VW			VW	/
FOF, Mustard green, India, leaf and stem, ASEAN, VN, MY, 100g EP										USDA	USDA			USDA	/
FOF, Mustard green, pickled, 100g (same as ASEAN)										VW	VW			VW	/
FOF, Noodle, rice, fresh, kulh-teow, ASEAN, TH, MY, 100g EP						USDA				USDA	USDA			USDA	/
FOF, noodle, wheat, ASEAN, TH, 234.8g, equiv to ckd, 1:2.3						USDA	USDA	USDA	USDA	USDA	USDA			USDA	/
FOF, noodle, wheat, dry, ASEAN, TH, 100g EP						USDA	USDA	USDA	USDA	USDA	USDA			USDA	/
FOF, onion, large, ASEAN, PH, VN, MY, 100g EP										USDA	USDA			USDA	/
FOF, Onion, spring (bunching), ASEAN, PH, MY, 100g EP										VW	VW			VW	/
FOF, orange juice, 100%, per 100mL, ASEAN, THQ, 100g						USDA				USDA	USDA			USDA	/
FOF, oyster sauce, ASEAN, TH, MY, 100g EP										USDA	USDA			USDA	/
FOF, palm fruit juice, 100%, ASEAN, TH, 100mL = 100g						USDA				USDA	USDA			USDA	Used coconut juice for VitA, B6, & zinc
FOF, Palm oil, 100g (same as ASEAN)					USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	/
FOF, Palm, fruit, pg. 67, VW, EP, 100g						ASEAN	ASEAN	ASEAN	ASEAN	ASEAN	USDA			ASEAN	Used ASEAN coconut, immature X 0.116
FOF, Papaya, ripe, ASEAN, PH, TH, VN, MY, 100g EP										USDA	USDA				/
FOF, papaya, unripe, raw, ASEAN, PH, TH, VN, 100g EP										USDA	USDA				/
FOF, paste, shrimp, fermented (Ka-pi), ASEAN, TH, 100g EP						USDA				USDA	USDA				Used Japanese fish paste for B6 & B12
FOF, peanut/groundnut, seed, w/skin, dried, raw, ASEAN, 100g EP										USDA	USDA				/
FOF, Pineapple, ASEAN, PH, MY, VN, TH, 100g EP										USDA	USDA				/
FOF, Pineapple, juice, pg. 452, VW, EP, 100g						USDA									/
FOF, Pork (hog), blood, cooked, ASEAN, TH, 100g EP						USDA	USDA			USDA	USDA				Used beef blood for B6 & B12
FOF, Pork (hog), lung, raw, ASEAN, VN..., 100g EP										VW	VW			VW	/

Food item added to ESHA database	Energy (kcal)	Prot (g)	Carb (g)	Fat (g)	H2O (g)	Vit A (RAE)	B1 (mg)	B2 (mg)	B3 (mg)	B6 (mg)	B12 (mcg)	Ca++ (mg)	Fe++ (mg)	Zn++ (mg)	Imputing notes (when food differed)
FOF, pork skin (=~ears), VW, 100g EP						USDA			USDA	USDA	USDA			USDA	/
FOF, pork, head meat, steamed, VW, pg. 348, 100g EP						USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	Used bacon, cured
FOF, Pork, lean and fat (bacon), pg. 294, VW, EP, 100g						USDA									/
FOF, pork, lean, pg. 298, VW, EP, 100g						USDA									/
FOF, Pork, leg, deboned, raw, ASEAN, PH, VN, 100g EP										VW	VW			VW	/
FOF, Pork, liver, raw, ASEAN, VN, PH, TH, 100g EP										VW	VW				/
FOF, pork, medium fat, pg 296, VW, EP, 100g						USDA									/
FOF, Pork, preserved, dried, crushed, EA, #1130, 100g EP						USDA				USDA	USDA			USDA	Used salami, dried, pork
FOF, Pork, rib, deboned, raw, ASEAN, VN, PH, HF, 100g EP										VW	VW				/
FOF, Pork, sausage, pg. 355, VW, EP, 100g						USDA		USDA	USDA	USDA	USDA			USDA	/
FOF, potato crisp, cracker, Win2, MY, SG, pkg 15g					USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	Used snack, potato crisp x 0.5; chips, plain for B1 & B2
FOF, Potato, fresh, raw, ASEAN, PH, TH, MY, 100g EP (white)										VW	VW			VW	/
FOF, Prawn, fresh water, raw, ASEAN, EP, 100g										USDA	USDA			USDA	/
FOF, Pumpkin, raw, ASEAN, TH..., 100g EP										VW	VW				/
FOF, Pumpkin, young leaf, raw, ASEAN, VN, TH, PH, 100g EP										VW	VW			VW	/
FOF, radish, dried, white, pg. 104, VW, EP, 100g						USDA									/
FOF, radish, pickled, EA, #675, 100g EP						USDA	USDA			USDA	USDA			USDA	/
FOF, radish, white, raw, ASEAN, EP, 100g						USDA				USDA	USDA				/
FOF, rambai fruit, ASEAN, TH, 100g						USDA				USDA	USDA				Used lychee, raw for B6 & B12
FOF, Rambutan, fruit, raw, EA, EP, 100g										USDA	USDA				/
FOF, red ant egg, ASEAN, TH, 100g						ASEAN				/	/			/	Used hornet, young; no imputed values for B6, B12, & zinc
FOF, red ant, ASEAN, TH, 100g						ASEAN				/	/			/	Used hornet, young; none imputed for B6, B12, & zinc
FOF, red pepper sauce concentrate, VW, 100g						USDA					USDA				/

Food item added to ESHA database	Energy (kcal)	Prot (g)	Carb (g)	Fat (g)	H2O (g)	Vit A (RAE)	B1 (mg)	B2 (mg)	B3 (mg)	B6 (mg)	B12 (mcg)	Ca++ (mg)	Fe++ (mg)	Zn++ (mg)	Imputing notes (when food differed)
FOF, RG, Beverage, Sweet, flavoured, 100g						USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	Used drink, fruit flavoured, <3% juice
FOF, RG, Candy, toffee, 100g						USDA	USDA	USDA		USDA	USDA			USDA	/
FOF, RG, leaves, pumpkin, boiled, 100g										/	USDA				No imputed value for B6
FOF, RG, Monosodium Glutamate (MSG), 100g						USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	Used salt, table
FOF, RG, Palm sugar, Jaggery (skor kr), 100g							USDA	USDA		USDA					Used sugar, granulated
FOF, RG, Rice Balls Fried (nom jien g), 100g					/	/				/	/				No imputed values
FOF, RG, Rice cake, deep fried (Kanom), 100g					/	/	/	/	/	/	/				No imputed values
FOF, RG, Rice cake, savoury, sticky r, 100g					/	/				/	/				No imputed values
FOF, RG, Rice cake, savoury, sticky r, 100g, WaterEDIT						/				/	/				No imputed values
FOF, RG, Rice cake, sweet, sticky rice, 100g					/	/				/	/				No imputed values
FOF, RG, rice flatbread (khmer pancake), 100g						/				/	/				No imputed values
FOF, RG, rice flatbread, khmer pancake, 100g						/				/	/				No imputed values
FOF, RG, sago cooked, 100g						ASEAN	ASEAN	ASEAN	ASEAN	/	ASEAN		ASEAN		Used sago flour x 0.226; no imputed value for B6
FOF, RG, Salt, table (umbull), 100g	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA			USDA	Used salt, table
FOF, RG, Sugar cane juice, 100g						USDA	USDA	USDA	USDA	USDA	USDA			USDA	Used INTL drink, <3% juice
FOF, RG, Sugar, white (skor sor), 100g						USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	Used sugar, granulated
FOF, RG, Sugarcane (Ampouv), 100g						/	/	/	/	/				/	No imputed values
FOF, RG, Vegetable oil (brang sondae), 100g					USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	Used canola and soybean oil
FOF, rice flour, ordinary, pg. 17, VW, EP, 100g						USDA									/
FOF, rice vermicelli, VW, 100g (assume ckd; 110kcal/100g)						USDA				USDA	USDA			USDA	/
FOF, rice, white, polished, ASEAN (avg recipe, porridge/borbor 1:1730)										VW					/
FOF, rice, white, polished, ASEAN, 257.5g (avg recipe, 1:1.575, ckd)										VW					/
FOF, rice, white, polished, raw, ASEAN, PH..., 100g EP (ordinary, dry)										VW					/
FOF, Roselle (Red sorrel), leaf, raw, ASEAN, TH, 100g EP (teung)										/	USDA		USDA	USDA	No imputed value for B6
FOF, sago tapioca, 100g (same as ASEAN sago flour)										USDA	USDA				/
FOF, salt, non-iodized, pg. 492, VW, EP, 100g										USDA					/

Food item added to ESHA database	Energy (kcal)	Prot (g)	Carb (g)	Fat (g)	H2O (g)	Vit A (RAE)	B1 (mg)	B2 (mg)	B3 (mg)	B6 (mg)	B12 (mcg)	Ca++ (mg)	Fe++ (mg)	Zn++ (mg)	Imputing notes (when food differed)
FOF, Sardine (fish), in oil, canned, drained, ASEAN, TH, 100g EP							USDA	USDA	USDA	USDA	USDA			USDA	/
FOF, Sauropus, sp. leaves, Star Gooseberry, VW, (same as other VW)						USDA				/	USDA				No imputed value for B6
FOF, Sauropus, sp. leaves, VW, pg. 168, 100g EP						USDA				/	USDA			USDA	/
FOF, Sesame, seeds, black or white, pg 69, VW, EP, 100g						USDA									/
FOF, Shrimp, dried, ASEAN, ID, VN, 100g EP						USDA	USDA	USDA		USDA	USDA				/
FOF, Shrimp, fresh water, pg. 412, VW, EP, 100g						USDA	USDA	USDA	USDA	USDA	USDA			USDA	Used shrimp, mixed species, large
FOF, Snack BiDo, Oishi brand (16g pkg from Cambodia)					USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	Used snack mix, oriental, rice
FOF, Snail, fresh water, all species, ASEAN, VN, 100g EP						USDA				USDA	USDA	USDA	USDA	USDA	/
FOF, soursop, ASEAN, PH, MY, 100g EP (Siamese custard apple)					USDA	USDA	USDA	USDA	USDA	USDA	USDA			USDA	/
FOF, soy milk, lactasoy, package, Thailand, 4.23floz, 125mL					USDA	USDA	USDA		USDA	USDA	USDA			USDA	/
FOF, Soy sauce, 100g (from VW, pg. 497, Soybean sauce)						USDA									/
FOF, soya drink, Yeo's, Yeos, Yoes, per 100g = 100mL					USDA	USDA	USDA		USDA	USDA	USDA			USDA	/
FOF, soya milk, lacta brand, HKI, 1 cup = 250g					USDA	USDA	USDA		USDA	USDA	USDA			USDA	/
FOF, Soybean curt cake pressed, raw, VW, 100g EP						USDA					USDA				/
FOF, Soybean oil (k'nar), 100g (same as ASEAN soybean oil per 100mL)					USDA	USDA			USDA	USDA	USDA	USDA	USDA	USDA	/
FOF, Soybean seed, yellow, dried, raw, ASEAN, PH..., 100g Ep										USDA	USDA				/
FOF, soybean sprouts, raw, ASEAN, VN, TH, YD, 100g EP										VW	USDA			VW	/
FOF, soybean, paste, white, ASEAN, MY, TH, 100g (fermented)										USDA	USDA			USDA	/
FOF, soymilk, Yeo's, Yoe's, 300mL can					USDA	USDA	USDA		USDA	USDA	USDA			USDA	/
FOF, Spinach, Malabar, raw, ASEAN, 100g (vinespinach, night shade)										USDA	USDA			USDA	/
FOF, squid, splendid, dried, ASEAN, TH, 100g EP						USDA	USDA	USDA	USDA	USDA	USDA		USDA	USDA	/
FOF, sugar, refined, pg. 473, VW, EP, 100g						USDA					USDA				/

Food item added to ESHA database	Energy (kcal)	Prot (g)	Carb (g)	Fat (g)	H2O (g)	Vit A (RAE)	B1 (mg)	B2 (mg)	B3 (mg)	B6 (mg)	B12 (mcg)	Ca++ (mg)	Fe++ (mg)	Zn++ (mg)	Imputing notes (when food differed)
FOF, Swamp cabbage, kangkong, raw, ASEAN, PH..., 100g EP										VW	USDA				/
FOF, sweet basil, leaf, ASEAN, TH, 100g EP										VW	VW				/
FOF, Sweet potato, leaf, raw, ASEAN, PH..., 100g EP										VW	VW			VW	/
FOF, sweet potato, white, fresh, raw, ASEAN, PH..., 100g EP						USDA				USDA	USDA				/
FOF, sweet potato, yellow, fresh, raw, ASEAN, ID, TH, 100g EP										USDA	USDA				/
FOF, Sweetened Condense Milk, 100g (same as ASEAN)										USDA	USDA			USDA	/
FOF, Tamarind, fruit, ripe, ASEAN, PH..., 100g EP (pulp, raw)										USDA	USDA			USDA	/
FOF, Tamarind, young leaf, raw, ASEAN, PH, TH, 100g EP										/	USDA			USDA	No imputed value for B6
FOF, tapioca pearls, VW, 100g EP						USDA		USDA	USDA	USDA	USDA			USDA	/
FOF, tapioca pearls, VW, 550g, equiv to ckd, 1:4.5						USDA		USDA	USDA	USDA	USDA			USDA	/
FOF, Taro (tuber), fresh, raw, ASEAN, PH..., 100g EP										VW	VW				/
FOF, Taro, stem, cooked, EA, EP, 100g					USDA	USDA	USDA			USDA	USDA			USDA	/
FOF, Tilapia (fish), all species, raw, ASEAN, 100g EP										USDA	USDA				/
FOF, Tomato, raw, ASEAN, PH..., 100g EP										VW	VW				/
FOF, Trai cay say, jackfruit, taro, yam, banana, dried, 28g					ASEAN	ASEAN	ASEAN	ASEAN	ASEAN		ASEAN			ASEAN	Used banana, dried x 0.28; ripe x 1.0 for VitA & B3
FOF, turmeric, rhizome, fresh, ASEAN, PH..., 100g (tumeric)										USDA	USDA			USDA	/
FOF, water hyacinth, leaves, raw, EA, #796, 100g EP						ASEAN	RG	RG	RG	/	ASEAN	ASEAN	ASEAN	RG	Used water lily, stem; no imputed value for B6
FOF, water mimosa, raw, ASEAN, TH, 100g (leaves)										/	USDA				No imputed value for B6
FOF, Waterlily stem, 100g (same as ASEAN, raw)							RG	RG	RG	/	RG			RG	No imputed value for B6
FOF, watermelon, ASEAN, PH..., 100g EP										VW	VW				/
FOF, winged bean, pod, fresh, raw, ASEAN, PH..., 100g EP (goa bean)										USDA	USDA				/
FOF, yard long bean, pod, green, fresh, raw, ASEAN, PH..., 100g EP										USDA	USDA			USDA	Used vinespinach, raw

Food item added to ESHA database	Energy (kcal)	Prot (g)	Carb (g)	Fat (g)	H2O (g)	Vit A (RAE)	B1 (mg)	B2 (mg)	B3 (mg)	B6 (mg)	B12 (mcg)	Ca++ (mg)	Fe++ (mg)	Zn++ (mg)	Imputing notes (when food differed)
Juice, Lychee (litchi), 25% canned, per 100mL, ASEAN, TH, 100g						USDA	USDA		USDA	USDA	USDA			USDA	Used juice drink
T&T, Chinese, golden lotus seed mooncake w/ yolk, 1pc=46.25g					ASEAN	ASEAN	RG	RG	RG	RG	RG		RG	RG	Used ASEAN mooncake x 0.4625; RG egg cake x 0.4625
T&T, instant noodle snack, Baby Star, 45g					USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	Used ramen, noodle x 0.45
T&T, jelly with coconut cream (same as ASEAN)							USDA	USDA	USDA	USDA	USDA		USDA	USDA	Used dessert, gelatin
T&T, milk soft candy, Four Seas, HK, 10.5 candies, 35g					USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	Used candy, honey, chews x 0.833
T&T, prawn crackers, Oishi, Phillippines, 60g					USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	USDA	Used snack mix, oriental x 0.6
T&T, shrimp cracker, Nongshim, Korea, 75g					USDA	USDA	USDA	USDA	USDA	USDA	USDA		USDA	USDA	Used snack mix, oriental x 0.75
T&T, Soursop drink, Number 1, Vietnam, 350mL, 350g					USDA	USDA	USDA	USDA	USDA	USDA	USDA			USDA	/

Notes: Imputed nutrient values entered into the ESHA database where indicated (spaces left blank indicate that values were available from the original source). USDA: USDA food composition database, ASEAN: ASEAN food composition database, VW: Vietnamese food composition database, RG: Foods analyzed by Victoria Anderson and Rosalind Gibson, FOF: signifies a new food item entered into the ESHA database for the FoF project, T&T: signifies international food products found in T&T grocery and entered into ESHA.

Appendix 6: Data entry protocol and assumptions made

24-Hour Recall Data Entry Notes Google Doc
For Vashti, Ingrid, and Mandy

IMPORTANT: After entering each mother/child and recipes (for endline), click the save icon. Then, go to "file" and click and "save to file". Save to the appropriate folder (i.e. "ESHA new ingredients," "EL Recipes", "EL 24HR" etc.). The program shuts down if you have too many people or recipes open, so just do one mother/child unit at a time, save and close. Then repeat. Thanks!

When exporting data for each "Person", click on "Multi-column" under "Reports" (on the left hand side), then click the "Reports" tab on the top, and click "Export report" → "To file" (to Libraries → Documents → ESHA endline 24HR).

Computer login: food
Locker combination: 15, 56, 35 (the lock is sticky)

NAMING SUBJECTS & RECIPES (must enter weight/age/etc → use generic values)

Endline mother: Name: EL999FOFmother Gender: Female Age: 25 yrs Activity level: Very active Height: 5'0" Weight: 100lbs	**Endline child:** EL999FOFchild Gender: female Age: 5 yrs Activity level: Very Active Height: 3'4" Weight: 40 lbs
Repeat: REL999FOFmother	**Repeat recalls:** REL999FOFchild
Intra-rater reliability check: VEL999FOFmother	**Intra-rater reliability check:** VEL999FOFchild

Recipe name: EL999FOF recipe name **For volume:** adjust water to match volume of recipe (if liquid based, like soups or porridge)
New ingredient names: FOF, food item name (broad → specific), database, portion size(s) eg) FOF, fish, sergeant, cooked, steamed, VW, EP, 100g
Naming Rosalind Gibson's (RG) food ingredients: eg) FOF, RG, food name, 100g

Fish/meat conversions (from raw to cooked): (cooked kcal) / (raw kcal) = conversion factor

Food - Fish (per 100g)	**ESHA (kcal) raw**	**ESHA (kcal) bkd, brld, stmd**	**FOF, VW, or ASEAN (kcal)**	**Conversion factor**
carp	127	162	96 (VW) to… 105 (ASEAN)	x 1.28 → x 1.3
snakehead	-	-	97 (ASEAN)	x 1.3
catfish (farm)	135	152	173 (VW) to… 188 (ASEAN) “steamed”	- NONE
perch	94	121	126 (VW) to... 145 (ASEAN)	- NONE
tilapia	96	128	100 (VW) to… 94 (ASEAN)	x 1.33 → x 1.3
sergeant fish (channastriata)	?	?	115 (VW) to… 97 (ASEAN for snakehead, so multiplied by 1.3 = 126.1kcal for cooked)	• NONE (okay, b/c mult. ingredient when change from sergeant to snakehead)
eel	184	236	180 (VW) to… 88 (ASEAN)	x 1.28 → x 1.3
dry/dried fish (misc)	127 average	-	208	(use dried fish measure) If raw fish used x 1.6
frog (leg)	73	106	90	- NONE
crab	90	115	87	x 1.3

Food - Meat (per 100g)	**ESHA (kcal) raw**	**ESHA (kcal) bkd, brld, stmd**	**FOF, VW, or ASEAN (kcal)**	**Conversion factor**
Pork	avg cuts: 211	avg cuts: 201	lean: 139 lean & fat: 260	none (raw ~= ckd)
Pork liver	raw: 134	braised: 165	116	= 1.23 = **x 1.2**

Chicken (without skin)	w/o skin: 114	w/o skin: 165	141	none (FOF ~= avg)
chicken (with skin)	w/ skin: 258	w/ skin: 285	NA - assume FOF w/o skin	= x1.1
beef	avg cuts select ⅛” trim: 223	avg cuts select ⅛” trim: 278	prime ⅛” raw: 127	**x 1.25**
snail	90	stmd: 247	84	x 2.7 (but use raw b/c in shell)
duck	w/o skin: 132 w/ skin: 404	w/o skin: 201 w/ skin: 227	VW “avg”: 267	none (FOF ~= avg of all 4)
sardine	w/o skin & bone, w/water: 217 Norwegian brisling: 160		124	too different, leave as is

Food - Other (per 100g)	**ESHA (kcal) raw**	**ESHA (kcal) bkd, brld, stmd**	**FOF, VW, or ASEAN (kcal)**	**Conversion factor**
Mango	fresh: 67	**dried**: 350	ripe: 62 unripe: 67	x 5.2 → **x 5** (for dried mango)
soybean	dry = 416	**cooked = 173**	dry = 400	used Esha cooked/dried (divide dry by 2.4 to get cooked amount)

If not listed on “Snack Package” spreadsheet, use these values:

100 Riel snack/cake package (bowl #2 or #3)	**200 Riel snack/cake package (bowl #2)**	**300 & 500 Riel snack/cake package (bowl #1, plate #3)**
Generic: 8g → use BiDo, Oishi brand *1/2 bowl #3 = 4g* *ladle #3, slice #1, piece #1 = 2g* *spoon #1 or 2 spoon #2 = 1g*	Generic: 8g → use BiDo e.g. banh trang cake	Generic: 18g → use BiDo

all other <spoon #1 = 0.5g		
/	/	BiDo: 16g (made with wheat flour)
LyLy (or Lala, Luxus) or Num Thung: 8g (rice/corn flour) Brand: corn, potato, cow Flavours: strawberry, durian → use USDA cereal, corn, rice If chocolate flavour → use USDA cereal, cocoa puffs (for ½ glass #3 = 4g)	LyLy: 22g (rice/corn flour) Brand: milk (fortified with iron but not captured here) → use USDA cereal	LyLy: 25 (wheat flour) Flavors: crab, onion, potato, burger, fish, shrimp, tomato, duck → use Bido
Sakura (octopus/squid, potato): 6g Sakura (crab): 8g Banh kem xap (shrimp) → use T&T shrimp crackers (for spoon #1=3g, #2 = 2g #3 = 1g)	Sakura (taro): 10g → use ESHA "taro chips" (Canadian)	Sakura: 18g → use T&T shrimp crackers
Fried (instant) noodle snack: 8g → use T&T noodle...	8g	18g (300 - 600 Riel)
nom sla cake: 6g (1 pkg) → rice, corn, chocolate, sugar, cocoa, butter oil (pic from SK) → use: ESHA "cereal, cocoa puffs"		
mung bean package cake → use ESHA peas, green, freeze dried		
package heart shape cake → use ESHA white cake w/o frosting, prep f/recipe → 1 slice #2 = 4g →**10g** (per HKI: wheat flour, sugar, butter, milk powder, vegetable oil, vanilla, artificial flavor, salt = 10g)		
long round cake, long cake (10cm) → assume 100Riel roll = 8g (per HKI: rice flour, sugar, coconut milk) → use ESHA cake w/rice flour, prep f/dry		→ assume 500Riel roll = 18g
chop stick cake → assume 1 piece #2 100Riel = 8g		

(per HKI: rice flour, deep fried in oil) → use RG rice cake deep fried (Kanom)		
Dried banana, jackfruit, taro, yam → use "Trai cay say…" (package bought in Cambodia) → assume 100Riel = 8g		→ assume 500Riel = 18g
If potato chips, use ESHA chips, potato, plain (use generic measures)		
Skin tiger cake 1 loaf = 9g (info for CHO, fibre, sugar, protein)		
Num changkes, chorngkes → use ESHA pretzels 100Riel = 8g		

Dessert Table
Red = original recipe, Purple = "MadeFor" recipe (or one from HKI)

Dessert recipe # Recipe = total H20 vol.	**Main ingredients**	**Similar cakes/desserts (for substitution)**	**Common measures**
#20 "chek bok, bot cake" Recipe = 3678g (3 soup bowl #1) (recipe makes 3607.8g)	glutinous rice flour, ripe coconut meat, sugar, oil	• chek bok • bot cake • num bat • num krouch (also #80) • num ko vech • bankery • num trom	plate #3 = 0.07 1 Piece #1 = 0.01 1 Piece #2 = 0.004 2 Piece #2 = 0.01 slice #1 = 0.007 bowl #2 = 5x piece #1 = 0.05 bowl #3 = 2x piece #1 = 0.02
"MadeFor nom porng cake" Recipe = 2160g (from #20, w/o 1.5kg ckd mung bean, w/o 92g coconut, w/o 18.5g oil, w/ 92g sesame)	glutinous rice flour, sugar, sesame seeds	• num porng cake • num kong (w/rice) • num kang • num treab • soi cake • porng rolork	Piece #1 = 0.02 (48kcal) Piece #2 = 0.006 (15kcal) Slice #1 = 0.01 Slice #2 = 0.0014 Plate #3 = 0.12 Plate #2 = 0.16 bowl #3 = 0.034 (81kcal) bowl #1 = 0.144 bowl #2 = 0.085 ladel #1 = 0.024

			ladel #3 = 0.015
MadeFor134 corn dessert Recipe = 2178g (from #20, w/o 1.5kg ckd mung bean)	corn, black sesame seeds, coconut meat, sugar	• corn dessert	bowl #2 = 0.085
"MadeFor nom pum cake" Recipe = 2160g (from #20, w/o 1.5kg ckd mung bean, w/o 18.5g oil, w/ 92g sesame AND 92g coconut)	glutinous rice flour, sugar, sesame seeds, coconut	• nom pum cake • num banh duk	See above "MadeFor nom porng"
"MadeFor nom pum cake 2" Recipe = 2160g (from #20, w/o 1.5kg ckd mung bean, plus 56g duck egg)	glutinous rice flour, coconut meat, sugar, oil, duck egg	• num pum (2nd) • bach cheo • banh cheo • ban cheo	See above "MadeFor nom porng"
#80 "nom banh ou" Recipe = **80 cakes (100kcal/cake)**	*glutinous rice ckd, ricebean ckd, palm sugar (minused 4,667g water to account for water in ricebean and rice)*	• num banh ou • num ansom chrouk • nom tean, tream • chableang • num krouch (looks like donut holes; also #20) • num kantom • num kantrom • banh sou	bowl #2 → 1 cake = 1/80 serving *(100kcal)* bowl #3, ½ bowl #2, 2 piece #1, glass #3 → ½ cake = 1/160 serving *(50kcal)* 1 pc #1, 2 pc #2, 1 ladle #3 → ¼ cake = 1/320 serving 2 piece #2 = ⅔ piece #1 = (⅔)x(1/320) = 2/960 = 1/480 ¾ cake (3 piece #1) = 3/320 plate #1 = ~3 cakes = 3/80 ladle #3 = 0.2 of cake = 0.0025 serving bowl #1 = 0.02 serving
#4 banh chaneork Recipe = 24,520g (20 soup bowls #1)	*sticky rice, ricebean, sugar, coconut meat*	banh chaneurk (also see below)	soup bowl #1 = 0.05 soup bowl #3 = 5 pc. #2 = 0.017 of rec.

			bowl #1 = 0.013
#565 Repeat: banh chaneork Recipe = 2452g (2 soup bowls #1)	*sticky rice flour, ckd ricebean, sugar, oil, garlic, salt, pepper*	banh chaneuk (also see below)	bowl #2 = 0.075 bowl #3 = 0.03
#102 "banh chaneork" Recipe = **1226g** = Soup bowl #1 (Rec. makes 1600g, but assume 457g H20 evaporated) *(used for a guide on black bean dessert, to add sugar, salt/portion)*	*glutinous rice flour, ricebean, coconut meat, palm sugar*	• banh chaneork • banh chanoeuk • kou cake • ricebean dessert • num kantuok • num kantork • banh bev cake • cha dov • treab (or MadeFor nom porng) • treap bay • casava dessert • akor (see HKI)	bowl #1 = 0.25 bowl #2 = 0.15 *(239kcal)* bowl #3 = 0.06 mug #2 = 0.22 *(756kcal)* mug #3 = 0.17 ladle #3 = 0.026 Plate #1 = 0.43 Plate #2 = 0.28 Plate #3 = 0.21 Piece #1 = 0.03 Piece #2 = 0.01 Slice #1 = 0.02 Slice #2 = 0.0024 spoon #1 = 0.007
"MadeFor Pong Ansong" Recipe = ~**1226g** (from #102 but w/o 36g coconut)	*glutinous rice flour, ricebean, palm sugar*	• pong ansang • pong ansong • pong ansorng • kom porng • banh bev • num pear cake	see #102 measures
"MadeFor puon skar" Recipe = 818g (from #102, minus 36g coconut = 4.5 spoon #1; & 300g adzuki = 2 bowl #2, subtract 408.5g water volume)	rice flour, palm sugar	• puon skar • num kantuok • num korng • num andat kou • num pa o ("rice flour only") • kang cake • num ko	bowl #1 = 0.38 bowl #2 = 0.22 (255kcal) bowl #3 = 0.09 piece #1 = 0.046 piece #2 = 0.016 slice #1 = 0.03 ladle #2 = 0.055

		• andat kor • num kor, korn • worm cake	
"MadeFor num lapov" Recipe = 1226 (from #102, replaced adzuki with pumpkin 300g for 300g, minus 36.7g coconut)	glutinous rice flour, pumpkin, palm sugar, salt	• Num lapov • pumpkin dessert	see #102 measures
"MadeFor num lapov 2" Recipe = 1226 (from #102, replaced adzuki with pumpkin 300g for 300g)	glutinous rice flour, pumpkin, palm sugar, salt, coconut	• Num lapov w/ coconut	see #102 measures
"MadeFor395, corn dessert" Recipe = 1226 (from #102)	corn flour, jack fruit, palm sugar, salt, coconut milk	• corn dessert	see #102 measures
#238 "num ansam chrouk" Recipe = 8420g (20 soup bowls #3)	glutinous rice, mung beans, pork, salt, msg, pepper, garlic	• num ansam chrouk	mug #3 = 0.025 (304 kcal) bowl #1 = 0.037 bowl #2 = 0.022 bowl #3 = 0.009 piece #1 = 0.004 piece #2 = 0.0015 slice #1 = 0.003 plate #3 = 0.03
MadeFor num kruok (Made from #238)	glutinous rice, mung beans, red ant, salt, msg, pepper, garlic		Used #238 measures
#253 "palm cake" Recipe #253 = 2452g (2 soup bowl #1)	rice, palm fruit, sugar	• palm cake **(also see #432 and #598)**	**bowl #2 = 0.075 (101kcal)** **bowl #1 = 0.13**
#354N "koun trey" Recipe = 1226g (Soup bowl #1)	glutinous rice flour, coconut meat, sugar	• koun trey • tien cake • Chkrachan	bowl #2 = 0.15 of rec. ⅔ bowl #2 = 0.10 of rec. (205kcal)

		Chakrachan Chakachan Chack Krochan	bowl #3 = 0.06 piece #1 = 0.03 soup bowl #3 = 0.34
#391 "mung bean dessert" Recipe = 1839 (1.5 soup bowl #1)		• mung bean dessert (use HKI recipe)	bowl #1 = 0.17 spoon #2 = 0.0016
#897 nom thnort Recipe = **4904g** (4 soup bowl #1)	*glutinous rice ckd, sugar, palm fruit, coconut*	• num/nom thnort/thnaot/ thnoat	bowl #1 = 0.064 (*443kcal*) piece #2 = 0.003 bowl #2 = 0.037
#432 "nom thnort" Recipe = **3678g** (3 soup bowl #1) Used cooked rice (per recipe: 3kg soaked rice) also see #897	*glutinous rice ckd, sugar, palm fruit, salt*	• num/nom thnort/thnaot • num ambaeng thnoat • thnaot chean (fried) • fried cake	Bowl #1 = 0.08 of rec. Bowl #2 = 0.05 of rec. (*392kcal*) Bowl #3 = 0.02 of rec. (*156kcal*) Glass #3 = 0.02 of rec. Piece #1 = 0.01 of rec. Piece #2 = 0.004 of rec. Soup bowl #3 = 0.11 of rec. Plate #2 = 0.09 of rec.
#494 num tnoat Recipe = 12,260 (10 soup bowl #1; was error in 24HR of 10 bowl #1)	palm fruit, rice flour, sugar, salt	• num tnoat	bowl #1 = 0.025 bowl #2 = 0.015 bowl #3 = 0.006
"MadeFor nom kang" Recipe = 2294g (from #432, w/o 1384g palm fruit = 2x soup bowl #1 measure; also used cooked rice)	*glutinous rice ckd, sugar*	• nom kang • num leach • num chang	2 piece #1 = 0.03 piece #2 = 0.0057 bowl #2 = 0.08 (*430kcal*) bowl #3 = 0.03 bowl #1(package) = 0.136 / 2 = 0.068 soup bowl #3 = 0.18
#598 "palm cake" Recipe #598 = 7356g (6 soup bowl #1)	*sticky rice ckd*, palm fruit, palm sugar, coconut, salt	• palm cake	**bowl #1 = 0.04 of rec (523kcal)** **bowl #2 = 0.025 of rec** **piece #2 = 0.002 of rec** **spoon #1 = 0.001** **Slice #1 = 0.0035**

"MadeFor num bamporng" (made from #598) Recipe = 5356g (6 soup bowls #1 minus 2000g from palm fruit)	sticky rice, palm sugar, sesame	• num bamporng • num kong • num kang	**piece #1 = 0.007 of rec.**
"MadeFor num koum" Recipe = 7356g (make from #598: replaced palm fruit with mungbean)	sticky rice, mung bean, coconut milk, palm sugar, salt	• num koum • mungbean dessert	**See measures for #598**
MadeFor soy cake dessert Recipe = 7356g (6 soup bowl #1) (made from #598)	sticky rice, mung bean, coconut meat, palm sugar, salt	• soy cake	**See measures for #598**
#624 "dessert" Recipe = 2452g (2 soup bowls #1)	sticky rice, coconut meat, palm sugar, salt	• dessert with sticky rice & coconut	**bowl #1 = 0.13 of rec.** **bowl #2 = 0.075 of rec.** **bowl #3 = 0.030 of rec.** **soup bowl #3 = 0.17 of rec.**
#810 "chek khtis" Recipe = NA	banana, palm fruit, salt,	• chek khtis/ktes	Weigh as cooked pumpkin (weight is ~average of banana and pumpkin)
#863 "banh chaev" (1 pancake = ~111g) Changed original recipe of 91 servings (per HKI: 91 pancakes correct; but gave new recipe, as per HKI, but included vegetables). OLD recipe: 3 soup bowls #1=3678g water msr.)	rice flour, bacon, blood, bunching onion	• banh chhaev • banh chaev	Assume: Plate #1 or #2 or bowl #1 = 1 pancake Plate #3, bowl #2 = ½ pancake Bowl #3 = ¼ pancake **Old corrected/changed: #863,209, 523**
"HKI ansom chek" Recipe = piece #1	sticky rice, banana, salt, ripe coconut	• num ansam chek • nom ansom,	piece #1 = ladle #3 = 48.15g slice #1 = 36g (0.75 x

		ansorm chek	piece #1) bowl #3 = 92.5g (~2x piece #1) bowl #2 = 4x piece #1 bowl #1 = 8x piece #1 ladle #1 = 1.37x piece #1 = 65.9g glass #3 = 2x piece #1
"HKI chek cheang" Recipe = Piece #1	rice flour, sugar, oil, banana, sesame seeds	• chek cheang	Piece #1 = 40.1g bowl #3 = 2 x piece #1 bowl #2 = 5 x piece #1
"HKI banana dessert" Recipe = N/A	banana, tapioca pearls, sugar, coconut milk	• namvar dessert	measure as mung bean dessert (on new spreadsheet)
"HKI Lort" Recipe = N/A (a more watery dessert)	glutinous rice flour, sugar, coconut milk	• Lort/Lorth • num dangkuv • ban em lot	measure as Koum cake (on new spreadsheet) e.g. 1 bowl #1 = 263g (82kcal) Piece #2 = 11g (263/312x13)
HKI Treab bai (less watery than Lort)	glutinous rice flour, palm sugar, coconut milk	• Treab bai	measure as Koum cake
HKI Chab Leang	condensed milk, coconut milk, syrup, apple, ice, gelatin		1 bowl #2 = 167.15g
MadeFor num kruok, from HKI Lort & chek cheang	glutinous rice flour, rice, sugar, coconut milk, oil, fish sauce	• num kruok	measure as Koum cake (on new spreadsheet)
Chinese cake Use "T&T, Chinese, golden lotus seed mooncake w/yolk"	T&T item	• duck egg cake • duck yolk cake	1ea. = piece #1 or slice #1 = 1 package = 46.25g 1ea. = (1 or ½ bowl #1) 1ea. = (1 or ⅔ or ½ bowl #2)

			½ bowl #3 = ½ cake = 23g bowl #3 = 1 each bowl #2 = 2 each bowl #1 = 6 each
"HKI **borbor** doung" Recipe = NA → HKI borbor sadov (made w/ soybean)	*glutinous rice, coconut meat, ricebean dry, salt, sugar*	• borbor doung	measure as mung bean dessert (on new spreadsheet)
"HKI **borbor** lapaov" Recipe = NA	pumpkin, tapioca pearls, sugar, salt	• borbor lapaov or lapoav	measure as mung bean dessert (on new spreadsheet)
"HKI **borbor** skar" Recipe = NA	sticky rice, sugar, salt, coconut milk	• borbor skar	measure as Koum cake (on new spreadsheet)
#403 young native melon dessert Recipe = 1863g (3 soup bowls #2)	young native melon, palm sugar		1 soup bowl #3 = 0.226
HKI akor			measure as Koum cake piece #2 = 11g (263/312x13)
MadeFor num ey dessert	sticky rice, coconut milk, sugar	• num ey	measure as sticky rice

Note: ricebean is similar to adzuki or mungbean
To search for recipes in ESHA, search "EL##" (e.g., "EL102")
Italics means that I reviewed the recipe ingredients to include ricebean (vs. adzuki or mung)

Databases to use

Database Protocol: Use ASEAN database 1st, VW 2nd, EA 3rd, USDA when no other

ASEAN electronic food composition database:
http://www.inmu.mahidol.ac.th/aseanfoods/download/books/dl1.php?file=A1 (See shared dropbox file) → Name as (eg) ASEAN-THD (THD is the country of origin; each item has the country listed on the left; country may also be TH, PH, VN, etc.)

Vietnamese Website:
http://www.fao.org/fileadmin/templates/food_composition/documents/pdf/VTN_FCT_2007.pdf **(**Assume**:** for "VW" retinol mcg = retinol RE)

East Asia: http://www.fao.org/docrep/003/X6878E/X6878E00.htm#TOC

Bangladesh website:
http://www.fao.org/fileadmin/templates/food_composition/documents/FCT_10_2_14_final_version.pdf

ESHA: okay to use "INTL" foods (i.e. may be from Philippines, etc.)

Other links to international databases: http://www.fao.org/infoods/infoods/tables-and-databases/asia/en/

Pacific Islands PDF: ftp://ftp.fao.org/docrep/fao/007/y5432e/y5432e00.pdf

Lyly brand (snack packages): http://lylyfood.com/

Acronyms used:
ASEAN = Assoc. of South East Asian Nations (2014)
VB = Vietnamese Book
VW =Vietnamese Website
EA = East Asia Website (FAO document)
EP = Edible Portion

ENDLINE ASSUMPTIONS for UNKNOWN FOODS (alphabetical)

additive color = IGNORE (usually very small amount, <1 spoon #3)
agati = sesbania grandiflora
banana = use portions from HKI, if size not listed, assume medium (60g each)
banh hoy (looks like thin, lacy/web-like rice noodles) = use rice noodles
banh kanh (Chinese noodle, big pieces, per HKI) = use rice noodle (like Khmer noodle)
banh sung, vietnamese noodle = use rice noodle (like Khmer noodle)
banh trang = picture from HKI looks like lettuce wraps; assume rice paper (for spring roll)
banle phaem = sweet leaf (looks like ma om or kangkong) = use kangkong
beef = use FOF or ESHA's (if specify ribs, lean or not, etc.)
beer = use ESHA beer, can/btl
Bacas, bacchas (250mL=120kcal), sting energy drink = use "drink, energy, can" ~=redbull
bamboo, fermented = use "FOF bamboo..." (use cooked weight measure)
bread (common) = use USDA white bread, soft (measure on new spreadsheet)
glass #1 = 44g, mug #3 = 31.8g, plate #3 = 39.15g (math: 0.15 x water)
bread with meat (is an error in food records, per HKI) = use white bread (1 sweet loaf = 55g)
bingsab = use ESHA white soft bread (it is bread per HKI)
bok choi, bok choy = use chinese cabbage
borbor, porridge = use FOF borbor 100:400

boullion cube, Knorr = use ESHA (1 cube = 12g = 1 slice #2 or spoon #2 or spoon #1; ladle #3 = 24g, ladle #1 = 36g, spoon #3 = 6g)
cabbage, napa = use Chinese cabbage
candy = use ESHA hard candy (assume 1 each = 1 spoon #1 or #2 or #3 or slice, unless amt. indicated); assume bowl #3 = 8 candies (73mL/9mL)
canned cake = "a kind of biscuit" (per HKI) = use Bido
cassava = arrow root, manioca, tapioca (sago)
cha-om, cha om = use acacia leaves (measure as kangkong)
cha plu = use sweet potato leaves
chab fish = use perch
chang trang leaves = use tamarind leaves
chahouy, cha houy, jahouy = it is gelatin = use FOF or T&T jelly
chi sanghum, or chi sang hom, like mint = use FOF mint (measure as sweet potato leaves)
chinese keys (type of ginger) = use ginger (measure as taro stem)
chres, chrash leaves = looks like amaranth = use amaranth
cicca nodiflora = use cassava leaves
coconut cake (100Riel) = use ESHA coconut macaroon
(estimate 100Riel = 8g, 200Riel = 8g, 500Riel = 18g)
coffee = use USDA coffee, brewed w/tap water
cooking oil, fat (if not specified, assume vegetable oil) = use RG oil
cucumis melo, muskmelon (type of melon, related to cantaloupe & honeydew) = use honeydew melon, but if leaf, use sweet potato leaf
custard apple, soursop = use FOF (fruit) or T&T juice (measure as raw green mango)
curry powder = use USDA spice blend, curry, pwd (sugar measure)
drumstick leaves = use sweet potato leaves
eggplant leaves = use sweet potato leaves
fate = translated in error, it is fat = assume oil
ferroniella lucida = see "krasaing"
fetus egg, fertilzed egg = use FOF embryonated duck egg (1 med = 60g = ~bowl #2)
fish sauce = use ASEAN fish sauce (note: Lobster brand and Koh Kong brands are NOT fortified)
fish, canned = use "canned mackerel" (measure as large fish, or pork if not available)
assume 1 can = 155g
fish (if unknown) = use FOF carp for raw/recipes (x1.3 if cooked used) or FOF catfish for cooked portions (x1.0) for spoon#1/2/3
ginger leaves = use ginger (measure as taro stem)
gooseberry leaves = use sweet potato leaves
grape juice = use USDA juice drink, grape, cnd
great galangal (a type of ginger) = use ginger (measure as taro stem)
herb (if ambiguous) = use FOF mint (measure as sweet potato leaves)
hog plum leaves = use amaranth leaves
hun = pork intestine
ice = use water (use measure for shaved ice or water if not available)
glass #1 = 294g, #2 = 111g, #3 = 74g
mug #1 = 328g, #2 = 246g, #3 = 194g
bowl #2 = 164.7g

ice cream and bread = is actually ice cream in a white bread (like a ½ french loaf or hotdog bun)
(use half portion as bread, half portion as ice cream), measure as sticky rice, or water if needed; "1 loaf" = 45g (per HKI), see more measures below
instant noodle (snack), "broken instant noodle" = use T&T instant noodle snack
(estimate 100Riel = 8g/pkg, 200Riel = 25g/pkg, 1000 riel = 120g)
ipil ipil leuceana (fern like) = use FOF cassia (measure as kangkong)
jam, mango or jujube/jujupe = use mango measure
jam with flour = this is a wrong translation per HKI; use fried white sweet potato
jelly, black, dessert (condensed milk, sugar, jelly) = use FOF, jelly w/ coconut cream or see recipe
(½ - 1 ladle #3 = 25g, 1 ea./ 1/2-1 glass #3/bowl #3 = 50g, ⅔ or ¾ bowl #2 = 75g, bowl #2 = 100g, bowl #1 or plate #3 = 150g, for slice/piece use ban. msr.)
black dessert jelly: mug #3 = 77.4g, glass #3 = 30g, 5 spoon #2 = 5.5g (or water x 0.368)
jew's ear, rat ear = type of mushroom (measure as bamboo raw/cooked)
Piece #1 = 17.1g, #2 = 5.9g; Slice #1 = 11.7g, #2 = 1.2g (0.45 x water)
juice (if vague/unknown) = use FOF pineapple juice (500Riel = ~270mL = 270g)
jujupe or jujube = use FOOF Jujube, Chinese date
kaboy leaf (like cassia occidentalis) = use cassia (measure as kangkong)
kaffir lime leaves = use basil leaves (measure as sweet potato leaves; for bowl #3 = 15g)
kambar, kambor leap malou = it is lime
kandieng, kandang leaves = unknown (no picture in HKI doc) = use kangkong
kantrang leaves, kantrung = ignore (like bay leaves, for flavor)
kantuot leaf = gooseberry leaves (per HKI) = use sweet potato leaves
kapi = shrimp paste (use pra hok/pa ork measure)
kchao dong = small shell
kcheay or kacheay = use ginger (measure as taro stem)
kdad pickle = pickled taro (made from great taro per HKI) = use taro stem cooked
khor = it is a stew/soup
kor chul (brand) energy drink = use Red bull (220kcal for a can)
korkos fruit (eat seed, not sweet per HKI) = assume like krasaing, use lime fruit (water measure, or mango, ripe for lime fruit)
komplork (stem) = water hyacinth (per HKI) = use amaranth leaves
kra av chouk = it is lotus root
krasaing, krasang, ferroniella lucida, wood apple, sandan = looks like a lime on the outside, guava on the inside → use lime (water measure)
kreung kanchab = ignore (it is a kind of seasoning per HKI, unknown type)
krob chi = use coriander seed (measure as sugar)
la meat = turmeric
lame = translated incorrectly, it is lime
lobster ball = use "ASEAN fish ball"
lou lok, lou lak = use beef (it is fried beef and vegetable per HKI)
luxus brand snack package = assume like LyLy brand (use USDA cereal, corn, rice measure)
ma om, ma-om (swamp leaf), assume also swamp fern or water fern = use kangkong
marigold, leadtree leaves = use amaranth
mango jam = use mango, ripe
mango leaves = use cassava leaves (weight as kangkong)

nam ngov, ngam ngov = it is fermented lime (per HKI) = use lime (or raw lime)
native melon = use waxgourd/winter melon
neang vong = it is basil
neem = use cassava leaves (weight as kangkong)
noodle, Khmer noodle = use rice noodle
noodle, instant noodle = use wheat noodles
noodle, misuo/musuor = wheat noodles
notopterus notopterus = use FOF knifefish or featherback
octopus, dried = use squid (dried fish measure)
orange leaves = ignore (added for flavor, like bay leaves)
pa em = dessert or sweet (per HKI)... clarified: sweet leaf (looks like ma om or kangkong per emailed picture from HKI) → use sweet potato leaves
pakachi, paka chi = garlic chives = use garlic leaf (measure as sweet potato leaves)
pak whan = use sauropus androgynus/star gooseberry leaves (measure as sweet potato leaves)
paark = pra ork ... “trichopsisvittata” → type of fish =
pean nut = assume/use peanut
pepper leaves, assume chili leaves = use FOF, chili, red
pepper (spice) = use ESHA http://amokcuisine.com/vegetables-and-herbs/category/15?start=80black ground pepper
phdao chaes = slek kontrop; used for flavor (per HKI) = use amaranth leaves (assumed previously)
phkas = use sauropus androgynus (star gooseberry) leaves (measure as sweet potato leaves)
pickle sauce (liquid with pickles) = use ½ vegetable broth, ½ white vinegar (of measure used)
plov kangkeb = pod fern, swamp fern (per HKI) = use kangkong
pork (if “meat only” or vague description) = use FOF medium pork (which is leaner)
pork (if “bacon”) = use FOF lean and fat (which is higher in fat)
pork, pig fat = use ESHA animal fat Lard/Pork (use “pork meat with fat [cooked]” measure)
porridge (borbor): 1:4 ratio (rice:water, 100g:400g) = use FOF borbor, 1:1730
prawn, dried = use dried shrimp (dried fish measure)
pumpkin vine, pumpkin leaves = use sweet potato leaves
pumpkin stem = meant to be pumpkin leaves = use sweet potato leaves
puon leaves = unknown, use kangkong
quail = use ESHA (Canadian) quail, cooked, total edible (measure as pork)
ramdul fruit = use soursop fruit (use banana measure)
rat ear leaves = peperomia pellucida - type of herb “pepper elder” (looks like basil) = use basil
ribbon = translated incorrectly, it is pork rib
rice: 1:2 ratio (rice:water, 100g:200g) = use FOF rice conv /3
rice bean or ricebean (it’s a pulse) = WAS using adzuki beans, now use “ASEAN ricebean” Made a cooked version, but comparing ESHA’s cooked/raw mung beans (i.e. 347kcal vs. 105kcal → divide raw by 0.3, or add ⅔ volume as water → 100g ricebean + 200g water)
ricebean shoots (fermented) = use bean sprouts (fermented)
Roddee food seasoning = seasoning (per HKI) → use Knorr (1 pkg = 1 cube = 12g)
romduoal fruit = use jackfruit
romeat = turmeric
romchek sauce (a “flavoring” per HKI) = use vanilla extract
sach phak lov = use FOF pork head meat

Sakura brand = use T&T prawn crackers (300 or 500Riel = 18g, 100Riel or 200Riel = 8g)
salt, if not specified whether iodized or not = use non-iodized
salt iodized = use ESHA Morton INTL iodized salt
salt, sea salt, ambel kruosh brand = use non-iodized
santol fruit, sandorica, sadorica = use mangosteen (1 whole = 130g, 30% as fruit = 39g; or measure as green mango)
sa om, sa-om (like ma om) = use kangkong
samurai energy drink = use ESHA red bull
sapodilla = use ESHA (1 med per ESHA is 170g)
Savmao prai shoots, sleuk sav mav prey = use cassava leaves (weigh as kangkong)
sea salt = use non-iodized salt
sero juice = picture from HKI looks like a can of tropical fruit juice (mixed fruits) - will use “juice drink, tropical punch, pouch”
shallots = use USDA chopped, fresh shallots
shark fruit = is actually “shaked fruit” (per HKI) - use “shaking fruit juice” recipe; for measure water x 0.657
skin, beef, cow = use pork skin
slek het chhneang = similar to sauropus androgynus (star gooseberry), measure as sweet potato leaves
slek kantrung (added to soup for flavor, not consumed per HKI) = ignore (used like bay leaves)
slek knoeng (leaves), assume also thnoeng = use cassava leaves (use kangkong measure)
slek kontrop/kantrob (leaves) = use amaranth leaves
slek krouch = kaffir lime leaves = use basil = measure as sweet potato leaves
slek mlou mint or sleuk malou (or cha-plu) or leap or slek mjou barang = use FOF mint (measure as sweet potato leaves)
slek mjou barang = it is Hibiscus sabdariffa (= chang trang leaves) → use tamarind leaves
slek sav mav prey = ignore (used like bay leaves)
slek thneng (like Krob Chi) = use coriander seed
sloek machou cheng kreng (chekraeng or mchou sangkranh) = use amaranth leaves
sour spice = use red ant (wrong translation of “sour spice” per HKI)
spey bokko = use chinese cabbage
sticky rice = use FOF glutinous rice conv /3
sugar = use USDA white, granulated sugar
sugar palm = use ESHA fresh international (not RG)
swamp leaf (ma om, ma-om) = use kangkong
swatow mustard = use mustard greens (measure as taro (raw), if not on “vegetable” spreadsheet)
sweet bread = use ESHA bread, sweet, mex-pan dulce (assume 500riel, bowl #1 = 44g)
syrup, red = use grenadine (USDA)
syrup, sugar (granulated) = use ESHA (Can.) corn syrup
taing Hun = use rice noodles
taing Chay = use pickled cabbage (per HKI)
taro cake = use ESHA taro chips (see snack table above)
teuk chek (a liquid to flavor desserts) = ignore (because a very small amount is used)
teuk Kreung = dipping sauce, not soup
teuk trey = fish sauce
teuk trey pa em = sweet and sour sauce (use recipe already made or ESHA)

tnoat, thnoat, borassus palm = palm fruit
tneung leaf = sorrel leaves….
http://amokcuisine.com/vegetables-and-herbs/category/15?start=80
trisoy = soymilk = use lactasoy
turmeric = use USDA turmeric
water lily = use swamp cabbage, kangkong
wax gourd juice = use winter melon juice
well water = use ESHA water, tap, f/well
well water (filtered) = use ESHA water, tap
white petiole, white flower = use Chinese cabbage/bok choy
wine, herbal = use ESHA wine, white, med
wood apple, feronia elephantium = use lime
vine spinach = use malabar spinach
vor yam = use orange flesh sweet potato (or yam)
van suy = cilantro/ coriander, use FOF coriander

ENDLINE ASSUMPTIONS for MEASURES (alphabetical)

***Assumptions based on available baseline values, and finding comparable values/foods on the new spreadsheet**

acacia leaves = measure as kangkong
ant, red = measure as young native melon (because measures for spoon #1 are the same)
apple = look at ESHA measures for fruit size (small = 149g); or measure as mango (raw, green)
banana = measure as 0.94 x water: soup bowl #1: 1152g, #2: 584g, #3: 396g
banana stem/core = measure as taro stem
banana flour = measure as 0.5 x weight of sponge gourd (raw)
banana flower = measure as 2 x weight of kangkong (if not on “vegetable” spreadsheet)
basil = measure as sweet potato leaves
bird nest drink = 1 can = 356g (like beer can/btl per ESHA)
bitter gourd leaves = measure as amaranth leaves
blood, pork = measure as water (piece #1 = 38g, piece #2 = 13g; slice #1 = 26g, slice #2 = 4g)
borbor = serving spoon #3: 26g (0.813 x borbor measure for ladle #3)
serving spoon #2 = 55.8g (1.24 x borbor measure for ladle #2)
serving spoon #1 = 101.2g (0.865 borbor measure for ladle #1)
bottle gourd leaves = measure as sweet potato leaves
broth/soup = measure as 0.76 x water measure
Serving spoon #1 = 34.2g, #2 = 42.6g, #3 = 19.8g
Water bowl #1 = 850g, #2 = 564g, #3 = 347g
Plate #1 = 400g, #2 = 263g, #3 = 221g
bunching onion = measure as amaranth (if not on “vegetable” spreadsheet)
stems as per ESHA “scallion” measure: 1 lg stem = 26g, 1 med = 15g, 1 sm = 5g
carrot = measure as bamboo (cooked), or for piece/slice measures as banana
cassava (casava) leaves = measure as kangkong (raw)
cassia (looks fern-like) = measure as kangkong
chicken, beef, duck, dog meat = measure as pork meat
chili = measure as amaranth (if not on “vegetable” spreadsheet - see “red pepper long”)
1 medium = 1.8g

cilantro, coriander = measure as sweet potato leaves
clams = measure as small fish
coconut = measure as cabbage, Chinese (raw); assume 1 medium unripe coconut flesh = 100g
coconut milk/juice = measure as water
condensed milk = measure as sugar sauce (or water if needed)
coriander = assume 2 small seeds = 0.5g
corn (if ambigous use white corn) = measure as taro stem (cooked)
crab = measure as small fish (or large fish if needed)
cricket = measure as small fish
cucumber = measure as 0.66 x water; water bowl #1: 738.5g, #2: 489.7g, #3: 301.6g
cucumis melo = is a type of melon = use honeydew and measure as native melon
cucumis melo leaves = use sweet potato leaf and measure as sweet potato leaf
curry powder = measure as sugar
dragonfruit dragon fruit = measure as cucumber (use ESHA item)
drumstick leaves = measure as sweet potato leaves
durian = measure as banana
egg (fried or otherwise) → use duck eggs if ambiguous = measure as pork meat or then small fish (if not listed on "meat" spreadsheet); 1 small = 48.6g, med = 54g, large = 62.2g
egg, hen, chicken = per ESHA: small = 38g, med = 44g, large = 50g
eggplant (raw) = measure as 0.407 x water for piece/slice: 1 piece #1 = 15.5g
fermented young native melon = measure as pumpkin (cooked); for piece/slice, measure as fish
ferroniella lucida (krasaing) = use lime but mango green measure
finger roots = measure as ginger
fish: see table on top of document for raw → cooked conversions
use "large fish" measures for carp, snakehead, tilapia, eel, catfish, & perch
fish, egg: use caviar USDA, measurement in old meat spreadsheet
fish head: waiting for Ian's analysis, measure as small fish for now (emailed Tim) - only 1, described as dried fish → use misc. dried fish
fish or squid (dried): slice #1 (23g), slice #2 (3g), piece #1 (33g), piece #2 (11g)
→ measure as 0.9 x water: bowl #2 = 165.6g, bowl #3 = 65.7g, ladle #2 = 28.8g
→ multiply by 1.6 to get raw weight if needed (but there is a FOF dry squid in ESHA)
fish, large: measure as 0.55 x water (if not on new spreadsheet)
fish, small: measure as 0.55 x water (if not on new spreadsheet)
fish (canned) = measure as large fish, or pork measure if needed
three lady cooks brand: each can = 155 g
(http://www.amazon.com/Canned-Weight-Drained-93grams-Tailand/dp/B00L391BFK)
fish sauce = measure as soy sauce, then water if needed; spoon #3 = 2.5g, bowl #3 = 73g
meat/fish/lobster ball = measure as small fish (x1.0)
frog = measure as small fish, or large fish for piece/slice; ladle #1 = 50g per HKI
garlic leek or cloves = measure as taro stem or use ESHA's measures for each piece
spoon #1 = 2 each or 6g, spoon #2 (or slice #2) = 1.5 each or 4.5g, spoon #3 = 1 each or 3g
bowl #3 = 28g, ladle #3 = 6 each or 18g
ginger = measure as raw green mango (if not on "vegetable" spreadsheet), piece #2 = 55g
gooseberry = lychee = measure as raw green mango
grapes = measure as raw green mango
guava = measure as raw ripe mango

ice cream (use vanilla when vague/unknown/ricebean flavor) = measure as sticky rice, or 0.7 x water if needed
assume 500 (or 100) Riel loaf = 45g (per HKI)
assume 1000 Riel piece = 90g (~½ cup)
glass #3 = 56.7g
glass #2 = 86.8
glass #1 = 220.5g, mug #2 = 188g (calculated by: 0.7 x water weight, as per sticky rice)
per #871: 2 loaf = 1 bowl #3 (70g)
instant noodle = dry =70g/pkg; cooked = 300g/pkg, otherwise, measure as khmer noodle
intestine, pork or hog = measure as pork meat
ivy gourd leaves = measure as amaranth
jackfruit = measure as raw green mango
jambolan = measure as raw green mango (3 each = 9 grams; 1 each = 3 grams, per ESHA)
jelly dessert (as ingredient) = see measures below, or measure as water
kaffir lime leaves = use basil = measure as sweet potato leaves
kale flower = measure as cabbage
lactasoy can 800Riel = assume 500ml = 500g
lemon = measure as raw green mango
1 medium = 58g (per ESHA); 1 lg = 84g (per ESHA); 1 small = 45g (estimated)
lemongrass = measure as amaranth leaves, or kangkong for slice measures
lemon grass leaf, leaves = 5g each (like spoon #1 for lemongrass)
1 piece #2 = 10g (estimate 2 leaves)
lemongrass stalk/stem = measure as bunching onion/scallion, or amaranth if needed
1 large = 26g, 1 med = 15g, sm = 5g (per ESHA)
lemon juice from 1 lemon (also lime juice) = assume 2 Tbsp = 30g juice per lemon
liver, pork/pig = measure as pork meat
lolot, piper, pepper leaves = measure as sweet potato leaves
longan = measure as raw green mango
lotus fruit = measure as sponge gourd (raw)
lotus seed dried or raw = use sugar measure
mango (raw, green) and similar fruit = water x 0.52 for other (missing) measures
mango (dried) = bowl #1 dried mango estimated = 87.5g, bowl #2 = 51.5g (water x 0.28)
measure as dried fish for piece and slice (x 5 to get fresh measure of mango)
mango, without pit (subtract 30% of pre-measured weight)
small = 122.5g, medium = 168g, large = 196g (x by 0.7 to get non-pit weight)
mango leaves = measure as kangkong (use cassava leaves)
milk 700Riel = assume 500mL (grams)
milk can = assume 250mL (grams)
MILO powdered drink (1 package) = 15g (as per #219)
mint = measure as sweet potato leaves
mungbean, ricebean, tapioca pearls (seeds, dry, raw) = measure as dry rice (0.84 x water)
mungbean sprout = measure as raw amaranth (if cooked sprout not on “vegetable” spreadsheet)
mung bean sprout, fermented = measure as taro (raw)
mushroom = measure as taro stem raw/cooked
mussels = measure as small fish
mustard greens, pickled = measure as taro (raw) (if not on “vegetable” spreadsheet)

noodle, instant, package = 70g/pkg (dry); ckd = 300g/pkg, otherwise, measure as khmer noodle
for 2 piece #1 dry noodle, assume = 35g
oil = 0.5 x water measure: plate #3: 130.5g, bowl #1: 156g, bowl #2: 92g, bowl #3: 37g
if oil is 100g (for frying total amount, per HKI) on 24HR, assume 10g only
onion = see new spreadsheet, otherwise measure as eggplant (raw) if needed
orange = measure as mango, raw, green (if not on fruit spreadsheet)
palm fruit (young) = measure as raw green mango
(water x 0.53): water bowls: #1 = 593g, #2 = 393, #3 = 242g
pancake = use #863
papaya = measure as pumpkin (cooked); assume unripe if in recipe, assume ripe if eaten on own
peanut = measure as sugar (see sugar on this list for extra weights)
peppers, bell, capsicum = measure as raw bamboo raw
pepper = measure as sugar
pepper sauce = measure as soy sauce (or water if needed)
phkas = measure as sweet potato leaves (use sauropus androgynus (star gooseberry) leaves)
prahok = use pa ork measures (assume perch prahok if ambiguous)
glass #3 = ~3x serving spoon #3 = 87g; plate #3 = 188g (water x 0.72)
multiply water measure by 0.68 to get new measures: soup bowl #1: 833, #2: 422, #3: 286
pork meat measures not on new spreadsheet: soup bowl #1 = 743g, #2 = 365g, #3 = 255g
(water x ~0.6) plate #3 = 156.6g
pork skin = measure as oil
pumpkin vine, assume pumpkin leaves = measure as sweet potato leaves
pineapple = measure as raw green mango
squid, dried = meaure as dried fish
radish, pickled or dried = measure as bamboo (cooked); for piece/slice measure as banana
rambutan = lychee = rambai = measure as raw green mango
rice flour: 1 cup (240mL) = 100g (estimated)
1 soup bowl #1 = 490g
water / 240 x 100… or water x 0.42
rice (cooked): serving spoon #1 = 50g, serving spoon #2 = 44.8g, serving spoon #3 = 26g
water x 0.58: mug #1 = 204.2g, mug #2 = 156g, mug #3 = 123g
water bowl #1 = 649g, water bowl #2 = 430.4g, water bowl #3 = 265g, piece #1 = 22g, piece #2 = 7.54g, glass #2 = 71.9g, slice #1 = 15g, slice #2 = 1.74g
glass #2 = 71.9g
rice (uncooked, dry): water x 0.84: mug #1 = 295.7g, glass #3 = 68g
ricebean = measure as dry rice (water x 0.84): water bowl #3 = 383.9g
saku (sago) flour, cooked = measure as cooked rice
salt = measure as sugar
sauropus androgynus (star gooseberry) leaves = measure as sweet potato leaves
if fruit = measure as raw green mango
sesame seeds = measure as sugar (but spoon #1 = 12g)
Sesbania leaves = measure as kangkong
shallots = measure as garlic; 1 each = 20g
shaved ice = mug #1 (328g), mug #2 (246g), mug #3 (194g); otherwise use water measure for ice
shrimp = measure as small fish

shrimp meatball = use shrimp fresh water, measure as fish meatball
shrimp paste = measure as soybean paste (on "food" spreadsheet), or ripe mango if needed
snail, small = (water x 0.60): bowl #1 = 187.2g, bowl #2 = 110g, bowl #3 = 43.8g
ladle #3 = 19.2g, mug #1 = 211g, soup bowl #3 = 252.6
if snail "meat" only, use small fish measure
snail sauce (from boiled snail) = measure as water
soy beans (dry) = measure as banana (if using "FOF soybean" it is dried, so divide by 2.4 to get cooked weight)
soybean paste = measure as ripe mango (if not on "food" spreadsheet)
soy sauce = measure as fish sauce (or water if needed)
soybean curd/tofu, "solid" = measure as pork meat
spinach = measure as kangkong
sponge gourd leaves = measure as sweet potato leaves
sticky rice = use 0.7x plain porridge (listed on "food" spreadsheet)
(water x 1.13): mug #1 = 397.8g
sugar = bowl #1 = 135g, bowl #2 = 78g, bowl #3 = 35g,
"500 Riel loaf" = 55g (per HKI)??
(water x 0.72): water bowl # 3 = 329g, water bowl #2 = 534g
For #478: 0.5 loaf of sugar, will use 0.5 spoon #1
sweet gourd leaves = measure as sweet potato leaves
sweet potato = measure as taro, for piece/slice measure as raw green mango
taro = measure as raw pumpkin
tamarind leaves = measure as amaranth leaves
tamarind fruit = measure as ripe mango, for piece measure as large fish (b/c measures match)
tomato (fruit) = 1 medium (whole) = 135g (per ESHA); use young native melon (raw) for other measures (e.g. plate #1 = 360g)
turmeric = measure as ginger, for piece/slice, use green mango raw measure)
tneung/sorrel leaves = measure as amaranth
water hyacinth leaves = measure as amaranth leaves
water lily = measure as kangkong
water mimosa = measure as kangkong
watermelon = measure as cucumber
wax gourd = measure as sponge gourd
yam leaves = measure as sweet potato leaves
yard long bean = measure as bamboo (raw)
young native melon (cooked) = measure as pumpkin (raw)

ENDLINE ASSUMPTIONS for RECIPES (protocol)

- When **recipe is listed but not given** (i.e. for purchased food), FIRST choose a similar recipe, or if description is vague, THEN choose recipe from a person nearby (neighbor)
- When **soup goes over total portion indicated,** keep water at 0g, unless the recipe is >10% over estimated total amount. In that case use ½ water indicated (due to evaporation, which is similar to other recipes), and still use portion size indicated for the person in 24HR. If no water is listed, but the recipe is still over estimated total amount, nothing needs to be done. *Note: the reason for adjusting "oversize" recipes (by using ½ the water listed) is so that the person will not get an exaggerated proportion of meat/etc.*

- When **soup recipe is under total portion indicated**, add water as per normal (to get up to the total recipe amount, using the soup broth measure). The water added should usually be less than stated, but can go over if needed. Sometimes water is forgotten, but it if needed.
- **When recipe is not a soup, and when no measure exists for the food/recipe**, use proportion of recipe as measurement (using water measures):
serving portion size / recipe portion size = multiplication factor (e.g. 0.25 of recipe)
- **For fish/meat recipes**, use proportion method (described above) or use the measure for fish/meat and multiply by (raw → cooked) factor if applicable (see tables above)
- When **Khmer noodle is listed with a soup** in the description (i.e. somlor pra hai), use full noodle portion and ⅔ portion of soup measure of similar soup
- For recipes described in 24 hour recall "food description" column, enter in a new recipe if measurements are present AND a total amount made OR if a comparable measure exists on the measurement spreadsheets (i.e. for grilled fish use fish measure).
If measurements are not provided, ignore items listed and enter main item (i.e. borbor "with salt/MSG/basil/etc." listed in description → use plain borbor only).
- For a "kangkong sour soup" recipe (#896), kangkong was not listed, so I randomly selected 5 other "kangkong sour soup" recipes (#257, 417, 476, 502, 604) and took the average amount of kangkong (which equaled 236g for a 830g bowl of soup).

Appendix 7: Iron requirement distribution percentiles

Table A-7.1: Probabilities of inadequate iron intakes and associated ranges of usual intake for menstruating women and children

Percentiles of iron requirement distribution	Probability of inadequacy (%)	Range of usual iron intake (mg/day) associated with requirement percentiles			
		Menstruating women	Infants 8-12 months	Children 1-3 years	Children 4-8 years
0 to 2.5	100	<4.42	<3.01	<1.0	<1.33
2.5 to 5.0	96	4.42–4.88	3.02–3.63	1.1–1.24	1.34–1.64
5 to 10	93	4.89–5.45	3.64–4.35	1.25–1.54	1.65–2.05
10 to 20	85	5.46–6.22	4.36–5.23	1.55–1.96	2.07–2.63
20 to 30	75	6.23–6.87	5.24–5.87	1.97–2.32	2.64–3.13
30 to 40	65	6.88–7.46	5.88–6.39	2.33–2.66	3.14–3.62
40 to 50	55	7.47–8.07	6.40–6.90	2.67–3.01	3.63–4.11
50 to 60	45	8.08–8.76	6.91–7.41	3.02–3.39	4.12–4.64
60 to 70	35	8.77–9.63	7.42–7.93	3.40–3.82	4.65–5.27
70 to 80	25	9.64–10.82	7.94–8.57	3.83–4.38	5.28–6.08
80 to 90	15	10.83–13.05	8.58–9.44	4.39–5.25	6.09–7.31
90 to 95	8	13.06–15.49	9.45–10.17	5.26–6.06	7.32–8.45
95 to 97.5	4	15.50–18.23	10.18–10.78	6.07–6.81	8.46–9.52
97.5 to 100	0	>18.23	>10.78	>6.81	>9.52

Notes: Table compiled from the Institute of Medicine (2000a). For percentiles and associated ranges of usual intake for iron at lower bioavailability levels, see Gibson & Ferguson (2008).

Appendix 8: Baseline comparison results

Table A-8.1: Pairwise comparisons of baseline characteristics, collected from women (n=450) in Prey Veng, Cambodia participating in the Fish on Farms baseline survey.

	HFP (n=150) - control (n=150)		HFP & aquaculture (n=150) - control (n=150)		HFP & aquaculture (n=150) - HFP (n=150)	
	Mean difference (95% CI)	Bonferroni adjusted p-value	Mean difference (95% CI)	Bonferroni adjusted p- value	Mean difference (95% CI)	Bonferroni adjusted p-value
Households with treated water	19 (2, 35)	0.02	15 (-1, 32)	0.08	-3 (-19, 13)	1.00

Notes: Data are presented as the mean percent difference (95% CI). Differences between intervention and control groups were examined using a generalized estimating equations binary logistic regression model, adjusted for the effect of clustering and using a two-tailed alpha (p<0.05) and the Bonferroni correction for multiple comparisons. Only characteristics with significant difference(s) between groups or tendencies to be different (p<0.10) are displayed. HFP: Homestead Food Production.

Table A-8.2: Pairwise comparisons of baseline 24HR results, collected from women between 19 and 50 years of age (n=450) in Prey Veng, Cambodia, participating in the Fish on Farms baseline survey.

	HFP** (n=150) - control* (n=150)		HFP & aquaculture (n=150) - control* (n=150)		HFP & aquaculture (n=150) - HFP** (n=150)	
	Mean difference (95% CI)	Bonferroni adjusted p-value	Mean difference (95% CI)	Bonferroni adjusted p- value	Mean difference (95% CI)	Bonferroni adjusted p-value
Fat (g/d)	5.7 (0.1, 11.2)	0.04	4.2 (-0.8, 9.2)	0.14	-1.5 (-7.0, 4.0)	1.00
Water (g/d)	69 (-39, 176)	0.38	111 (8, 213)	0.03	42 (-63, 147)	1.00

* One participant in the control group was 51 years of age.
** One participant in the HFP plus aquaculture group was 17 years of age.

Notes: Data are presented as the mean difference (95% CI). Differences between intervention and control groups were examined using a generalized estimating equations gamma regression model with log link, adjusted for the effect of clustering and using a two-tailed alpha (p<0.05) and the Bonferroni correction for multiple comparisons. Only nutrients with significant differences (p<0.05) between groups or tendencies to be different (p<0.10) are displayed. HFP: Homestead Food Production.

Table A-8.3: Pairwise comparisons of baseline 24HR results, collected from children between 6 months and 5 years of age (n=296) in Prey Veng, Cambodia, participating in the Fish on Farms baseline survey

	HFP (n=99) - control (n=102)		HFP & aquaculture (n=95) - control (n=102)		HFP & aquaculture (n=95) - HFP (n=99)	
	Mean difference (95% CI)	Bonferroni adjusted p-value	Mean difference (95% CI)	Bonferroni adjusted p- value	Mean difference (95% CI)	adjusted p-value
Zinc (mg/d)	0.33 (-0.23, 0.88)	0.47	0.58 (-0.04, 1.19)	0.08	0.25 (-0.48, 0.98)	1.00
Calcium (mg/d)	25.2 (-9.3, 59.6)	0.24	30.6 (-0.5, 61.6)	0.06	5.4 (-34.0, 44.8)	1.00
Vitamin A (RAE/d)	-113 (-266, 41)	0.24	76 (-165, 317)	1.00	189 (-10, 387)	0.07
Niacin (mg/d) [i]	0.06 (-0.04, 0.16)	0.47	0.10 (-0.01, 0.20)	0.09	0.04 (-0.08, 0.16)	1.00

Notes: Data are presented as the mean difference (95% CI). Differences between intervention and control groups were examined using a generalized estimating equations gamma regression model with log link, adjusted for the effect of clustering and using a two-tailed alpha ($p<0.05$) and the Bonferroni correction for multiple comparisons. Only nutrients with significant difference(s) between groups or tendencies to be different ($p<0.10$) are displayed. HFP: Homestead Food Production.

[i] Niacin (mg/d) is preformed niacin.