THE IMPACT OF POLICY ON CHILDHOOD UNDERNUTRITION IN CAMBODIA

THE SUCCESS OF THE NATIONAL NUTRITION STRATEGY OF CAMBODIA OF 2009 IN REDUCING CHILDHOOD UNDERNUTRITION, EVALUATED USING ECONOMETRIC REGRESSION MODELS

By ABBY EMDIN, B.Sc.

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LAY ABSTRACT *(147 words)*
Although childhood malnutrition is well studied, Cambodia continues to have high rates of undernutrition[1]. A key goal of the National Nutrition Strategy (NNS), implemented in 2009 to address this challenge, was evaluated for success using economic regression models, applied to cross-sectional data from 2000-2014. Six nutritional status indicators, relating to size or weight at birth or children's weight and height, were analyzed. Linear and logistic regressions revealed the complex relationship between nutrition status indicators and covariates. Results of more robust estimators suggested the implementation of the policy had an overarching negative effect on the prevalence of stunting, wasting, and underweight. Lack of staffing and experience managing large-scale programs contributed to the negative effect of the NNS on nutritional status indicators. Nutrition in Cambodia is definitely progressing, despite the lack of effect of NNS.

ABSTRACT (278 words)
Although both the causes and effects of childhood malnutrition are well studied, Cambodia continues to have high rates of childhood undernutrition. The National Nutrition Strategy (NNS) was implemented in 2009 by the National Nutrition Program (NNP) to address these challenges. The success of one of the key goals of the policy was evaluated through cross-sectional data across four time points (2000, 2005/2006, 2010, and 2014). The results of economic regression models were applied to discuss the effectiveness of the implementation of the NNS. Six nutritional status indicators, three that described size and weight at birth, and three that described WHO anthropometric indicators, were analyzed. The descriptive data suggested the objectives of the policy goal were achieved, however, in comparison to neighboring Vietnam, the achievement in reducing childhood malnutrition in Cambodia became less clear. Differences in descriptive statistics suggested Vietnam was having a greater impact on its nutrition indicators during the period the policy was in effect in Cambodia. Linear and logistic regressions were performed, and demonstrated the complex relationship between nutrition status indicators and covariates, and informed the more complex estimators. The doubly robust (DR) estimator, inverse probability weighted regression adjustment (IPWRA), suggested the implementation of the policy had an overarching negative impact on anthropometric measures and weight at birth ($p<0.05$). A nearest-neighbour matching (NNM) model found similar results as the IPWRA analysis, confirming that the treatment had a significant negative effect on most of the nutritional indicators of interest. The negative impact of the policy was probably due to lack of staffing and experience managing large-scale programs of the NNP at time of implementation. The nutritional status of children in Cambodia is progressing, despite the NNS of 2009.

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Acronyms and Abbreviations

AIPW: Augmented Inverse Probability Weighting
ATE: Average Treatment Effect
ATET: Average Treatment Effect on the Treated
BMI: Body Mass Index
CARD: Council fro Agricultural and Rural Development (Cambodia)
DiD: Difference-in-Differences
DHS: Demographic and Health Survey
DR: doubly robust
FAO: Food and Agriculture Organization of the United Nations
GDP: Gross Domestic Product
GOF: Goodness of fit
HAZ: Height-for-Age (standard deviations)
HIV: Human immunodeficiency virus
IMCI: Integrated Management of Childhood Illness
IPW: Inverse Probability Weighting
IPWRA: Inverse Probability Weighting with Regression Adjustment
IQ: Intelligence Quotient
MCIS: Multiple Cluster Indicator Survey
NGO: Non-governmental organization
NIS: National Institute of Statistics (US)
NNP: National Nutrition Program (Cambodia)
NNM: Nearest-neighbour matching
NNS: National Nutrition Strategy
OR: Odds Ratio
PEM: Protein-energy malnutrition
RA: Regression Adjustment
TBA: Traditional birth attendant
UNICEF: United Nations Children's Fund
UNESCO: United Nations Educational, Scientific and Cultural Organization
USAID: United States Agency for International Development
WAZ: Weight-for-Age (standard deviations)
WB: World Bank
WHO: World Health Organization
WHZ: Weight-for-Height (standard deviations)
WFP: World Food Programme (United Nations)

Declaration of Academic Achievement

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CHAPTER 1: INTRODUCTION

In the last two centuries, many of the improvements seen in health globally have been attributed to advances in hygiene, public health and nutrition[2]. Disease of nutritional deficiencies, pellagra, rickets and vitamin A deficiency for example, remained relatively high in Europe, North America and most of the world in the 19th century, only being largely eradicated with the help of the industrial revolution[2]. Nutritional deficiencies still, however, account for a large burden of morbidity and mortality in low-income countries, particularly in southern Asia and sub-Saharan Africa[2,3]. Malnutrition is the most important risk factor for the burden of disease in low-income countries [4]. It directly causes the deaths of almost half a million people per year, but more importantly contributes to the susceptibility and severity of disease, with the risk of death being directly correlated with the degree of malnutrition[3,5,6]. Malnutrition has been estimated to be indirectly responsible for half of all deaths in young children[3,7].

1.1 INTRODUCTION TO CAMBODIA

Cambodia is a small country nestled in South-East Asian in the Mekong region, bordered by Vietnam, Laos PDR, Thailand and the Gulf of Thailand in the South China Sea. The history of Cambodia has been punctuated by civil wars and 'cynical foreign interventions reflecting external geopolitical interests' [8]. Cambodian state power, weakened from the 1960s, when the Vietnam War spilled in Cambodia, into the 1980s. The war coupled with the genocidal regime of the dictator Pol Pot from 1975-1979, resulted in the death of millions of Cambodians. Economic liberalization in 1989, backed by the UN and external state policies in 1989 lead to a 1991 peace agreement, attempting to end a long-standing civil war. The economic liberalization process incorporated several techniques: privatization of land, legalization of private enterprise, sell-off of state owned enterprises, abandonment of state purchasing and agricultural tax and gradual reduction of state controls on prices, imports and movements of goods[8].

Although the civil war has ended, Cambodia retained a large military force, with significant political influence, as seen in the attempted military coup of 2016[9]. Continued militarization in the 1990s was associated with multiple human rights abuse and use of violence to appropriate land and resources continued. The Cambodian government continues to have extremely high defenses expenditures, of 18.2% of total government expenditure[10]. Total expenditure on education, health, rural development and agriculture only exceeded expenditure on defense and security for the first time in 2002[8]. Foreign investment was limited in Cambodia because of overall insecurity and the need to pay brides. Cambodia's past has great implications for the health of its population now.

The implications of the violent and corrupt past of Cambodia have had massive impacts on human development[8]. Services such as education and health have limited funding, as resources continue to be directed to the military. Lack of transparency in the privatization of land and natural resources continues to contribute to displacement and poverty. Corruption has seen post-war improvements benefit a small proportion of the population, typically wealthy and affluent people least in need[11]. Even with economic growth, the disparity between rich and poor has continued, a condition that has been associated with poorer average health[12]. When compared to other Asian countries like China, Thailand and Vietnam, there has been limited analysis on the factors that produce malnutrition in Cambodia. Further, because of Cambodia's history, past data are often unreliable or unavailable and has effected the ability to draw conclusions and evaluate trends[13]. Political conditions in Cambodia throughout the 20th century have had a great impact on the current state of nutrition in Cambodia, and in a cyclical fashion, the nutrition status of women and children in Cambodia continues to effect economic potential of the country.

1.2 NUTRITION & UNDERNUTRITION

Nutrition status is a complex issue that depends on multifactorial interaction between variables such as geography, socioeconomic status, culture, and current infections. Policies regarding nutrition can shape of the access of a population to food and education. Access to food is defined by the United Nation's Food & Agricultural Organization (FAO) as the continuous "physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life, a difficult definition that many low-income, and some high income countries are not meeting"[14]. Longitudinal studies have shown that undernutrition is not only correlated with poor health and survival outcomes, but affects physical and cognitive development, education ability, and productivity in adulthood [14]. Because of these costs, there is heightened international interest in reducing childhood malnutrition. Good nutrition was identified as key to reaching the health, education and economic objectives of the Millennium Development Goals (MDGs), now the Sustainable Development Goals (SDGs)[15]. The World Health Assembly agreed to a set of six nutrition targets to be achieved by 2025, including: reducing stunting in children under 5 years, reducing low birth weights, and reducing anemia in women of childbearing age. The 2030 Agenda for Sustainable Development also places an increased onus on the integration of food, livelihood and management of natural resources in policies and solutions[15]. These policy changes highlight the importance placed on improved nutrition on a global scale and the need to comprehensively evaluate the cost of malnutrition and the effectiveness of policies developed to reduce malnutrition[15]. The lower work performance, productivity and earnings associated with undernutrition provide incentive for countries to create policies that impact nutrition, not only for to positive effect health, but to improve the economic functioning of that country. To understand the impact of nutritional policies, a basic understanding of what the policies are hoping to impact is necessary.

Nutrition greatly effects the ability of a child to develop, physically and cognitively. Undernutrition is defined as a form of malnutrition, and although the latter term includes overnutrition, malnutrition and undernutrition are often used interchangeably. Children who are undernourished have a greater risk of stunting and impaired brain development later in life [16]. Early nutritional status in children can be correlated with IQ, and undernutrition is related to reduced educational attainment [17,18]. Studies have found that children who are malnourished are more likely to suffer from physical and intellectual impairments in adulthood, and have higher levels of chronic illness and disability[19]. Malnutrition not only correlates to future impairments, but is also associated with childhood mortality. Half of all deaths in young children are associated with malnutrition[3]. Unfortunately, the causes and results of undernutrition are complex.

Undernutrition can result from "inadequate ingestion of nutrients, malabsorption, impaired metabolism, loss of nutrients due to diarrhea, or increased nutritional requirements (as occurs in cancer or infection)" (*n.p.*) [20]. Symptoms of undernutrition are classified according to the cause and type: protein energy malnutrition (PEM) is a form of undernutrition of inadequate caloric or protein intake, while micronutrient deficiency is undernutrition resulting from a lack of necessary vitamins or minerals[3]. PEM is defined by measurements that fall below 2 standard deviations under normal weight-for-age, height-for-age and weight-for-height (anthropometric measures described in more detail in section 1.3). PEM is typically starts before children reach their second birthday and is associated with, "early weaning, delayed introduction of complementary foods, a low protein diet, and severe or frequent infections"[3]. PEM is caused most commonly by a low supply of macromolecules, carbohydrates, protein and fat, but can also be caused by infections, such as helminthes infections or diarrheal diseases[3]. PEM affects the immune system, the metabolism of fat, the anabolism of pigments, etc[3]. There were an estimated 852 million people with PEM in the early 2000s, with 96% living in low-income countries[21].

PEM is further sub-defined in the categories of severe wasting (marasmus), severe wasting with edema (marasmic kwashiorkor) and malnutrition with edema (kwashiorkor)[3]. Severe wasting presents as a triangular face, amenorrhea, abdominal extension and anal or rectal prolapse from loss of fat[22]. In severe wasting, almost all subcutaneous fat and muscle have been metabolized due to lack of dietary macromolecules and calories[3]. Wasting in combination with edema manifests in changes to pigmentation in hair and skin, anemia, swelling of the liver, immunodeficiencies and increased mortality[3]. In combination with malnutrition, edema can cause the degradation of organs, such as the skin, heart and intestine, leading to such effects as cardiac failure, hypothermia, and inability to absorb nutrients. Co-infections of bacteria, fungus, viruses or parasites is common in children with malnutrition due to immunodeficiencies, including the inability to produce the acute phase proteins that lead to fever[3,22,23]. Management for severe PEM includes initial focus on treatment of hypoglycemia, hypothermia and dehydration, controlling intake in terms of volume and protein to avoid heart failure and liver stress[3]. A 10-step scheme was created by the WHO to treat severe PEM, which treats hypothermia, hypoglycemia, dehydration, micronutrients, infection, electrolytes, starter nutrition, tissue building nutrition, psychosocial stimulation and prevention of relapse in order[3]. Their original treatment strategy suggested by the WHO in 1995 of moderate malnutrition was titled, "Integrated Management of Childhood Illness (IMCI), suggestions for community based treatment of malnutrition and proposed recommended nutrient densities for moderately malnourished children"[24–26]. Recommendations to IMCI were made in 2005 that focused on ensuring children receive food that provides them with all the nutrients needed for full recovery, not just food choices that focus on the cheapest option to treat PEM[27]. These revisions to the IMCI by the WHO show an changing understanding of malnutrition, one that began to release the importance of micronutrient deficiencies.

The second category of malnutrition is micronutrient deficiency malnutrition. Deficiencies in micronutrients such as iron, iodine, vitamin A, and zinc continue to major health problems in low-income countries[28]. Micronutrient deficiencies are thought to affect over 2 billion people worldwide[3]. Iodine deficiency alone affects 740 million people, resulting in clinical manifestations such as goiters, or brain damage due to fetal deficiency[3]. Almost a third of the population of the world is deficient in zinc, while 1 billion people have iron-deficiency anemia. A quarter billion people suffered from Vitamin A deficiency in 2005, primarily young children and pregnant women[3]. A lack of iron in the diet affects the functioning of various enzymes, and the production of hemoglobin and myoglobin. Iron deficiency can lead to anemia, fatigue, impaired cognitive development and reduced physical growth[3]. There are multiple proven prevention strategies for iron deficiency, including addition of iron-dense foods to diet, supplementation for children and pregnant women, and the fortification of iron in cooking[3,29].

Iodine deficiency is essential for the proper functioning of the thyroid, specifically in producing thyroid hormone. Iodine insufficiency can cause goiters (a large mass in the throat caused by the overworking of the thyroid gland), hypothyroidism, and constipation[3]. More permanent iodine deficiency can cause mental and physical growth disabilities, such as cretinism. Iodine deficiency can be managed by an iodine supplement, iodine fortified salt or seafood. As people in high income countries have diets lower in table salt, dairy products, fish and other seafood, the required supplementation of table salt with iodine has limited the re-emergence of iodine deificiencies[30]. Salt iodization was identified as one of the most cost-effective ways to target iodine deficiency, at approximately US$0.02-0.05 per child covered, the productivity gain recovered from lower physical and cognitive impairment has a tenfold monetary return[31,32].

Vitamin A is another common micronutrient deficiency that contributes to high rates of malnutrition in low-income coutnries[3]. Necessary for the proper functioning of the eyes and immune system, Vitamin A deficiency can cause night blindness, and inflammation and dryness of the cornea and conjunctiva. Vitamin A is critical to the proper functioning of the immune system, and deficits can lead to immune deficiencies. Vitamin A metabolites, such as retinoic acid, can enhance cytotoxicity and T-cell proliferation[33]. Metabolites mediate cell balances between the different immune responses and plays a role in tissue-specific lymphocyte homing[33]. Vitamin A deficiency is associated with increased mortality in diarrheal and acute respiratory infections[33,34]. Treatments and management of vitamin A deficiency can include regular supplementation, increased intake of dark green leafy vegetables in the diet, or fortification of oils and fat (with mixed success)[3,35]. Both vitamin A and zinc supplementation may contribute to decreased child mortality by decreasing the incidence and severity of childhood diarrheal diseases[36].

Zinc is another micronutrient with an important role in preventing malnutrition in low-income countries. Diets based primarily on refined carbohydrates that are poor in animal products are the primary cause of zinc deficiency[3]. Zinc is involved in the most basic cell functioning, replication, as a factor in the transcription, translation and gene replication phases of cellular growth[36]. Zinc acts as a co-factor in over 200 enzyme reactions and contributes to proper immune system functioning. Zinc deficiency is associated with atrophy of the lymphoid tissue, hypersensitivity of immune response, a lower number of antibody forming B-cells, and reduced activity of T cells[36]. Evidence from the study of acrodermatitis enteropathica, a congenital immunosuppressive disorder, suggests that zinc has a role to play in causing diarrhea[36]. Studies have demonstrated that zinc supplementation reduces the severity and duration of childhood diarrhea[36]. During diarrhea, absorption of zinc is decreased, and zinc deficiencies are exasperated.

The presence of one micronutrient deficiency is associated with the likelihood of other key micronutrient deficiencies. The best solution for alleviating micronutrient deficiencies is an improvement to daily diet, however, there are communities that cannot access micronutrient rich foods, either seasonally or year round, therefore, other interventions often need to be implemented. Micronutrient based malnutrition is correlated to PEM. Measurements that look at weight, height, and age, promoted by the WHO, have been widely used for decades, and can give researchers and policy makers an understanding of the amount of PEM in a country. Micronutrient malnutrition, however, is often more difficult to assess. Measures of related diseases caused by micronutrient deficiencies and measures of blood hemoglobin for iron-deficiency related anemia can suggest the prevalence of micronutrient deficiencies in the population. Assessment of treatment of micronutrient malnutrition can also be made through evaluating the proportion of salt that is iodinated, the amount of vitamin A rich food ingested, and the supplementation of both zinc and vitamin A, as well as through the evaluation of other factors. Data for measuring PEM remains more readily available for population surveys, although more recent surveys have begun to include the measurement of some micronutrient deficiencies. The ways to measure the exceedingly complex and multi-factorial disease that is malnutrition are discussed below.

1.3 MEASURING NUTRITION STATUS

A few commonly used measures that researchers use as indicators for undernutrition include low birth weight, weight-for-height, height-for-age, and weight-for-age. Low birth weight has been associated with both maternal and infant nutritional status[37–39]. The WHO defines underweight as being born under 2500g, regardless of gestational age[40]. Low birth weight is associated with infant mortality and morbidity[41]. Further, low birth weight has been found to be correlated with the future growth and development of children. Low birth weight children who live past infancy are at increased risk for health problems including, diabetes, cardiovascular disease, and cognitive impairments[40,42]. Unfortunately, because of the low number of babies who are not delivered health facilities in low-income countries, and mothers are often unable to later recall or estimate weight at birth[43]. One study found that from 1990 to 2000, of all the DHS reports available, on average, only 48.7% of infants were weighed at birth, and that reported weights were often multiples of 500 grams, indicating estimates by either the mother upon recall or the health professional upon weighing[40]. Some demographic surveys have attempted to control for this by asking for a scalar estimate from mothers, that is, to have mothers recall the size of child on a scale[40]. Weight at birth, estimates of weight and maternal identification of infants as much smaller than average on a scale are often the best indicators available of nutritional status at birth.

The measurement of PEM is frequently done through the evaluation of height and weight for age. The WHO suggests three anthropometric indices for assessing the growth status of a child: weight-for-height, height-for-age, and weight-for-age[44]. Low weight-for-height is referred to as wasting, frequently as a serve loss of weight, such as starvation or due to disease[44]. The prevalence of wasting is usually below 5 percent and shows a peak at 18 months in children in most countries [44]. High weight-for-height is termed overweight, generally due to obesity. Low height-for-age is known as stunting, and is indicative of poor health conditions, including those of poor nutrition, that limit height[44]. High levels of stunting are highly correlated with poor socioeconomic conditions, and inappropriate feeding practices[44]. The prevalence of stunting worldwide varies from 5 to 65 percent[44]. The WHO distinguishes that children over the age of 2-3 years have 'failed to grow’ and have been stunted, while those under the 3 years of age who are 2 standard deviations from the median are ‘failing to grow’ or currently being stunted. Low weight-for-age criteria fails to distinguish tall, thin children who are not adequate weight for their height, however, when wasting is not prevalent, it can provide similar information compared to height-for-age, due to a similar distribution in the population[44]. These three anthropometric measures are related to the National Center for Health Statistics (NCHS/WHO) growth reference, based on references from three cross-sectional representative surveys conducted in USA in 1960 to 1975[44]. Recent studies have demonstrated the NCHS/WHO growth reference to be flawed, leading to mismanagement and possibly harmful behaviors, for example, the previous recommendation that food be introduced to children who should be exclusively breastfed. Recognition of these flaws lead to the creation of the new WHO child growth standard in 2006 [45]. Although these factors indicate most frequently PEM, which affects physical growth, low weight-for-height, weight-for-age, or height-for-age can also be indicative of other micronutrient deficiencies that affect normal growth patterns, such as consistent iron and iodine deficiency[3].

1.4 NUTRITION IN CAMBODIA

The negative lifelong impacts of malnutrition (discussed in Section 1.2) are well studied. Cambodia has a high burden of maternal and child malnutrition, with high proportions of children being stunted, underweight or wasted. Fifty percent of young children in Cambodia have higher than normal risk of death and sixty thousand deaths over the next decade in Cambodia will be linked to child or maternal nutritional health factors[19]. Poor maternal nutrition factors, including lack of breastfeeding and micronutrient deficiencies, like vitamin A and zinc deficiencies, have been linked to 2.5 million cases of childhood diarrhea and respiratory infections in Cambodia per year[19]. Other factors implicated in malnutrition, anemia, and stunting, lead to mental and physical defects such as those recorded in two-thirds of Cambodian children[19]. A study by Fujji in 2005, using weight-for-age and height-for-age suggested that almost half of the children in Cambodia under the age of 5 were malnourished [46].

Most recent statistics indicate that malnutrition is still extremely prevalent in Cambodia. In 2014, 32% of children under the age of 5 were stunted, 10% were wasted and 24% were underweight[1]. Nine percent of children were severely stunted, and the prevalence for stunting was higher in poor, rural areas[1]. Five percent of children were severely underweight, and the percent of underweight children peaks at 40-42, probably due to improper feeding practices[1]. Further, socioeconomic status puts Cambodian children at increased risk of being underweight, as children born to mothers in the lowest wealth quintile are more than twice as likely to be underweight than those in born to mothers in the highest quintile and fourteen percent of women were found to be underweight (BMI<18.5) in 2014.[1]

Micronutrient malnutrition is more difficult to measure. Current survey results suggest that 69% of household have salt with some iodine, a decreased proportion from the houses with iodized salt in 2010[1,47]. Sixty-nine percent of children live in households with iodized salt and 70% of children received vitamin A supplementation in the 6 months before the survey. Only 6% of children received iron supplementation in the 7 days before the survey. More than half (56%) of the children in Cambodia in 2014 were anemic, with higher prevalence seen in rural and poor households. When tested for the plasma retinol-binding protein concentrate, nine percent of children were found to have vitamin A deficiency in 2014. Forty-five percent of women were determined to be anemic, with 38 suffering from mild anemia and 7 percent from moderate anemia. Women had high rates of iron/folate supplementation during pregnancy, with 76% taking the supplements for 90 days or more[1].

The high prevalence of intestinal parasites in Cambodia also negatively impacts nutritional status of women and children. In 2014, nineteen percent of women and 10% of children were infected with at least one parasite, the most common being the hookworm[1]. A recent study in Siem Reap found high rates of infection in children who were symptomatic, with hookworm, *Strongyloides stercoralis* and *Giardia lamblia* being the most prevalent types of parasites, also finding a correlation between defecating in the forest and hookworm infection, and not using soap for hand washing and *G. lamblia* infection[48]. Low weight-for-age and height-for-age has been found to be associated with parasitic infections, and parasitic infections have been shown to be associated with malnourishment, showing the complex interaction between nutritional status and immune defense[49]. Developmental status can also be affected by the presence of intestinal worm infections and malnutrition associated intestinal helminthes infections could play a role in developmental disabilities[49].

The effects of malnutrition in Cambodia are not only loss of quality of life and loss of life. Malnutrition also has a negative effect on Cambodia's economic development. A joint study completed by CARD, UNICEF and WFP using DHS data in 2010 estimated that malnutrition is depressing GDP by $180 million per annum due to the physical and cognitive impacts of malnutrition that follow individuals from childhood into adulthood[19]. From the data, CARD et al (2013) determined the current effects of malnutrition on pregnant women and children less than 5 years of age and predicted the cost of this physical and cognitive impacts on future earnings and productivity. Current effects of anemia in adults on productivity and wages were also calculated. Overall, a $419 million annual loss was calculated, or 2.6% of GDP in 2013, representing losses due to anemic status of adults and losses due to future effects from children currently undernourished[19]. The effects of childhood malnutrition are carried throughout life. For children who are currently malnourished, through increased mortality, and lowered productivity and earnings, GDP in Cambodia is projected to be depressed by over $180 million annually[19]. Over 3.3 million anemic adults, whose work and productivity can be decreased by 5 percent or more are projected to decrease labour outputs by $138 million[19]. A continued commitment to reduce childhood malnutrition is necessary to both public health and the health of the economy.

CARD et al (2013) delineated magnitude of losses due to malnutrition in Cambodia concluding that, "the $250-$400 million in projected losses described the scale for economic benefits that might be secured by investment in effective and affordable interventions to lower prevalence of these specific indicators of malnutrition" (p 6). The authors highlighted the need for an effective policy that targets malnutrition and concluded that investment in nutrition programs in Cambodia will offer high returns and low cost-benefit ratios[19].

1.5 CAMBODIA'S NATIONAL NUTRITION STRATEGY

The National Nutrition Strategy of Cambodia was developed by the Ministry of Health in 2009 to target the challenge of maternal and childhood malnutrition in Cambodia. It outlined three key goals that attempted to provide clear focus and long-term direction to address maternal and child malnutrition in Cambodia[50]. A plan was developed with regards to other national strategic frameworks, such as, the Cambodia Millennium Goals and the National Strategic Development Plan 2006-2010[50]. The plan suggests that eradicating extreme poverty and "achieving all the Cambodia Millennium Development Goals related to health and education are largely dependent on progress in nutrition" (p 1)[50]. The NNS was the first long term nutrition strategy developed by the Government. The first objective of the Strategy focused on reducing protein-energy malnutrition and micronutrient deficiencies in young children and the second hopes to achieve the same in women. Micronutrient deficiencies like vitamin A, iron, iodine and zinc are the key focuses of the strategy. The last key goal of the nutrition policy, strengthening national leadership, cross-sectorial collaboration and increased allocation of resources to ensure food security and nutrition, was not considered in this thesis because of difficulty measure and analyzing outcomes of the goal that would require utilizing a quantitative methodology.

1. Reduction in protein-energy malnutrition and micronutrient deficiencies in young children
2. Reduction in protein-energy malnutrition and micronutrient deficiencies in women
3. Strengthened national leadership, cross-sectorial collaboration and increase allocation of resources in the area of food security and nutrition

Figure 1. The three key results of the National Nutrition Strategy document. Adapted from the NNS, page 11[50].

The NNS used the previous work of the National Nutrition Program (NNP) to generate the three key results and related underlying objectives. In 1994, Cambodia began the first vitamin A supplementation program in response to a 1993 Ministry of Health/Helen Keller International report that indicated night blindness in 6% of children one to six years old. The NNP was begun in 1995. In 2001, the National Infant and Young Child Feeding Policy was developed by the NNP and was later revised in 2008[51]. This report focused on the importance of breastfeeding, and tried to reduce the dependence of mothers on infant formula[51]. In 2002, the vitamin A policy was revised to include supplementation for post-partum women because of a survey that indicated night blindness in one to seven percent of lactating women. Between 2004 and 2007, national guidelines were also created for iron/folate and vitamin A supplementation and communications strategies were developed for the various supplementation programs. In 2008, an analysis called the Nutrition Situation Analysis lead to the creation of the NNS for implementation in 2009. The past programs of the NNP have lead to the creation of the NNS whose mandate is to solidify the previous and new guidelines, communication strategies, and policies into one manageable, measurable policy.

Currently, the NNP falls under the Ministry of Health and has units dealing with malnutrition, vitamin A and iron/folate supplement, deworming, and salt iodization. The unit does policy development, evaluation, curriculum development and training for health professionals and community based programs, and financial program management. The NNP manages the stock of supplementation capsules and tablets and monitors distribution. It operates on a two-fold strategy: providing nutritional supplements for prophylactic or therapeutic purposes, and providing educational resources to promote nutrition at home or in the community. The NPP sits on the National Sub-committee for the Control of Iodine Deficiency Disorders, which attempts to ensure salt iodization at production sites, through quality monitoring and technical assistance. The NNP also participates in the National Sub-committee for Food Fortification (previously, the National Sub-committee for Iron Deficiency Anemia). [50]

The main programming of the NNP is implemented through hospitals and health centres, with health centres providing counseling and community outreach. Hospitals offer the services of treating severe malnutrition and micronutrient supplementation. Fifteen hospitals have trained staff who deal with malnutrition and have equipment and supplies appropriate for treatment. Vitamin A and iron/folate capsules and tablets are provided for women and children which an identified deficiency or prophylactically to pregnant women. Health centre staff are also trained to provide micronutrient supplementation but are not equipped to treat serve malnutrition cases. Health centres also provide information to mothers on feeding during and following illness, utilizing a protocol based on the Integrated Management of Child Illness (IMCI) [24,50]. Health centre staff provide community outreach, specifically offering information on breastfeeding, feeding practices, and micronutrient supplementation, during antenatal and postnatal care activities. Health centres also offer a place to host Baby Friendly Community Groups, an initiative that acts as a soon-to-be and new mother support group. Vitamin A and deworming medication are distributed through the health centres twice annually to ensure uniformity between these supplementation programs.

Key Result One: Reduction in protein energy malnutrition and micronutrient deficiencies in young children.

1.1 Increase the rates of immediate and early initiation of breastfeeding and exclusive breast feeding until six months
1.2 Increase the rates of appropriate complementary feeding of infants and young children (6-23 months of age), focusing on energy and nutrient density
1.3 Increase the rates of appropriate care for and feeding of sick children
1.4 Improve management of severely malnourished children at facility and community levels
1.5 Improve the management of nutrition/feeding of HIV-positive children, including counseling of HIV positive pregnant women and mothers
1.6 Increase and expand the coverage of vitamin A supplementation/Mebendazole distribution and vitamin A treatment for young children
1.7 Reduce the rate of anemia and zinc deficiency in young children
1.8 Increase the proportion of household using adequately iodized salt, targeting areas with lowest coverage
1.9 Promote nationwide coverage of zinc treatment during diarrhea
1.10 Strengthen the response capacity to nutrition emergencies, natural or manmade

Figure 2. Key result one of the NNS has ten sub-goals, eight of which will be evaluated through

regression analysis of population data. Replicated from NNS, page 11[50].

The NNP created the NNS based on its current programming and its ability to target women and child through hospital and health centre outreach. The first key result the strategy hopes to achieve the reduction in PEM and micronutrient deficiencies in young children and is dependent on several sub-goals. The early initiation of breastfeeding and exclusive breastfeeding, complementary feeding, and appropriate feeding of young children and sick children are all objectives in the NNS key result 1 (Figure 2). Coverage of micronutrient supplementation programs, such as vitamin A, zinc, and iodine, and the reduction of their related deficiencies are also objectives for improving childhood health in the NNS. Objectives that pay special attention to HIV-positive women and children are not analyzed in this report due to lack of available data (Objective 1.5). Further, Objective 1.10 is not analyzed because of the abstract and qualitative nature of the goal that makes it better suited to a qualitative analysis.

The purpose of the strategy was to create a unified goal for both the National Nutrition Program and development partners, including NGOs, to achieve in a specific time frame. The strategy was developed through a focus group series with key stakeholders, in addition to using current guidelines and best practices from the WHO, FAO and other international organizations. The main vision of the strategy was to have all women and children, "health, well-nourished and secure" living happy lives to their full potential in environmental sustainability[50]. Although the main vision of the strategy as a whole might be difficult to measure, key result one and its underlying objectives offer manageable goals to measure success against. These objectives will be used in the evaluation of the policy.

1.6 INTRODUCTION TO VIETNAM

In the evaluation of policy, a comparison population can be helpful to determine if the changes in indicators are a direct result of the policy or are due to other factors. In this study, a comparator population was needed to determine if increases in child and infant nutrition indicators were due to the implementation of the policy, or merely due other factors, such as the economic growth in Cambodia at the same time. Vietnam, located on the eastern and northeastern borders of Cambodia with a population of 92.7 million, was chosen because of its geographical proximity and the availability of similar demographic data through surveying over a fourteen-year period. Additional factors that make Vietnam suitable for use as a comparator country to Cambodia are their rice-based diets and economies. Their geographic proximity results in similar variety of dietary foods[52,53]. Although the economic growth of Vietnam was much more rapid than Cambodia during the period of investigation, statistical methods explained in Section 1.8 attempt to control for these and other differences between populations, allowing Vietnam to be used as a "control" to "treatment" population of Cambodia, as Vietnam did not have the NNS introduced in 2009.

Despite advances in reducing child mortality and decreasing fertility rates, before the 1990s, child nutrition in Vietnam remained high[52]. From 1993 onwards, as real GDP grew 8.4 percent per annum and poverty rates declined, the nutritional status of children in Vietnam improved substantially [52]. The percent of GDP contributed to healthcare increased in the 1990s and Vietnam introduced policies to tackle nutritional deficiencies, such as the Hunger Eradication and Poverty Reduction Program and the National Action Plan for Nutrition[52]. Increased income inequality over this time, however, was reflected in increased disparity in nutritional status.

In Vietnam today, only 59 percent of children under 2 years of age receive a diet sufficient in diversity and frequency[54]. Further, one recent study of hospitalized pediatric patients found a rate of wasting of 19 percent and a rate of stunting of 13.9 percent[55]. Although there have been advancements in nutritional status in Vietnam, recent studies indicate that Vietnam is still far from reaching food security with having access to food for all citizens. The persistence of malnutrition in the population at such substantial rates allows for the comparison of nutritional indicators in Vietnam to those of Cambodia.

1.7 RESEARCH GAP

Many studies that analyze food security and malnutrition in Cambodia completed up until the mid-2000s are qualitative and descriptive studies. For example, Hong et al (2007) analyzed the risk of mortality in infants utilizing DHS data from 2000 only, relating to wealth characteristics, pregnancy care, birth weight and maternal nutrition[11]. The National Institute of Statistics (NIS) produced a report for each year the DHS survey was done, however, the report include descriptive statistics in each category, only infrequently suggesting trends from the results of previous iterations of the survey[1]. Indicators of undernutrition in Cambodia suggest a significant burden on national human, social, and economic development, indicating the need for intervention [14]. Although nutrition has improved in recent years, undernutrition still remains a leading public health problem and a key contributor to mortality in children under five[56]. There is a need for a thorough evaluation of Cambodia's 2009 National Nutrition Strategy, in order to determine if its was successful in meeting its objectives and if not, to identify unsuccessful objectives, so that policies can be adjusted or created to improve the nutrition status of children across Cambodia. Evaluation over time may also identify areas and methods for improvement in similar nutrition policies in other countries where malnutrition is prevalent. Reviews completed for WHO suggests that the impact of large scale nutrition programs is often uncertain, suggesting the need for a more definite way to investigate large scale programs[27,57]. This investigation applies economic models, not frequently used in conjunction with observational epidemiological data, to the evaluation of a large-scale program (NNS) in order to attempt to address these gaps.

1.8 ECONOMETRIC MODELS FOR OBSERVATIONAL DATA

The difficulty in determining the effect of a national treatment, especially one as abstract as the implementation of a policy, in an observational study is well documented[58]. Classical statistical analysis through the presentation and examination of descriptive data through the years and regression analysis provide key information about trends, and the relationship between variables. Classic regressions like linear and logistic regressions can also help researchers select variables to include for more complex analysis[59–61]. Although useful, regression models have low statistical significance or low significant effect in epidemiological studies where the outcome of interest is affected by multiple variables. All regression analyses do not perfectly account for unmeasured confounding factors, unless all of the covariates are included in the regression, and any unobserved confounders are uncorrelated to the treatment, but the regressions can still provide good estimations of the effect of treatments. Linear and logistic regressions can be equally effective as more rigorous analysis, but models that utilize regression adjustments, inverse probability weights, or matching techniques can be helpful in further solidifying the suggestion of a casual treatment effect, and offer some protection against mismodelling.

Unbiased and efficient estimation of the difference in the means of the treated versus untreated group would suggest a difference attributable or caused by the treatments, the average treatment effect (ATE), but this ideal is difficult to obtain using observational data (Equation 1)[58]. Theoretically, to calculate ATE, each subject would need an outcome as if each subject had been treated (Y_1) and as if each subject had also been in the control group (Y_o). Obviously, in practical terms, each person is either in the treated or untreated group, not both. This creates a problem of missing data, where for a person who is in the treatment group, another outcome must be estimated as if they were in the control group to complete Equation 1. In order for estimated causal ATE to an accurate and unbiased estimation, the postulated model would need to include all of the covariates related to the outcome [62]. Perfect regression models are nearly impossible for population data, when many confounders affect variables of interest, and an inaccurate regression model can introduce bias into the estimation of the ATE. Other methods, such as incorporating other variables into a linear or logistic regression to measure the impact on the dependent variable, can attempt to reduce this bias and bring the regression model estimate closer to the true treatment effect. However, this approach assigns a functional form relationship between the variable of interest and the specified covariate, for example, a linear relationship between age and weight-for-age. More robust models that offer protection from mismodelling, that is, they have more flexibility in the relationships between variables, to estimate ATE and solve the missing data problem.

$$\Delta = \mu_1 - \mu_2 = E(Y_1) - E(Y_0)$$

Equation 1. Average treatment effect (ATE), where Y_0 and Y_1 are the values of the response that would be seen if the subject were to receive control or treatment, respectively

Inverse probability weights (IPW) estimators correct for missing data using a two-pronged approach. First, IPW models estimate the parameters of the treated model and compute the estimated IPW[63]. Second, IPW estimators use the above IPW to compute weighed averages of the outcomes for each treatment level, in this case, treated and untreated. The difference in these weighted averages estimates the ATE. Inverse weighting is a technique that creates a pseudo-population in which there are no confounding factors, so that the weighted averages reflect averages in the true population[58,62].

Another model called regression adjustment (RA) solves the missing data problem of Equation 1 in a different way. The method of the RA model is two-pronged, like the IPW regression. First, the RA fits separate regression models of the outcome on a set of covariates for each treatment level[63]. Second, the average of the predicted outcomes for each subject and treatment level are calculated. These averages, called potential outcome means (POMs) are representative of the means predicted for each outcome for each person. The difference between these means provides the estimate of the ATE. Further, the means can be calculated for only the treated subjects. The difference between the means of only the treated subjects estimates the average treatment effect on the treated (ATET) (Equation 2).

$$\Delta = \mu_1 - \mu_2 = E(Y_1|t) - E(Y_0|t)$$

Equation 2. Average treatment effect on the treated, where Y_0 and Y_1 are the values of the response that would be seen if the subject were to receive control or treatment, respectively, given treatment (t)

Doubly robust (DR) estimators solve the problem of missing data by incorporating regression adjustments and inverse probability weighting into one model. DR models attempt to reduce bias being introduced into the estimated treatment effect[62]. The regression-adjustment (RA) model, as discussed above, fits regression models on a set of covariates, ultimately modelling the outcome[63,64]. The DR estimator can be a more accurate predictor in trying to determine the effect of a treatment on a population because it combines regression models with inverse weighting parametric models[58,62]. The inverse probability weighted estimator (IPW) models the treatment, rather than modeling the outcome, as with RA estimator[63]. The double robust estimator combines the postulated model for the true IPW and the logistic regression model fitted by least of squares to create a modified estimator that will be correct if one of its components is mismodelled and the other component is correctly modelled[62]. If the regression model is incorrect, but the IPW model is correct, or if the IPW model is incorrect but the adjusted regression model is correct, then the DR estimator will be a consistent estimator for the treatment effect[64]. In this way, the DR estimator offers protection against mismodeling[62]. If the IPW estimator is modeled correctly, DR estimator will have smaller variance than the IPW estimator alone. If the regression is modeled correctly, the DR estimator may have larger variance than the regression model alone, however, the efficiency gain from regression only would be at risk if the regression was not accurate[63].

There are different DR estimators that one can use, both following the same basic principle. First, Robins and Rotnitzky (1995) and others suggest an augmented-IPW (AIPW) estimator[62,65,66]. AIPW estimator removes bias if the IPW (treatment) model is wrong and the outcome model correct, and removes the augmented term if the IPW (treatment) model is correct and the outcome model is wrong[63,64,66]. A second DR estimator, the inverse-probability-weighted model with regression-adjustment (IPWRA), is favoured by a more recent paper by Wooldridge[67]. If the RA model is correct, the IPW model does not affect the accuracy of RA estimator, however, the IPW corrects the RA estimator if the RA model is incorrect. Both models have a correction system, where the AIPW begins with the IPW model and corrects using RA, the IPWRA begins with the adjusted regression model and adjusts with IPW[63]. The DR estimators allow for the difference between treated and non-treated groups to be compared, even in light of unmeasured confounding variables.

A different approach is taken to solve the same problem of unmeasured confounding variables present in observational studies in the econometric estimators that use matching[67,68]. Two different estimators "match" pairs of data from a treatment group to a person in the non-treatment group (in this study, a person from Cambodia to a person from Vietnam). Matching can occur on a one-to-one basis, or can be adjusted to assess one treated individual to the average of a number of untreated, similar individuals. Nearest-neighbour matching (NNM), explored by Abadie and Imbens (2006, 2011), uses the weighed differences by the inverse of the sample covariance matrix to define distance between two "neighbours" [63,68–70]. For each treated individual, NNM uses an average of similar individuals who did not receive the treatment to estimate the POMs. A scaling matrix determines the similarity between two individuals using Mahalanobis distance technique, inverse variance or Euclidean measurement [63]. The DR estimators (IPWRA and AIPW) have a functional-form assumption, that is, the model assumes a certain regression form like a linear or logistic relationship. The NNM estimator has more flexibility to estimate ATE for a wider class of models. The NNM needs a large amount of data to match, especially for continuous variables, so variables with small sample sizes will produce large bias in the estimate[68,69]. The formulas for the estimated ATE and ATET using NNM are available on page 114 to 115 of the Treatment-effects manual[63] or Abadie and Imbens[69,70]

The second iteration of a matching estimator is the propensity-score matching model (PSM). First, an introduction to the propensity score is needed. The propensity score (Equation 3), is the probability of treatment given the observed covariates[58]. In practice, the propensity score is unlikely to be known, so it is estimated from observed data (typically using Equation 4). The PSM estimator matches on a probability of treatment, as determined by other variables. More formally, PSM uses a treatment model to model the conditional probability that observation i receives treatment Z given covariates X_i. Since the propensity score essentially turn all the other variables into one, there is no need for bias adjustment.

$$e(X) = P(Z = 1|X), 0 < e(X) < 1$$

Equation 3. Theoretical propensity score, where X contains all the cofounders, Z is the indicator of an observed treatment exposure

$$\sum_{i=1}^{n} \psi_B(Z_i, X_i, \beta) = \sum_{i=1}^{n} \frac{Z_i - e(X_i, \beta)}{e(X_i, \beta)\{1 - e(X_i, \beta)\}} \partial/\eth\beta\{e(X_i, \beta)\} = 0$$

Equation 4. Propensity score estimator, from observed data, by assuming e(X) follows a parametric model

There are multiple methods for estimating the effect of the treatment on sample data. In observational studies, a problem emerges in applying traditional regression models due to unmeasured covariates. To account for these confounding variables, more accurate estimators of the treatment effect model either the treatment or the outcome. The DR estimators, IPWRA and AIPW, use regression-adjustment and inverse probability weighting to model the outcome and treatment, and accurately estimate the difference between treated and untreated groups. The matching estimators, NNM and PSM, use specified covariates to match treated and untreated individuals, and estimate the ATE and ATET by comparing the means between the two groups. In this study, all of these regression models are applied to better understand the effect of the policy on nutrition status of children in Cambodia.

CHAPTER 2: METHODOLOGY

Cross-sectional data from two surveys across four time points were appended to create one database. Nutritional indicators were evaluated through economic regression models, and the results were applied to discuss the effectiveness of the implementation of the NNS. Overall, the study was designed with feasibility, measurability and applicability of results in mind. The study was a secondary data analysis. The success of the policy was evaluated through six nutritional indicators using trends in descriptive statistics, linear and logistic regressions, a doubly robust estimator, and a matching estimator to estimate the effect of the policy on each indicator. The results of the analysis of these six indicators and descriptive statistics for confounding and related variables informed the discussion of whether the NNS was successful in reducing childhood malnutrition.

2.1 DATA COLLECTION

Survey creation and data collection for Cambodia was implemented by the Directorate General for Health (DGH) of the Ministry of Health and the National Institute of Statistics (NIS) of the Ministry of Health, through funding from USAID and other partners, and with technical assistance from ICF International[1]. The survey included questions on demographics, family planning, maternal health, child health, and HIV/AIDS, and was implemented through three questionnaires (Household, Men's and Women's). The Women's questionnaire was used for the creation of the database of the current study as it contains the demographic and nutritionally related information for children and women. The Demographic and Health Survey (DHS) women's questionnaire sample is a nationally representative sample of women between the ages of 15 and 49, representing all 24 provinces. The stratified sampling of household was performed so data could be used to produce accurate national estimates. Questionnaires were available in English and Khmer and presented by trained field staff. Data was edited and entered by data processing personnel. Further details on sampling, training and development of the questionnaires are available from DHS[1,47,71–73].

Data collection for Vietnam was implemented by Viet Nam General Statistics

Office in collaboration with UNICEF. The Multiple Indicator Cluster Survey (MICS) was developed by UNICEF in the 1990s to collect statistically sound and internationally comparable data. The sample for Vietnam was also designed to provide estimates of indicators that would be representative at the national level. Stratified sampling technique was also used. Households were selected within six geographic regions. Three questionnaires were developed (Household, Women's and Children's). The data from the women's and children's questionnaire was utilized to the create database used in this study. Data was double entered and check for consistency. More information on the data collection and entry for Viet Nam can be found in MICS final reports[54,74–76].

2.2 DATABASE CREATION

Data permission was given from USAID for access to the Cambodian DHS from 2000 to 2014. Permission was also received for use of UNICEF's MCIS data from Vietnam surveys from the years 2000 to 2014. Datasets were examined in order to select appropriate variables that could be used to evaluate objectives from the NNS. Variables were also selected that were used as demographic indicators in the nutrition section of each of the DHS final reports, as these factors were postulated by previous technicians to have an impact on the nutrition indicators that were selected[1,47,71,72]. For example, the indicators weight-for-height, weight-for-age and height-for-age were all selected for their ability to reflect the nutritional status of children. The DHS report further separates descriptive data by sex, age, province, mother's education, wealth quintile, etc[47]. Therefore, variables that were used in other nutrition studies, or those that were thought to have an impact on nutritional status were included in the database.

The availability of variables at different time points meant that some variables would not be useful in analysis, due to a lack of data. Variables were kept if data were available before and after implementation of the NNS (such as weight-for-height, weight-for-age and height-for-age, which was available for 2000 and 2010 only). Variables were kept if they were available for Cambodia, but not Vietnam, but discarded if they were only available for Vietnam. Data was renamed for Cambodia to have consistent variable names across each year. Variables were renamed for the MCIS data to ensure consistency between data labels and definitions across years. Data for Vietnam was merged between the women's survey and the children's survey utilizing specific ID codes. Data was recoded to have the same code be indicative of the same response for each country, and some variables were recoded as binary responses. Data from Cambodia was recoded according to the DHS Standard Recode Book and the country and year specific coded answers (found in the questionnaires available at the end of each report)[1,47,71–73]. Data from MICS for Vietnam was recoded according to the questionnaires specific to each year found in the MICS Tool and country specific questionnaire coding found at the end of each final report[54,74–80]. The database was then appended for each country, for all four years. Data was finally appended into one dataset, containing data from Cambodia from 2000, 2005, 2010 and 2014 and data from Vietnam from 2000, 2006, 2010-2011 (2010), and 2013-2014 (2013). All database creation and management was completed in Stata14[81].

2.3 DESCRIPTIVE STATISTICS

Descriptive statistics were calculated in Stata, Version 14[81]. Descriptive statistics allowed initial trends to be determined, and showed characteristics about the data that are necessary assumptions for more analytical tests. The presented descriptive statistics included summaries of means, median, percentiles, standard deviation and skewness. for each variable, where appropriate. The change was calculated between 2000 and 2010, 2000 and 2014, 2005 and 2010, 2005 and 2014, and averages before (2000 and 2005) and after (2010 and 2014). These differences allowed trends to be analyzed over time from different years, especially if data was not available for certain years, and allowed differences to be compared across the two countries over time (Equation 5).

$$\Delta X = X_2 - X_1$$

Equation 5. Difference between two variables

The data from Vietnam is essentially used as a control population while discussing the descriptive data, comparing changes in nutritional indicators or covariates in Cambodia to those changes in Vietnam of the same time period.

Difference-in-differences were calculated to for an additional comparison that attempts to negate initial differences between the two populations, over the four years (Equation 6).

$$\hat{\delta} = \left(\overline{y_{B,2}} - \overline{y_{B,1}}\right) - \left(\overline{y_{A,2}} - \overline{y_{A,1}}\right)$$

Equation 6. Difference-in-differences estimator

The DiD method, based on work by Ashefelter and Card[82], subtracts the average change in the control group from the average change in the treatment group (Equation 6). This removes biases in second period comparisons between treatment and control groups that could be due to other factors[67]. DiD was calculated for Cambodia and Vietnam if data was available for all four years to analyze if the rate of change differed before or after implementation, and how the rates compared between the two populations. For example, the difference between proportions of children who were underweight in Cambodia over five years before treatment (*A*: 2005 – 2000) and after treatment (*B*: 2014 – 2010) were compared. The change in the difference over a four or five year period was calculated (*B*-*A*). Finally, this was compared to the change in difference over four or five year period in Vietnam (DiD= [*B*-*A*] – [*C*-*D*], where C is 2005 – 2000 in Vietnam and D is 2014 -2010 in Vietnam). This method of analyzing descriptive data allows the comparison of two populations over time, while reducing some of the bias caused by differences between the two groups.

2.4 REGRESSIONAL ANALYSIS

Regressions were performed for nutritional indicators of interest. First, a linear or logistic regression was run between the nutritional indicator and the treatment, for Cambodian data only and for all data, to determine if the treatment had a significant effect on that nutritional indicator. Next, a series of linear or logistic regressions were run on the nutritional indicators that examined the relationship between covariates, the treatment and the nutritional indicator. Variables were grouped into categories to determine the effect of that category on the nutritional indicators of interests, and how it affected the relationship between the treatment and the dependent variable of interest. Variables needed to be grouped to examine their effect on dependent variables of interest because the overall regressions had too many collinear associations to reach convergence due to the high number of binary variables dependent on each other (e.g., the treatment of diarrhea options will always be correlated with 'had diarrhea recently'). Dependent variables of interest in this study are indicators of nutritional status, which are the WHO anthropometric measures and weight at birth. The variables were investigated in categorical fashion to determine significance and impact for the DR and propensity-matching regressions of true interest. For example, variables related to mother's education level were grouped, and these grouping was used to estimate the effect of education of women on weight at birth, and the changing effect of treatment, given education of the women. The results from these regressions were presented, and these provided additional information for discussion of variable selection for the DR and nearest-neighbour matching regressions. Conclusions could only be drawn about the variables grouped in the model and their effect on the nutritional indicator of interest.

Linear regression was performed for continuous dependent variables, such as weight at birth, weight-for-age, height-for-age and weight-for-height (Equation 8). Linear regression assigns a line of best fit to a set of data, minimizing the sum of squared difference between the original data and fitted line.

$$y = \beta_o + \beta_1 x_1 + \ldots + \beta_n x_n$$

Equation 8. Linear regression model

Key measurements were recorded for the regressions including standard error, the t-statistic, the probability that the correlation is statistically significant (p>t) and the 95% confidence interval. Pearson's correlation coefficient (R) determines the strength of the relationship between two variables (Equation 9). The squared of Pearson's correlations (R^2), also known as the Coefficient of Determination determines how much of the variation of the dependent variable is due to the independent variables, or in this case, the category of interest (Equation 10). Using the previous example, R^2 shows us how much of the variance in weight at birth is explained by mother's education.

$$R = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}}$$

Equation 9. Pearson's correlation coefficient (R)

$$R^2 = \frac{\sum(\hat{y}_i - \overline{y})^2}{\sum(\hat{y}_i - \overline{y})^2 + \sum(y_i - \overline{\hat{y}_i})^2}$$

Equation 10. Coefficient of Determination (R^2)

The F-statistic was also recorded. The F test utilizes the mean of squares and divides by the associated degrees of freedom to determine in the slope of the regression line is significantly different from the horizontal, that is, if there is a relationship between the variables of interest.

For dependent variables of interest that were binary data, logistic regressions were run (Equation 11). The logistic regression provides the odds ratio, standard error, z score, and the probability that the odds ratio is significant. Classification tables were run for each logistic regression which provides information about the ability of the regression model to predict real data, that is, how often would the logistic regression model be correct in predicting a success or failure in the original data.

$$\pi = P(Y = 1 | X_1, \dots, X_p) = \frac{\exp(\beta_0 + \beta_1 X_1 + \ldots + \beta_p X_p)}{1 + \exp(\beta_0 + \beta_1 X_1 + \ldots + \beta_p X_p)}$$

Equation 11. Logistic regression model

Further tests were run following each regression to help determine the goodness-of-fit (GOF) of the logistic regression. First, the Pearson GOF test was run (Equation 12). Pearson's chi-squared model determines likelihood that differences between frequency distributions of datasets are significant, and is most accurate in large samples of unpaired data. If the number of observations is similar to the number of covariate patterns, the Pearson chi-squared test may not be the most appropriate estimate for GOF[83]. Another GOF test was also run for each regression. The Hosmer-Lemeshow GOF test is a better fit when there are one or more continuous predictors in the model (Equation 13)[84,85]. The Hosmer-Lemeshow test was demonstrated to be as distributed as Chi-squared for certain data simulations, a classical way of determining the significance of odds ratios[84]. The Hosmer-Lemeshow test can only be applied to categorical data. The data is grouped in ten groups by predicated probabilities, however, if the sample size is low, the Hosmer-Lemeshow test may be unreliable, and Pearson's GOF maybe be more realiable[83]. For both Pearson chi-squared and Hosmer-Lemeshow, if the p value is low, the GOF of the model is low[84].

$$\sum_{k=0}^{1}\sum_{l=1}^{g}\frac{(o_{kl}-e_{kl})^2}{e_{kl}}$$

Equation 12. Pearson's GOF model for logistic regressions

$$\hat{\pi}=\frac{\exp\,(\widehat{\beta_0}+\widehat{\beta_1}X_1+\ldots+\widehat{\beta_p}X_p)}{1+\exp\,(\widehat{\beta_0}+\widehat{\beta_1}X_1+\ldots+\widehat{\beta_p}X_p)}$$

Equation 13. The Hosmer-Lemeshow GOF model for logistic regression

Stata also produces a pseudo R^2 that was recorded for each logistic regression. Like the ordinary R^2 for ordinary-least-squares regressions, the pseudo-R^2 hopes to produce a measure of goodness-of-fit. The pseudo-R^2 can be calculated through various models, such as Efron's pseudo-R^2 or McFadden's adjusted pseudo-R^2 [86]. However, there is large variance between each of the models and classification tables and other measures of GOF are typically more accurate, therefore, the pseudo-R^2 was not used frequently in interpretation of the results.

The next aspect of analysis was a double robust estimator, introduced in Chapter 1. There are two DR estimators discussed in Chapter 1. The inverse propensity weight with regression adjustment (IPWRA) estimator uses a RA estimator to model the outcome to account for nonrandom treatment assignment, and an IPW estimator to model the treatment to account for the nonrandom treatment assignment. An IPWRA DR estimator was chosen for use, over the other DR estimators, because of the three-step process, which ensures the predicted IPW did not get too large. First, the IPWRA estimated the parameters of the treatment model and computed IPW, which the model then used to fit weighted regression models of the outcome, for each treatment level. The treatment-specific predicted outcomes for each individual were calculated, and the difference in the POMs for the treated and untreated groups provided the estimate of the ATE or ATET. The selection of covariates or confounding factors to include in the DR model has been debated in recent literature, although some key suggestions are constant[87]. The DR estimator is most accurate when the selection of covariates to include in the model are variables that are not related to the exposure to treatment, but more strongly related to outcome[62,88]. Further, variables that are related to exposure to treatment but unrelated to outcome can be omitted, as they have been found to increase the bias of the estimator. Variables were selected based on selection criteria outlined in previous studies; based on scientific literature that previously have indicated a casual effect on the outcome or using results from the linear and logistic regressions that had determined a significant relationship between the covariate and the outcome[59–61].

The results of the DR determined the average treatment effect (ATE), which estimates the effect for each subgroup regardless of which treatment was actually received, or the average treatment effect on the treated (ATET), which demonstrates the effect of the treatment only on the treated (Equation 1 and 2). Both the ATE and ATET were determined for each of the six nutritional indicators, weight at birth, very small at birth, underweight at birth, height-for-age, weight-for-age and height-for-weight. The ATET is useful because it shows the effect of the treatment (policy) only on those who received the treatment (Cambodian people, after 2009). The ATE shows the effect of the treatment on both the treated, and non-treated[64]. Although there might be some spillover effects of the implementation of the policy in Vietnam, such as by the border provinces, this study focuses on the evaluation of the effects of the policy on nutritional status of children in Cambodia, which is why ATET is of greater interest. The ATE and ATET were determined using the DR estimator for each of the six nutritional indicators, for Cambodian data only (to determine the treatment effect on Cambodian people compared to before the policy) and Cambodian and Vietnamese data (to determine the treatment effect compared to data from Vietnam).

A final estimator was used to measure the effect of the implementation of the policy on the nutritional status of children. A matching estimator was used because of its ability to reduce bias and provide a different estimation of ATE and ATET, which can be compared to simple linear or logistic regressions and the DR estimator. Although the NNM introduces more error when matching continuous variables, when most variables are binary or discrete it can be less biased than the PSM model. Further, the PSM rejected similar binary variables as collinear, such as the variable to separate Vietnam from Cambodia (1 for Cambodia, 0 for Vietnam) was collinear to treatment variable (which is

1 for all Cambodian in 2010 and 2014, and 0 for all other data). The PSM was further determined to be less suitable for this study, as it is most accurate when the determinants of treatment status are known. A wide variety of variables could affect the treatment status, that is, the probability of being from Cambodia after policy implementation, or from Cambodia and Vietnam before policy implementation is difficult to determine. Since the treatment is being applied to a population, the determinants of treatment status are not known fully[68]. The NNM was selected because of its suitability to the data used and its ability to provide a more unbiased estimator compared to the DR model. The selection of variables used for matching between Cambodian and Vietnamese individuals was done based on current literature[60,61,88,89]. The NNM was adjusted to remove large-sample bias that the continuous covariates introduced into the estimator, using methods from Abadie and Imbens (2006), which is integrated in the statistical software[68,70]. The statistical software uses a Mahalanobis distance metric which adapts to covariance between variables and variance within variables to allow matching[63]. The ATE and ATET were estimated for the six nutritional indicators, matching individuals from Cambodia to those from Vietnam based on a number of metrics. More on the code used to determine the DR estimation and NNM estimation of ATE and ATET of the policy on the nutritional indicators can be found in the Stata Treatment-Effects Reference Manual (2013)[63].

CHAPTER 3: RESULTS

3.1 INTRODUCTION

Variables are described briefly, but for more extensive background on each variable please refer to *CHAPTER 1*. For specific coding details for each variable, please refer to *APPENDIX A-Recode Book*. Treatment refers to the implementation of the policy; therefore, observations from Cambodia after 2009 are "treated". For ease of charting and comparison, data from Vietnam for 2006 is labeled 2005 in tables and charts. Data from Vietnam from 2010-2011 and from 2013-2014 is referred to as 2010 and 2014, respectively, in all cases. The policy was implemented in 2009, so before implementation refers to observations in the years 2000 and 2005 (2006) and after implementation refers to data from 2010 and 2014. First, the six nutritional indicators are analyzed. Descriptive statistics were presented for each indicator, for Cambodia and Vietnam from 2000 to 2014. Linear and logistic regressions are performed that analyzed the relationship between covariates, the treatment, and the nutritional indicator. Next, the effect of the treatment on the nutritional indicator is analyzed using a DR estimator. Finally, a NNM estimator is used as a second method to estimate the ATE and ATET on each nutritional indicator, and these results were compared with the DR estimator. Finally, descriptive statistics and trends in the data of the covariates used is presented to help inform the discussion around the effect of the policy on the nutritional indicators.

For a summary of results, please turn to Section 3.10 (p. 99).

3.2 NUTRITIONAL INDICATORS: SIZE AND WEIGHT AT BIRTH

3.2.1 Weight at birth (g)

Maternal under nutrition contributes to 800 000 neonatal deaths annually through small for gestational age births, highlighting the importance of size and weight at birth as an indicator for both maternal and child nutritional status[90]. The mean weight at birth was analyzed to determine policy implementation effects. First, descriptive statistics were analyzed to look at trends and differences in weight at birth between the two countries. Second, a linear regression was run between weight at birth and treatment, to determine if there was a significant relationship between the treatment and weight at birth, using data from Cambodia only and from Cambodia and Vietnam. Finally, linear regressions were completed to look at the relationship between covariates, treatment and weight at birth. The results from these final linear regressions helped to determine if there were statistically significant relationships between different covariates and the nutritional indicator, weight at birth.

Mean weight at birth in Cambodia rose from 2000 to 2005, and then decreased from 2005 to 2014 by approximately 100g. The median stayed fairly consistent, ranging between 3200g and 3100g over the four years. Mean weights for the population recorded were approximately normally distributed. On average, from 2000 to 2014, children weighed 3145.68g in Cambodia. Mean birth weight in Vietnam only varied by no more than 15g from 2000 to 2014, with an average of 3098.53g for all data across the four time points. Weight at birth in Vietnam also approximated a normal distributed. (Table 1) The analysis between time points before and after implementation showed decreasing average weight at birth in Cambodia, and small increases between years in Vietnam in 2000 to 2014, 2005 to 2014 but not 2005 to 2010. An estimate suggests the rate of change of was a much larger negative integer after implementation in Cambodia, compared to Vietnam, which had a decreasing rate of change (Table 10). (Figure 3)

		2000	**2005**	**2010**	**2014**
Weight at birth (g)					
Cambodia	**Mean**	3200.815	3214.268	3156.118	3094.481
	Median	3100.000	3200.000	3200.000	3100.000
	Std. Dev.	638.640	670.898	565.620	508.666
	Skewness	0.153	0.337	0.049	-0.043
Vietnam	**Mean**	3102.243	3091.403	3088.678	3110.481
	Median	3100.000	3100.000	3100.000	3100.000
	Std. Dev.	475.341	436.333	453.206	446.063
	Skewness	-0.287	-0.145	-0.403	-0.037

Table 1. The mean and distribution of weight at birth (g) in Cambodia and Vietnam in 2000 to 2014. Mean weight at birth was given in grams and could have been reported by the mother or recorded on a birth certificate or other document.

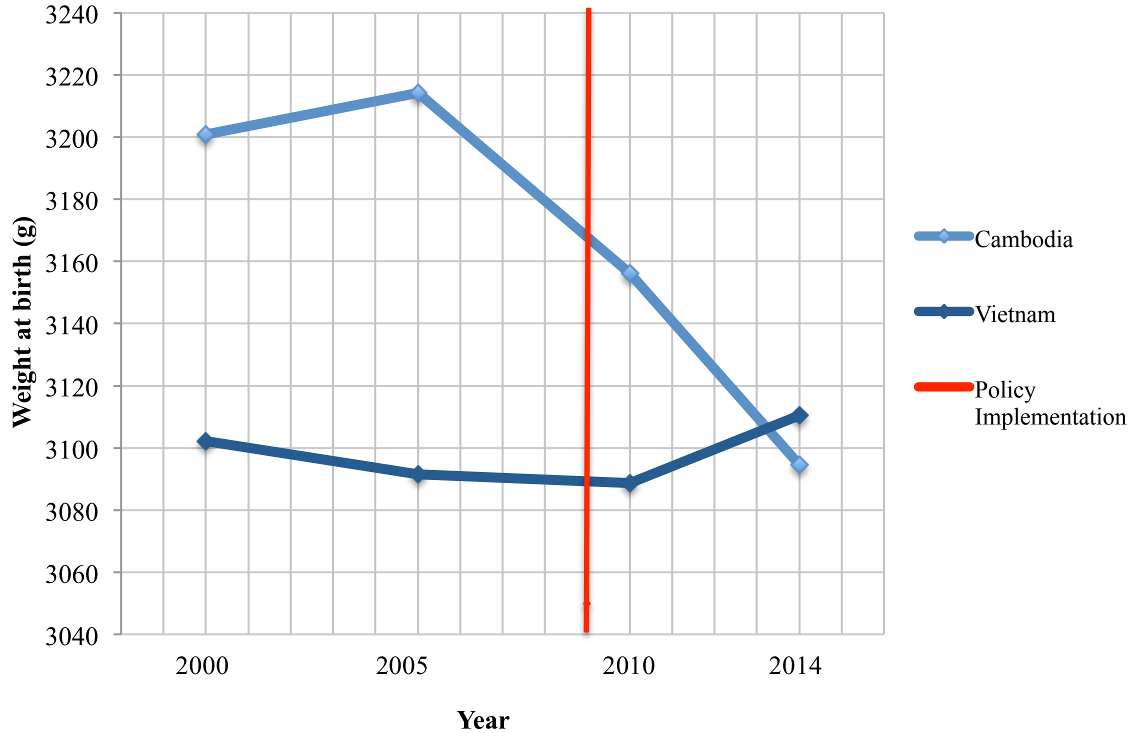

Figure 3. Weight at birth (g) in Cambodia and Vietnam from 2000 to 2014. Mean weight at birth was given in grams and could have been reported by the mother or recorded on a birth certificate or other document.

A linear regression performed with only weight at birth and treatment indicated that, although treatment had a statistically significant effect on weight at birth, this effect was negative, that is, those who were in the treatment group decreased in weight. The treatment explained little of the variance of weight at birth, demonstrated by the R^2 value. Similarly, treatment was negatively correlated with weight at birth and the strength of association between the two variables was even less when data from both Cambodia and Vietnam was included (Table 2).

	Coeff	**Std. Error.**	**t**	**P>t**	**R^2**	**Prob>F**	**Root MSE**	**95% Conf Int**	
Cambodia	-86.67	10.27	-8.44	0.000	0.0043	0.0000*	57.33	-106.82	-66.537
All data	-30.39	7.811	-3.89	0.000	0.0007	0.0001**	549.69	-45.706	-15.085

Table 2. Linear regression results for the correlation between weight at birth (g) and 'treatment' for Cambodia, and all data (Eq13). *F(1, 16341)=71.15 ** F(1, 20536)=15.14

Linear regression were then performed to determine if certain variables had an effect on the association between treatment and weight at birth, that is, to determine covariates and identify important confounding variables. The first grouping of variables examined the effect of demographic and characteristics of women, including education, age at marriage, age, current contraception use, etc. (Table 3). When these characteristics were added to the regression, the treatment had no statistically significant effect on weight at birth, but age at marriage of the women and sex of the child were significantly correlated (p=0.000). The model overall had a R-squared value of 0.0237 (p=0.0000), showing a low level of explanation for the variance in weight at birth.

	All data						**Cambodia**					
	Coeff	**Std. Error.**	**t**	**P>t**	**95% Conf Int**		**Coeff**	**Std. Error.**	**t**	**P>t**	**95% Conf Int**	
Demographic and characteristics of women												
Treatment	-50.52	378.5	-0.10	0.919	-780.6	703.28	-50.30	15.367	-3.27	0.001	-80.46	-20.14
Any education*	-	-	-	-	-	-	-	-	-	-	-	-
Highest education level attended	3.64	39.87	0.02	0.985	-77.432	78.89	3.85	39.87	0.02	0.985	-77.433	78.893
Highest education level completed	7.40	19.29	0.48	0.633	-28.605	47.02	7.49	19.291	0.48	0.633	-28.606	47.024
Highest grade completed	3.68	3.090	1.17	0.243	-2.4519	9.663	3.71	3.090	1.17	0.243	-2.452	9.664
Age at 1st marriage	-12.55	1.830	-6.82	0.000	-16.068	8.893	-12.44	1.830	-6.82	0.000	-16.071	-8.895
Martial status	-4.07	10.54	-0.41	0.683	-24.979	16.36	-3.92	10.546	-0.41	0.681	-25.005	16.342
Contraception used	-2.89	6.954	-0.70	0.481	-18.532	8.731	-2.61	6.955	-0.71	0.481	-18.536	8.730
Child was planned	-12.44	11.47	-1.14	0.256	-35.529	9.452	-12.389	11.473	-1.14	0.256	-35.536	9.448
Female child	-91.22	12.28	-7.40	0.000	-114.948	693.4	-91.14	12.285	-7.39	0.000	-114.926	-66.762
Child's age in yrs.	-35.77	21.73	-1.68	0.092	-79.152	6.032	-35.84	21.732	-1.69	0.092	-79.224	5.980
Child's age in months	2.70	1.78	1.56	0.118	-0.7058	6.278	2.71	1.781	1.57	0.117	-0.7018	6.283
Mother's age	7.93	4.41	1.88	0.060	-0.3609	16.93	7.93	4.4108	1.88	0.061	-0.3668	16.926
Mother's age group	16.06	21.31	0.67	0.504	-27.528	55.99	16.10	21.305	0.67	0.503	-27.495	56.034
	Number of obs= 7565 R^2= 0.0237 f(15, 7549)=12.23 Adj R^2= 0.0218 prob>F= 0.0000 Root MSE= 533.69						Number of obs= 7563 R^2= 0.0237 f(14, 7548)=13.09 Adj R^2= 0.0219 prob>F= 0.0000 Root MSE= 533.72					

Table 3. Results of linear regressions for demographics and characteristics of women and weight at birth (g). The effect of 'controlling' for demographic and characteristics of women, such education, contraception used, age, or sex, on the child's weight at birth(g) and the ATE was investigated through linear regressions. Regressions were performed for all data (Cambodia and Vietnam) and Cambodia only.

The impact of wealth indicators, such as flooring material, ownership of an automobile, time needed to get water, etc., showed no correlation for all data, and minimal correlation for certain characteristics (owning a scooter/motorcycle and a refrigerator) for Cambodian data only (Table 4). The wealth scores had a correlation that was statistically different from 0, but the R^2 value showed a very small correlation (0.0006) (Table 4). The previous survival outcomes of children were statistically correlated with weight at birth, and the addition of these factors to the regression made the treatment effect statistically significant for both all data and Cambodia only (Table 5). Although statistically significant, the association of the overall model was still low (R^2 <0.01). Assistance at birth from doctors, midwifes or nurses, traditional birth attendants (TBA) and others showed a significant impact on weight at birth, and the associated treatment effect for all data remained significant, but none of the assistance at birth variables were significantly associated with weight at birth for data from Cambodia only (Table 6). Breastfeeding practices and feeding practices were investigated. The treatment was had a significant impact on the variance of weight at birth(g) in the feeding model for all data and Cambodia only, but only had a significant impact on weight at birth for the breastfeeding model for data from Cambodia. Low R^2 values indicate that both feeding practices 24 hours after birth and breastfeeding practices predicted very little of the variance in weight at birth (Table 7).

	All data					
	Coeff	**Std. Error.**	**t**	**P>t**	**95% Conf Int**	
Treatment*	0	-	-	-	0	-
Source of drinking water	-1.161	6.953	-0.170	0.867	-14.815	12.494
Time to get water	-4.79	2.525	-1.900	0.058	-9.753	0.164
Type of toilet facility	-5.94	13.114	-0.450	0.650	-31.702	19.806
Floor material	-38.69	20.587	1.880	0.061	-79.127	1.735
Has electricity	-108.16	84.599	-1.280	0.202	274.311	57.985
Has bicycle	-20.71	58.277	-0.360	0.722	-135.165	93.740
Has radio	18.37	63.606	0.290	0.773	-106.543	143.296
Has TV	-83.22	70.363	-1.180	0.237	-221.412	54.967
Has refrigerator	-18.85	340.104	-0.060	0.956	-686.806	649.090
Has motorcycle/scooter	14.04	66.436	0.210	0.833	-116.440	144.515
Has car/truck	-104.06	214.484	-0.490	0.628	-525.297	317.176
	Number of obs=608 R^2= 0.0203 f(11, 596)=1.12 Adj R^2= 0.0022 prob>F= 0.3412 Root MSE= 687.93					

Table 4. Results of linear regressions for wealth indicators and weight at birth (g). The effect of wealth indicators, such as owning a automobile, time to water, owning a scooter, etc., on the child's weight at birth (g) and the ATE was evaluated through a linear regression model. Regressions were performed for Cambodia only because of data restrictions. Treatment was excluded because of co-linearity.

	All data						Cambodia					
	Coeff	**Std. Error.**	**t**	**P>t**	**95% Conf Int**		**Coeff**	**Std. Error.**	**t**	**P>t**	**95% Conf Int**	
Survival of previous children												
Treatment*	-53.63	8.94	-6.00	0.00	-71.17	-36.11	-78.63	10.38	-7.58	0.00	-98.98	-58.29
Children ever born	-20.31	7.61	-2.67	0.01	-35.22	-5.40	35.84	3.08	-11.64	0.00	29.80	41.88
Surviving children	56.33	8.76	6.43	0.00	39.16	73.50	-	-	-	-	-	-
# of children who have died*	-	-	-	-	-	-	-61.11	14.68	-4.16	0.00	-89.90	-32.33
Ever had children who have died	-30.40	6. 27816	-4.84	0.00	-42.71	-18.10	-22.11	23.76	-0.93	0.35	-68.68	24.46
	Number of obs=20538 R^2= 0.0107 f(4, 20533)=55.59 Adj R^2= 0.0105 prob>F= 0.0000 Root MSE= 546.98						Number of obs=16343 R^2= 0.0128 f(4,16338)=53.03 Adj R^2= 0.0126 prob>F= 0.0000 Root MSE= 568.94					

Table 5. Results of linear regressions for children's survival in the family and weight at birth (g). The effect of the survival of other children belonging to the same mother was on the weight of the child at birth was evaluated through a linear regression model. Regressions were performed for all data (Cambodia and Vietnam) and Cambodia only.

	All data						Cambodia					
	Coeff	**Std. Error.**	**t**	**P>t**	**95% Conf Int**		**Coeff**	**Std. Error.**	**t**	**P>t**	**95% Conf Int**	
Type of assistance at birth												
Treatment	-41.65	8.57	-4.86	0.00	-58.45	-24.85	-83.17	10.54	7.89	0.000	-103.8	-62.50
Doctor	-32.10	16.71	-2.89	0.004	-32.28	33.22	-20.18	15.81	-1.28	0.202	-51.18	10.82
Nurse/midwife	5.55	14.09	0.39	0.693	-22.67	32.58	-29.05	22.55	-1.29	0.198	-73.91	14.56
Trad. Birth Attendant	40.17	22.58	2.13	0.033	28.31	116.82	-3.93	25.97	-0.15	0.88	-46.75	72.83
Relative/friend	11.32	24.22	0.50	0.615	-12.63	82.32	31.16	24.76	1.26	0.208	-10.08	97.52
Other	12.25	56.08	0.22	0.825	-74.63	145.22	34.32	69.01	0.50	0.619	-100.9	169.6
No one	-174.50	208.32	-0.87	0.402	-589.23	227.42	-217.1	217.17	-1.01	0.31	-645.69	205.73
	Number of obs=20435 R^2= 0.0025 f(8,20426)=6.42 Adj R^2= 0.0021 prob>F= 0.0000 Root MSE= 549.71						Number of obs=16337 R^2= 0.0050 f(8, 16328)=10.16 Adj R^2= 0.0045 prob>F= 0.0000 Root MSE= 571.3					

Table 6. Results of linear regressions for determining the association between type of assistance at birth and weight at birth (g). The effect of the type of assistance used at the child's birth, such as having a doctor present, on the child's weight at birth (g) and the ATE was evaluated through a linear regression model. Regressions were performed for all data (Cambodia and Vietnam) and Cambodia only.

	All data						Cambodia					
	Coeff	**Std. Error.**	**t**	**P>t**	**95% Conf Int**		**Coeff**	**Std. Error.**	**t**	**P>t**	**95% Conf Int**	
Feeding practices within 24 hours of birth												
treatment*	-38.21	10.49	-3.64	0.00	-58.77	-17.66	-98.47	13.46	-7.32	0.00	-124.86	-72.09
Plain water	-8.70	18.01	-0.48	0.63	-44.01	26.60	12.04	26.60	0.45	0.65	-40.11	64.20
Baby formula	16.68	12.81	-1.30	0.19	-41.79	8.42	-21.28	19.00	-1.12	0.26	-58.53	15.96
Other milk	-32.68	11.99	-2.72	0.01	-56.19	-9.17	-8.21	19.57	-0.42	0.68	-46.57	30.14
Fruit juice	27.87	12.97	2.15	0.03	2.45	53.30	12.08	17.74	0.68	0.50	-22.70	46.87
Other	11.69	14.22	0.82	0.41	-16.18	39.56	-1.43	17.92	-0.08	0.94	-36.57	33.70
Semi-solid or soft food	26.51	13.88	1.91	0.06	-0.68	53.72	2.02	24.51	0.08	0.93	-46.03	50.08
	Number of obs=22035 R^2= 0.0026 f(7,11027)=4.04 Adj R^2= 0.0019 prob>F= 0.0002 Root MSE= 514.54						Number of obs=7471 R^2= 0.0080 f(7, 7463)=8.58 Adj R^2= 0.0070 prob>F= 0.0000 Root MSE= 542.98					
Breastfeeding practices												
Treatment	-14.26	10.63	-1.34	0.18	-35.10	6.58	-94.34	16.46	-5.73	0.00	-126.62	-62.06
Ever breastfeed	841.62	517.70	1.63	0.10	-173.17	1856.42	901.10	544.73	1.65	0.10	-166.73	1968.94
Early initiation of breastfeeding	39.06	12.35	3.16	0.00	14.85	63.27	64.76	15.50	4.18	0.00	34.37	95.14
Continued breastfeeding at 1 yr.	-35.59	19.72	-1.80	0.07	74.25	-3.07	-38.89	26.40	-1.47	0.14	-90.65	12.86
Continued breastfeeding at 2 yrs.	-34.01	30.91	-1.10	0.27	-94.61	26.58	-37.87	38.21	-0.99	0.32	-112.78	37.04
Currently breastfeeding	-36.79	11.24	-3.27	0.00	-58.82	-14.75	-36.62	14.00	-2.61	0.01	-64.07	-9.16
	Number of obs=9911 R^2= 0.0034 f(6, 9904)=5.66 Adj R^2= 0.0038 prob>F= 0.0000 Root MSE= 517.54						Number of obs=7112 R^2= 0.0076 f(6,7105)=9.06 Adj R^2= 0.0068 prob>F= 0.0000 Root MSE= 544.48					

Table 7. Results of linear regressions for feeding practices and breastfeeding practices and weight at birth (g), respectively. The effect of feeding practices within 24 hours of birth, such as providing the infant water, tinned milk or infant formula, on the child's weight at birth (g) and the ATE was evaluated through a linear regression model. Similarly, breastfeeding practices were evaluated for their impact on weight at birth and the ATE. Regressions were performed for all data (Cambodia and Vietnam) and Cambodia only.

For all data, the treatment effect became insignificant but the HAZ, WAZ and WHZ were all significantly correlated with weight at birth (g). WAZ was positively associated with weight at birth, while HAZ and WHZ were inversely related. The R^2 values for both all data and Cambodia indicated that the z-scores of anthropometric measures later in life explained little of the variance of weight at birth. The regressions for all data and Cambodia only were significantly different from the horizontal. (Table 8)

	All data						Cambodia					
	Coeff.	**Std. Error.**	**t**	**P>t**	**95% Conf Int**		**Coeff.**	**Std. Error.**	**t**	**P>t**	**95% Conf Int**	
Weight and height measurements												
Treatment	-3.01	11.42	-0.26	0.79	-25.39	19.37	-83.61	14.48	-5.78	0.00	-111.98	-55.22
HAZ	-57.43	17.60	-3.26	0.00	-91.94	-22.92	-59.29	19.85	-2.99	0.00	-98.20	2.10
WAZ	200.14	29.32	6.83	0.00	142.66	257.61	213.45	33.45	-6.38	0.00	147.89	279.02
WHZ	-93.45	22.38	-4.17	0.00	-137.33	-49.57	-93.76	25.44	-3.69	0.00	-143.63	-43.89
	Number of obs=9752 R-squared= 0.0392 f(4, 9747)=99.46 Adj R-squared= 0.0388 prob>F= 0.0000 Root MSE= 527.33						Number of obs=8275 R-squared= 0.0455 f(13, 9139)=41.96 Adj R-squared= 0.0451 prob>F= 0.0000 Root MSE= 539.53					

Table 8. Results of linear regressions for the association of anthropometric measures to weight at birth (g). The association between the height-for-age, weight-for-age and height-for-weight measures later in life and the child's weight at birth was evaluated through a linear regression model. The regression was performed all data (Cambodia and Vietnam) and Cambodia only.

3.2.2 Underweight or 'very small' at birth

Two factors were evaluated for identifying the percent of children who were small at birth. First, descriptive statistics were analyzed to look at trends and differences between the two countries. Second, a logistic regression was run between being identified as very small at birth and treatment alone, to determine if there was a significant relationship of the treatment on being identified as very small at birth, using data from Cambodia only and from Cambodia and Vietnam. Next, a logistic regression was run between being underweight at birth and treatment, to determine if there was a significant relationship of the treatment on being identified as very small at birth, using data from Cambodia only and from Cambodia and Vietnam. Finally, logistic regressions were completed to look at the relationship between covariates, treatment and being born underweight or being identified as very small. The results from these logistic regressions help to determine if there were statistically significant relationships between different covariates and the nutritional indicators being underweight at birth or being identified as very small at birth.

Determining the rate of very small or underweight newborns is typically a more reliable indicator of unhealthy newborns than weight at birth, which are dependent on sex and can vary widely while remaining healthy. The first measure was children who were born underweight, with underweight being defined as <2500g, as recommended by the

WHO. The second measure identified children as 'much smaller than average' at birth in Cambodia and Vietnam. This was recalled by the mother on a scale of 'much small than average' to 'much larger than average' (1 to 5). Overall, there was typically a lower percentage of children identified as very small at birth than underweight (Table 9), which suggests mothers may introduce their own bias in 'normalizing' the size of their child upon recall. The number of children underweight in Cambodia was higher per year, and overall, compared to Vietnam (Table 9). The percent of underweight children decreased between all time points, except in a comparison between 2000 and 2005, which may have occurred due to more people weighing their children at birth. Overall, Vietnam decreased the percentage of children born underweight before and after implementation at a higher rate (Table 9). For children identified as 'very small' at birth, Cambodia decreased the percentage more overall, with Vietnam's percentage of children changing very little between years (Table 9). A DiD analysis showed Vietnam had a smaller integer for children identified as underweight at birth, that is, it had a lower rate of change after implementation than before. This was smaller than the change observed in Cambodia. For children identified as 'very small' at birth, Cambodia had a larger DiD, in comparison to post implementation Vietnam (Table 10). (Figure 4 and 5)

		2000	2005	2010	2014
Cambodia	Underweight	0.1463	0.1610	0.1414	0.1386
	Very small at birth	0.0330	0.0476	0.0249	0.0256
Vietnam	Underweight	0.1028	0.0979	0.0869	0.0804
	Very small at birth	0.0182	0.0172	0.0161	0.0127

Table 9. Proportion of children identified as underweight (<2500g) at birth or 'very small' at birth in Cambodia and Vietnam from 2000 to 2014. Children were identified as underweight if they were less than 2500g (WHO guidelines). Their mothers on a scale of 1 to 5 identified children as 'much smaller than average' in birth size.

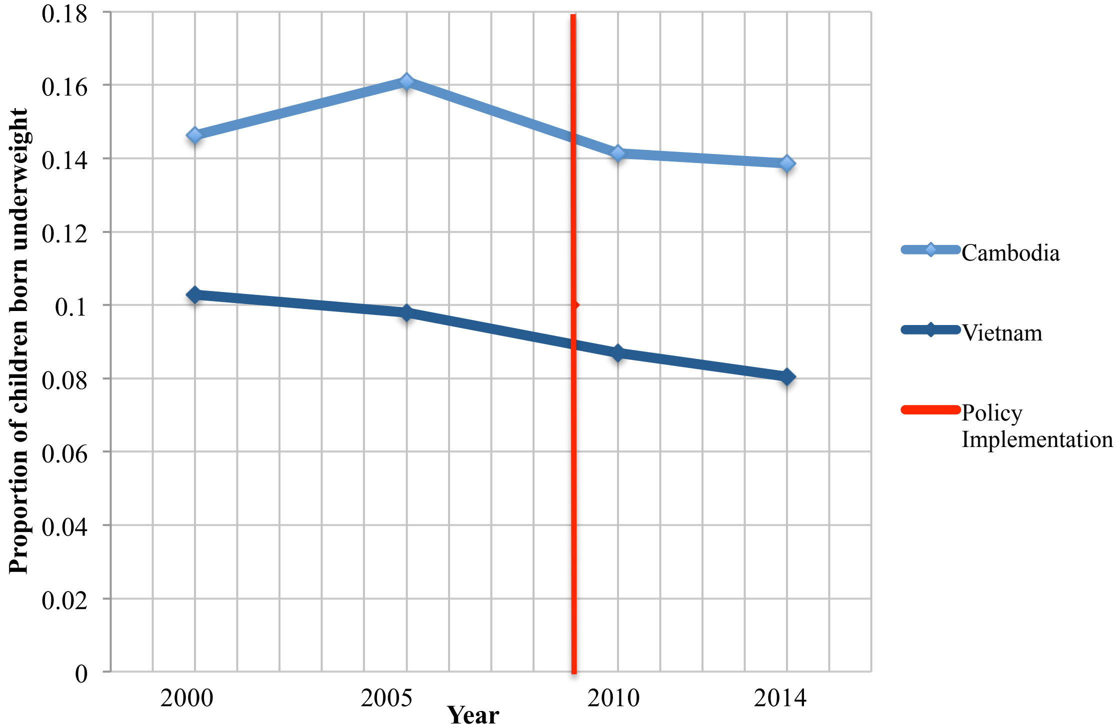

Figure 4. The proportion of children born underweight (<2500g) in Cambodia and Vietnam, between 2000 and 2014.

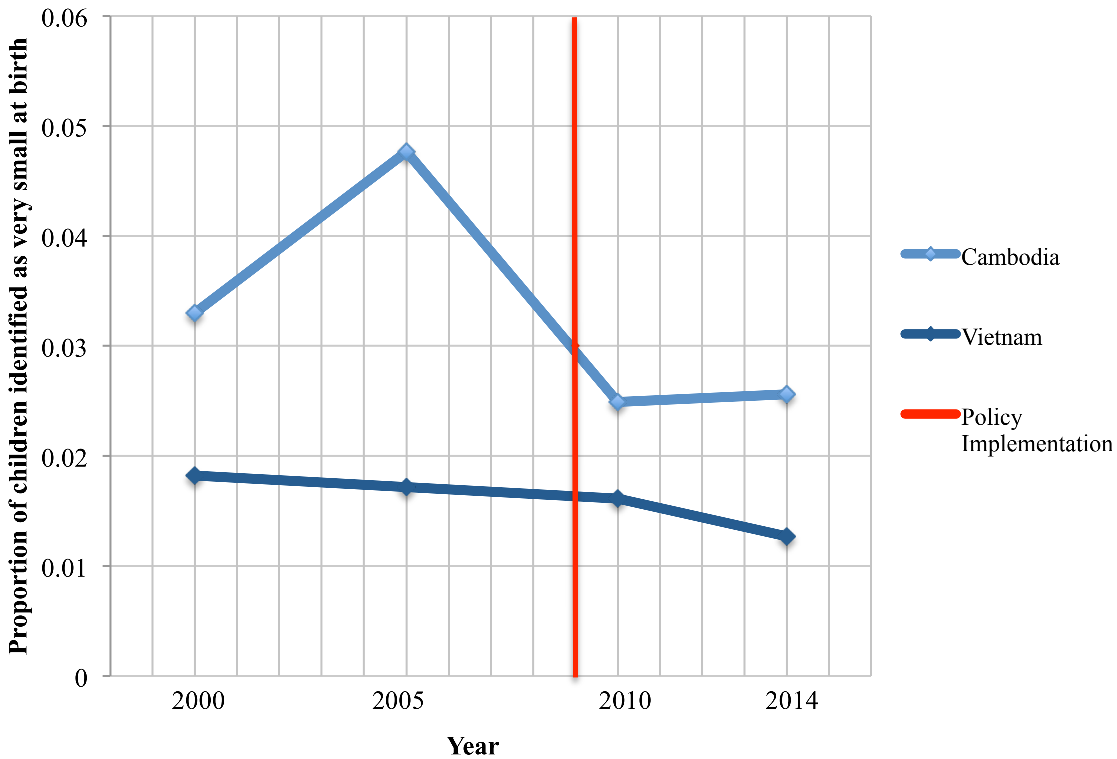

Figure 5. The proportion of children identified as very small at birth in Cambodia and Vietnam, between 2000 and 2014.

	Mean weight at birth (g)	Percentage of children underweight at birth	Percentage of children very small at birth
Cambodia	-75.09	0.0175	0.01395
Vietnam	32.643	0.00167	0.0024
DiD	-107.733	0.01583	0.01155

Table 10. Difference in difference analysis for the rate of change in the mean weight at birth, the percentage of children born underweight (<2500g) at birth and the percentage of children identified as 'very small' at birth. The DiD calculation uses Equation 6 to compare the rate of change before implementation to the rate of change after implementation.

Logistic regression analysis was performed using the same methodology as the linear regressions, by categorical groupings to investigate the effect of a category of variables on children who were underweight and identified as 'very small', and the relationship of the treatment and the nutritional indicators of interest, in conjuncture with these categories. A logistic regression was also performed to look at the effect of treatment with no other variables (Table 11). Data suggests that the OR produced by logistic regression were statistically significant each time and classification tables produced reasonably accurate predictions, however, other more robust GOF tests suggests the regressions were not significantly well-fitted models (Table 11). The OR for children born underweight and children identified as very small for Cambodian data suggested the presence of the treatment decreased the risk of being small or underweight at birth. The OR for children identified as very small also indicated a decrease in the presence of treatment for all data, however, it suggested that the treatment increased risk of being born underweight (Table 11). This initial data suggests that the treatment does have an effect on reducing underweight and very small births, but these models may be poorly fitted and therefore inaccurate.

		Odds Ratio	**Std. Error**	**z**	**P>z**	**Correctly classified**	**Pearson Chi^2 (0)**	**Hosmer-Lemeshow (0)**
Cambodia	**Children born underweight**	0.8753	0.4379	-2.66	0.008	85.58	0.00	0.00
	Children identified as 'very small' at birth	0.6186	0.3994	-7.44	0.00	96.69	0.00	0.00
All data	**Children born underweight**	1.1699	0.0496	3.70	0.000	86.73	0.00	0.00
	Children identified as 'very small' at birth	0.7223	0.0457	-5.14	0.00	96.93	0.00	0.00

Table 11. Logistic regression analysis of the number of underweight children, the number of children identified as 'very small' at birth and 'treatment'.

Evaluation of the effect of the treatment on being born underweight or very small in relation to different covariates was performed through logistic regressions. Living close to the border for both Cambodian only and all data suggested a significantly increased risk of being born underweight, however, GOF tests only demonstrated a correlated model for all data (Table 12). Regression models for family planning, such as birth control, and family history, survival and deaths of children from the same mother, pointed to a statistically significant effect of contraception and whether the child was wanted, however, the GOF tests indicated the model was not well fit between these variables

(Table 13). For all data, increased number of surviving children decreased the risk of being born underweight, although the model as a whole, was not strongly correlated to being underweight (Table 13). The type of assistance given at birth showed statistically significant reductions in risk for if a doctor or traditional birth attendant is present for all data, but the same results were not found in Cambodian data alone. A low pseudo R^2, Pearson's Chi^2 p, and Hosmer-Lemeshow Chi^2 p suggest that assistance at birth is a poor explanation for being born underweight in Cambodia (Table 13). Marriage characteristics and the education of women variables showed a low statistical significance on the GOF tests. Only the treatment effect and the highest level of education achieved reduced the odds of being born underweight significantly within the model (Table 15). In a regression with feeding practices within 24 hours of birth, treatment had no effect. GOF tests indicate that a model based on feeding practices was a reasonable predictor of being underweight (Table 16). Breastfeeding practices, in Cambodia data, were found to be good predictors of being underweight through GOF tests, with early initiation of breastfeeding being a statically significant predictor within the model for reducing the odds of being born underweight (Table 16).

	All data				**Cambodia**			
	Odds Ratio	Std. Err.	z	P>z	Odds Ratio	Std. Err.	z	P>z
Treatment	0.874	0.044	-2.690	0.007	0.870	0.044	-2.780	0.005
Province	1.000	0.002	1.250	0.212	1.006	0.384	1.590	0.112
Border province	1.103	0.046	2.350	0.019	1.102	0.050	2.140	0.032
	LR chi2 (4)=115.71, pseudo R^2=0.0072 Correctly classified: 86.74 Pearson Chi^2 (224): 313.78(p=0.0001) H-L Chi^2 (8): 6.15(p=0.6308)				LR chi2 (3)=14.34, pseudo R^2=0.0011 Correctly classified: 85.68 Pearson Chi^2 (65): 129.70 (p=0.0000) H-L Chi^2 (8): 26.94 (p=0.0007)			

Table 12. Results for logistic regression analysis into the relationship between regional factors, ATE and being identified as underweight at birth (<2500g). Results were tabulated for both all data and for Cambodia alone. Inclusion of border province indicates whether the Cambodians lived in a province that borders Vietnam.

	All data				**Cambodia**			
	Odds Ratio	Std. Err.	z	P>z	Odds Ratio	Std. Err.	z	P>z
Birth control and family planning indicators								
Treatment	1.153	0.051	3.190	0.001	0.883	0.045	-2.440	0.015
Contraception used	0.950	0.246	-1.970	0.049	0.992	0.023	-0.330	0.740
Child was planned	1.066	0.289	2.340	0.019	1.049	0.033	1.510	0.130
	LR chi2 (3)=21.92, pseudo R^2=0.0014 Correctly classified: 86.69 Pearson Chi^2 (37): 128.72(p=0.0000) H-L Chi^2 (3): 30.17(p=0.0000)				LR chi2 (3)=9.32, pseudo R^2=0.0007 Correctly classified: 85.58 Pearson Chi^2 (36): 52.31 (p=0.0387) H-L Chi^2 (4): 3.57 (p=0.4678)			
Survival and death of previous children								
Treatment	1.056	0.050	1.150	0.248	0.917	0.047	-1.690	0.090
Children ever born	1.518	0.052	12.260	0.000	1.076	0.625	1.260	0.209
Surviving children	0.629	0.026	-11.280	0.000	0.871	0.540	-2.220	0.026
Ever had children who died	0.820	0.030	-5.380	0.000	1.664	0.168	5.040	0.000
	LR chi2 (4)=156.72, pseudo R^2=0.0097 Correctly classified: 86.71 Pearson Chi^2 (118): 344.91(p=0.0000) H-L Chi^2 (7): 54.09(p=0.0000)				LR chi2 (4)=115.14, pseudo R^2=0.0085 Correctly classified: 85.58 Pearson Chi^2 (110): 246.53(p=0.0000) H-L Chi^2 (6): 724.95 (p=0.0003)			

Table 13. Results for logistic regressions for the analysis of the relationship between family history, ATE and being born underweight (<2500g). Two models were run, one that focused on family planning and birth control, and another than looked at children's survival in family history. All data and Cambodia only data were regressed separately.

	All data				**Cambodia**			
	Odds Ratio	Std. Err.	z	P>z	Odds Ratio	Std. Err.	z	P>z
Type of assistance at birth								
Treatment	1.096	0.056	1.780	0.075	0.966	0.545	-0.610	0.539
Doctor	0.744	0.070	-3.150	0.002	0.886	0.109	-0.980	0.325
Nurse/ midwife	0.989	0.083	-0.130	0.894	0.980	0.113	-0.170	0.864
TBA	1.720	0.210	4.450	0.000	1.559	0.237	2.920	0.003
Relative/ friend	0.829	0.107	-1.460	0.145	0.702	0.100	-2.470	0.013
Other	0.909	0.277	-0.310	0.755	0.884	0.309	-0.350	0.723
No one	2.096	1.721	0.900	0.368	2.054	1.695	0.870	0.383
	LR chi2 (8)=153.11, pseudo R^2=0.0095 Correctly classified: 86.70 Pearson Chi^2 (28): 74.69(p=0.0000) H-L Chi^2 (5): 11.66 (p=0.0397)				LR chi2 (8)=76.65, pseudo R^2=0.0057 Correctly classified: 85.56 Pearson Chi^2 (26): 53.42 (p=0.0012) H-L Chi^2 (3): 7.97 (p=0.0467)			

Table 14. Results for logistic regressions for the analysis of the relationship between birth factors, ATE and being born underweight (<2500g). Two models were run, one that focused on the type of assistance at birth, and another than analyzed other birth related factors, such as the place of birth or the type of birth. All data and Cambodian data only were regressed separately.

	All data				Cambodia			
	Odds Ratio	Std. Err.	z	P>z	Odds Ratio	Std. Err.	z	P>z
Marriage characteristics								
Treatment	0.878	0.044	-2.590	0.010	0.875	0.438	-2.680	0.007
Age at 1st marriage	1.002	0.006	0.360	0.718	1.002	0.058	0.390	0.697
Martial status	1.047	0.035	1.350	0.177	1.049	0.035	1.410	0.158
	LR chi2 (3)=8.53, pseudo R^2=0.0006 Correctly classified: 85.59 Pearson Chi^2 (198): 219.97(p=0.1359) H-L Chi^2 (8): 18.55 (p=0.0174)				LR chi2 (3)=9.13, pseudo R^2=0.0007 Correctly classified: 85.58 Pearson Chi^2 (197): 218.91 (p=0.1360) H-L Chi^2 (8): 18.16 (p=0.0201)			
Education of women								
Treatment	1.041	0.052	0.810	0.421	0.875	0.048	-2.420	0.016
Ever had education	1.487	0.735	0.800	0.422	1.000	-	-	-
Highest educational level	0.752	0.042	-5.070	0.000	0.669	0.133	-2.020	0.044
Highest completed level of education	0.987	0.037	-0.350	0.728	1.046	0.098	0.480	0.630
	LR chi2 (5)=126.62, pseudo R^2=0.0092 Correctly classified: 87.39 Pearson Chi^2 (120): 166.51(p=0.0032) H-L Chi^2 (8): 17.85 (p=0.0224)				LR chi2 (4)=62.28, pseudo R^2=0.0055 Correctly classified: 86.15 Pearson Chi^2 (42): 31.13 (p=0.8912) H-L Chi^2 (8): 5.14 (p=0.7424)			

Table 15. Results for logistic regressions for the analysis of the relationship mother's characteristics, ATE, and being born underweight (<2500g). Two models were run, one that focused on the type of the education of women, and another than analyzed marriage factors. All data and Cambodian data only were regressed separately.

	All data				Cambodia			
	Odds Ratio	Std. Err.	z	P>z	Odds Ratio	Std. Err.	z	P>z
Feeding practices								
Treatment	1.060	0.067	0.920	0.355	0.871	0.063	-1.900	0.057
Water	0.991	0.113	-0.080	0.939	1.000	0.152	0.000	0.999
Baby formula	0.867	0.071	-1.740	0.082	0.880	0.095	-1.190	0.236
Other milk	0.816	0.062	-2.660	0.008	1.019	0.011	0.180	0.857
Fruit juice	0.778	0.065	-3.030	0.002	0.867	0.095	-1.430	0.152
Other	1.064	0.091	0.720	0.468	0.964	0.095	1.720	0.086
Soft food	1.326	0.011	-23.350	0.000	1.273	0.179	1.720	0.000
	LR chi2 (7)=42.37, pseudo R^2=0.0054 Correctly classified: 88.45 Pearson Chi^2 (90): 116.65 (p=0.0310) H-L Chi^2 (7): 10.04 (p=0.1865)				LR chi2 (7)=14.37, pseudo R^2=0.0025 Correctly classified: 87.07 Pearson Chi^2 (74): 93.61 (p=0.0615) H-L Chi^2 (6): 3.28 (p=0.7727)			
Breastfeeding practices								
Treatment	1.311	0.085	4.210	0.000	0.912	0.079	-1.060	0.289
Ever breastfed	-	-	-	-	1.000	-	-	-
Early initiation of breastfeeding	0.659	0.459	-5.990	0.000	0.821	0.669	-2.420	0.016
Cont'd breastfeeding at 1 yr.	1.237	0.142	1.850	0.064	1.193	0.165	1.270	0.202
Cont'd breastfeeding at 2 yrs.	1.385	0.236	1.910	0.056	1.327	0.255	1.480	0.140
Currently breastfeeding	0.964	0.066	-0.530	0.596	0.972	0.075	-0.380	0.707
	LR chi2 (5)=51.54, pseudo R^2=0.0072 Correctly classified: 88.18 Pearson Chi^2 (11): 17.77(p=0.0.0872) H-L Chi^2 (5): 12.02(p=0.0.0345)				LR chi2 (5)=44.80, pseudo R^2=0.0132 Correctly classified: 86.77 Pearson Chi^2 (11): 6.48 (p=0.8397) H-L Chi^2 (5): 1.65(p=0.8948)			

Table 16. Results for logistic regressions for the analysis of the relationship between feeding and breastfeeding practices of infants, ATE, and being underweight at birth. Two models were run, one that focused on feeding practices 24 hours after birth, and another than analyzed breastfeeding practices. All data and Cambodia only were regressed separately.

As with the analysis performed on relationships between covariates and begin underweight at birth, being identified as very small was also analyzed. Of regional factors considered, living in a border province increased the odds of being identified as very small. In a model with regional factors, treatment decreased the odds of being very small compared to just treatment alone in Cambodia (Table 17). Results of a low pseudo R^2, Pearson's Chi^2 p, and Hosmer-Lemeshow Chi^2 p suggest that regional factors are a poor predictor for being very small in Cambodia. The results of regression models for family planning and family history suggested that the use of contraception lowered the risk of being born very small, while whether a child was not wanted, would also increase the likelihood of being born small (Table 18). Family planning decreased the effect of treatment on reducing risk of being very small, compared to treatment alone for all data, but increased the effect for Cambodia alone. Classification tables indicated high probabilities, but pseudo R^2, Pearson's Chi^2 p, and Hosmer-Lemeshow Chi^2 p were small indicating a poor fit for the model. Family history, that is, the survival and death of children from the same mother, also found significant odds ratio associated with increasing number of surviving children lowering risk of having a small child. Interestingly, for all data, having increasing number of children who had died lowered risk of having a small child, but this was only significant for all data. Again, both models had low pseudo R^2, Pearson's Chi^2 p, and Hosmer-Lemeshow Chi^2 p, underlining the need for adjustments to the model (Table 18).

	All data				**Cambodia**			
	Odds Ratio	Std. Err.	z	P>z	Odds Ratio	Std. Err.	z	P>z
Treatment	0.619	0.399	-7.440	0.000	0.623	0.040	-7.330	0.008
Province	1.001	0.000	0.320	0.749	0.619	0.040	-7.440	0.000
Border Province	0.954	0.058	-0.780	0.438	1.157	0.050	3.380	0.001
	LR chi^2 (4)=112.30, pseudo R^2=0.0110 Correctly classified: 96.63 Pearson Chi^2 (229): 939.96 (p=0.0000) H-L Chi^2 (8): 71.83(p=0.0000)				LR Chi^2 (3)=65.80, pseudo R^2=0.0070 Correctly classified: 96.69 Pearson Chi^2 (66): 712.52 (p=0.000) H-L Chi^2 (8): 96.53 (p=0.000)			

Table 17. Results for logistic regression analysis into the relationship between regional factors, ATE and being identified as very small at birth. Results were tabulated for both all data and for Cambodia alone. Border province indicates whether the Cambodians lived in a province that borders Vietnam.

	All data				**Cambodia**			
	Odds Ratio	Std. Err.	z	P>z	Odds Ratio	Std. Err.	z	P>z
Birth control and family planning indicators								
Treatment	0.714	0.046	-5.240	0.000	0.632	0.415	-6.980	0.000
Contraception used	0.846	0.030	-4.740	0.000	0.908	0.027	-3.190	0.001
Child planned	1.086	0.038	2.340	0.019	1.070	0.041	1.770	0.077
	LR chi2 (3)=65.13, pseudo R^2=0.0064 Correctly classified: 96.90 Pearson Chi^2 (41): 124.91(p=0.0000) H-L Chi^2 (4): 33.34(p=0.0000)				LR chi^2 (3)=72.72, pseudo R^2=0.0077 Correctly classified: 96.69 Pearson Chi^2 (40): 51.08 (p=0.1126) H-L Chi^2 (5): 18.49 (p=0.0024)			
Survival and death of previous children								
Treatment	0.765	0.051	-4.010	0.000	0.707	0.048	-5.190	0.000
Children ever born	1.386	0.040	11.350	0.000	1.143	0.488	3.140	0.002
# of surviving children	0.733	0.027	-8.500	0.000	0.865	0.409	-3.060	0.002
# of dead children	0.857	0.049	-2.690	0.007	1.483	0.147	3.970	0.000
	LR chi2 (4)=151.30, pseudo R^2=0.0148 Correctly classified: 96.63 Pearson Chi^2 (150): 372.61(p=0.0000) H-L Chi^2 (7): 51.28 (p=0.0000)				LR chi2 (4)=148.70, pseudo R^2=0.0158 Correctly classified: 96.69 Pearson Chi^2 (140): 304.32 (p=0.0000) H-L Chi^2 (7): 28.16 (p=0.0002)			

Table 18. Results for logistic regressions for the analysis of the relationship between family history, ATE and being very small at birth. Two models were run, one that focused on family planning and birth control, and another than looked at children's survival in family history. All data and Cambodia only were regressed separately.

A strong association was seen between the presence of a doctor at birth and reduced risk of being born very small. GOF estimates revealed that this was a strong model, indicating type of assistance at birth, specifically a doctor, may reduce risk strongly of being born very small (Table 19). Further evaluation into other birth factors suggested that being identified as under 2500g or 3000g greatly increased risk of being identified as very small at birth. In Cambodia, martial status outside of 'currently married' was associated with increased risk of being very small at birth (Table 51). As education level increased, risk of having a child that was very small decreased. Education models were supported by reasonably associated GOF p values, however, the regression for marriage characteristics was only supported by Hosmer-Lemeshow Chi^2 test (Table 20). Feeding practices 24 hours after birth had no significant impacts on the likelihood of a child being very small. When breastfeeding practices were included, the OR for treatment increased in Cambodia and overall. Early initiation of breastfeeding and continued breastfeeding at one year were associated with reduced risk of being very small at birth. GOF tests indicated low p-values, suggesting poor modeling (Table 21).

	All data				Cambodia			
	Odds Ratio	Std. Err.	z	P>z	Odds Ratio	Std. Err.	z	P>z
Type of assistance at birth								
Treatment	0.916	0.069	-1.160	0.246	0.840	0.066	-2.240	0.025
Doctor	0.405	0.060	-6.070	0.000	0.514	0.100	-3.430	0.001
Nurse/midwife	0.821	0.124	-1.300	0.192	0.846	0.171	-0.830	0.408
TBA	0.935	0.156	-0.400	0.687	0.829	0.181	-0.860	0.391
Relative/ friend	1.097	0.158	0.650	0.519	1.110	0.172	0.670	0.502
Other	0.367	0.113	3.250	0.001	0.420	0.129	-2.820	0.005
No one	2.170	1.340	1.250	0.210	2.133	1.349	1.200	0.231
	LR chi2 (8)=164.87, pseudo R^2=0.0161 Correctly classified: 96.92 Pearson Chi^2 (32): 35.30(p=0.3150) H-L Chi^2 (4): 0.67(p=0.9550)				LR chi2 (3)=128.18, pseudo R^2=0.0136 Correctly classified: 96.69 Pearson Chi^2 (30): 13.46 (p=0.9959) H-L Chi^2 (3): 0.69 (p=0.8759)			
Other birth factors								
treatment	1.732	0.315	3.020	0.003	0.840	0.066	-2.240	0.025
Place of delivery	0.991	0.011	-0.800	0.423	0.992	0.107	-0.710	0.480
Number of antenatal visits	1.006	0.027	0.220	0.826	0.994	0.030	-0.210	0.837
Birth was caesarian section	1.281	0.261	1.210	0.225	1.828	0.507	2.180	0.029
weight at birth	0.996	0.002	-17.300	0.000	0.996	0.002	-15.740	0.000
<2500g at birth	1.424	0.336	1.500	0.135	1.798	0.459	2.300	0.022
<3000g at birth (small)	4.543	3.325	2.070	0.039	3.665	2.706	1.760	0.079
	LR chi2 (7)=1320.71 pseudo R^2=0.4439cla Correctly classified: 96.63 Pearson Chi^2 (3633): 3137.66(p=1.000) H-L Chi^2 (8): 10.57 (p=0.2272)				LR chi2 (7)=1133.98, pseudo R^2=0.4387 Correctly classified: 98.17 Pearson Chi^2 (3466): 2487.88 (p=1.000) H-L Chi^2 (8): 10.48 (p=0.2330)			

Table 19. Results for logistic regressions for the analysis of the relationship between birth factors, ATE and being very small at birth. Two models were run, one that focused on the type of assistance at birth, and another than analyzed other birth related factors, such as the place of birth or the type of birth. All data and Cambodia only were regressed separately.

	All data				Cambodia			
	Odds Ratio	Std. Err.	z	P>z	Odds Ratio	Std. Err.	z	P>z
Marriage characteristics								
Treatment	0.624	0.040	-7.290	0.000	0.401	0.088	-4.150	0.000
Age at 1st marriage	0.989	0.008	-1.340	0.181	1.123	0.106	1.220	0.222
Martial status	1.032	0.051	0.630	0.529	1.384	0.230	1.960	0.051
	LR chi2 (3)=59.09, pseudo R^2=0.0063 Correctly classified: 96.70 Pearson Chi^2 (227): 322.96(p=0.0000) H-L Chi^2 (8): 6.97(p=0.5395)				LR chi2 (7)=57.90, pseudo R^2=0.0138 Correctly classified: 97.13 Pearson Chi^2 (8448): 9158.99 (p=0.000) H-L Chi^2 (8): 8.14 (p=0.4201)			
Education of women								
Treatment	0.870	0.069	-1.760	0.078	0.802	0.064	-2.750	0.006
any education	1.000	-	-	-	1.000	-	-	-
highest education level	0.772	0.091	-2.200	0.028	0.480	0.173	-2.030	0.042
highest education level completed	0.826	0.065	-2.450	0.014	1.052	0.177	0.300	0.762
	LR chi2 (4)=90.36, pseudo R^2=0.0132 Correctly classified: 97.39 Pearson Chi^2 (117): 120.51(p=0.3933) H-L Chi^2 (8): 7.64(p=0.4692)				LR chi2 (4)=69.96, pseudo R^2=0.0113 Correctly classified: 97.15 Pearson Chi^2 (42): 36.92 (p=0.6931) H-L Chi^2 (8): 10.92 (p=0.2064)			

Table 20. Results for logistic regressions for the analysis of the relationship of characteristics of the mother, ATE, and being very small at birth. Two models were run, one that focused on the education of the woman, and another than analyzed marriage factors. All data and Cambodian data only were regressed separately.

	All data				**Cambodia**			
	Odds Ratio	Std. Err.	z	P>z	Odds Ratio	Std. Err.	z	P>z
Feeding practices								
treatment	1.000	-	-	-	1.000	-	-	-
Plain water	3.079	1.920	1.800	0.071	3.079	1.920	1.800	0.071
Times given plain water	0.889	0.050	-2.070	0.039	0.889	0.050	-2.070	0.039
Baby formula	1.910	1.527	0.810	0.418	1.910	1.527	0.810	0.418
Times given baby formula	0.819	0.230	-0.710	0.479	0.819	0.230	-0.710	0.479
Other milk	0.628	0.393	-0.740	0.457	0.628	0.393	-0.740	0.457
Times given other milk	1.353	0.216	1.900	0.058	1.351	0.216	1.900	0.058
Fruit juice	0.847	0.276	-0.510	0.610	0.847	0.276	-0.510	0.610
Times given fruit juice	1.196	0.206	1.040	0.301	1.196	0.206	1.040	0.301
Other	0.248	0.096	-3.610	0.000	0.248	0.096	-3.610	0.000
Semi-solid or soft food	1.362	0.212	1.980	0.047	1.041	0.302	0.140	0.890
Times given semi or soft food	1.041	0.302	0.140	0.890	0.955	0.560	-0.780	0.437
treatment	0.955	0.056	-0.780	0.437	0.955	0.056	-0.780	0.437
	LR chi2 (12)=33.58, pseudo R^2=0.0227 Correctly classified: 96.79 Pearson Chi^2 (783): 1041.19(p=0.0000) H-L Chi^2 (8): 9.18(p=0.3270)				LR chi2 (12)=33.58, pseudo R^2=0.0227 Correctly classified: 96.79 Pearson Chi^2 (783): 1041.19(p=0.0000) H-L Chi^2 (8): 9.18(p=0.3270)			
Breastfeeding practices								
treatment	0.884	0.099	-1.100	0.272	0.667	0.083	-3.260	0.001
Ever breastfeed	-	-	-	-	1.000	-	-	-
Early initiation of breastfeeding	0.586	0.062	-5.040	0.000	0.762	0.093	-2.240	0.025
Cont'd breastfeeding at 1 yr.	1.361	0.228	1.850	0.065	1.379	0.246	1.800	0.072
Cont'd breastfeeding at 2 yr.	0.751	0.227	-0.950	0.343	0.647	0.213	-1.320	0.186
Currently breastfeeding	1.222	0.132	1.850	0.064	1.318	0.150	2.430	0.015
	LR chi2 (5)=43.27, pseudo R^2=0.0112 Correctly classified: 97.47 Pearson Chi^2 (13): 25.50(p=0.0198) H-L Chi^2 (6): 13.18(p=0.0403)				LR chi2 (5)=44.80, pseudo R^2=0.0132 Correctly classified: 97.19 Pearson Chi^2 (13): 35.49 (p=0.0007) H-L Chi^2 (6): 25.52 (p=0.0003)			

Table 21. Results for logistic regressions for the analysis of the relationship between feeding and breastfeeding practices of infants, ATE, and being very small at birth. Two models were run, one that focused on feeding practices 24 hours after birth, and another than analyzed breastfeeding practices. All data and Cambodia only were regressed separately.

Generally most of the regression models selected predicted weight at birth, being born very small or being born underweight poorly. Certain variables were, however, found to have significant correlations within models, which was useful in selection criteria for the DR and PSM analysis of Section 3.4 and 3.5.

3.3 NUTRITIONAL INDICATORS: WHO ANTHROPOMETRIC MEASURES

The most important nutritional indicators used are the anthropometric measures recommended by the WHO. As most previous studies use standard deviations to determine wasting, stunting or underweight, regressions were applied to height-for-age, weight-for-age and weight-for-height z-scores or standard deviations from the mean. Standard deviations from the mean was calculated by WHO growth standards, and pre-code by DHS and MCIS[44]. First, descriptive statistics were analyzed to look at trends and differences between the two countries. Second, linear regressions was run between each of the three anthropometric measures, to determine if there was a significant relationship of the treatment on HAZ, WAZ and WHZ, using data from Cambodia only and from Cambodia and Vietnam. Finally, linear regressions were completed to look at the relationship between covariates, treatment and each of the anthropometric measures. The results from these linear regressions help to determine if there were statistically significant relationships between different covariates and the three WHO recommended nutritional indicators.

For HAZ, Cambodia had a larger mean negative standard deviation compare to Vietnam, both before and after implementation. The height for age mean standard deviation became less negative overall, from 2000 to 2014, indicating better average height for age for children in Cambodia over time. The mean standard deviations for weight for age decreased from 2000 to 2014 in Cambodia. The mean standard deviation was much less negative in Vietnam compared to Cambodia for both 2000 and 2010, before and after the implementation of the policy. The last measure of undernutrition, weight-for-height (WHZ), had the smallest mean negative standard deviation. The WHZ decreased from 2000 to 2005, increased from 2005 to 2010, and then decreased again 2010 to 2014. The mean standard deviation of WHZ was more negative in Cambodia compared to Vietnam. Data was not available from 2006 and 2014 from Vietnam. (Table 22) (Figure 6 to 8)

		2000	2005	2010	2014
Height-for-age (standard deviations)					
Cambodia	**Mean**	-1.8039	-1.320541	-1.5099	-1.2703
	Median	-1.85	-1.68	-1.55	-1.33
	Std. Dev.	1.6406	1.3205	1.335	1.2902
	Skewness	0.2995	-0.0639	0.3299	042537
Vietnam	**Mean**	-1.4236	-	-0.9196	-
	Median	-1.63	-	-0.94	-
	Std. Dev.	1.387	-	1.350	-
	Skewness	0.1234	-	0.2361	-
Weight-for-age (standard deviations)					
Cambodia	**Mean**	-1.7859	-1.6320	-1.557	-1.381525
	Median	-1.89	-1.72	-1.65	-1.51
	Std. Dev.	1.1902	1.0677	1.0569	1.0947
	Skewness	0.5163	0.6136	0.5341	0.7551
Vietnam	**Mean**	-1.5517	-	-0.8113	-
	Median	-1.67	-	-0.99	-
	Std. Dev.	1.1013	-	1.2911	-
	Skewness	0.7889	-	0.9338	-
Weight-for-height (standard deviations)					
Cambodia	**Mean**	-0.88687	-0.7711	-0.8045	-0.75624
	Median	-0.93	-0.85	-0.87	-0.84
	Std. Dev.	1.197	0.9469	1.0196	1.0521
	Skewness	0.5796	0.7991	0.4162	0.75389
Vietnam	**Mean**	-0.6717	-	-0.28042	-
	Median	-0.79	-	-0.41	-
	Std. Dev.	1.0469	-	1.2057	-
	Skewness	1.1085	-	0.9413	-

Table 22. The distribution and measures of central tendency for WHO anthropometric measures. HAZ, WAZ and WHZ were all calculated by DHS and MCIS using the NCHS. Data was only collected in Vietnam in 2000 and 2010.

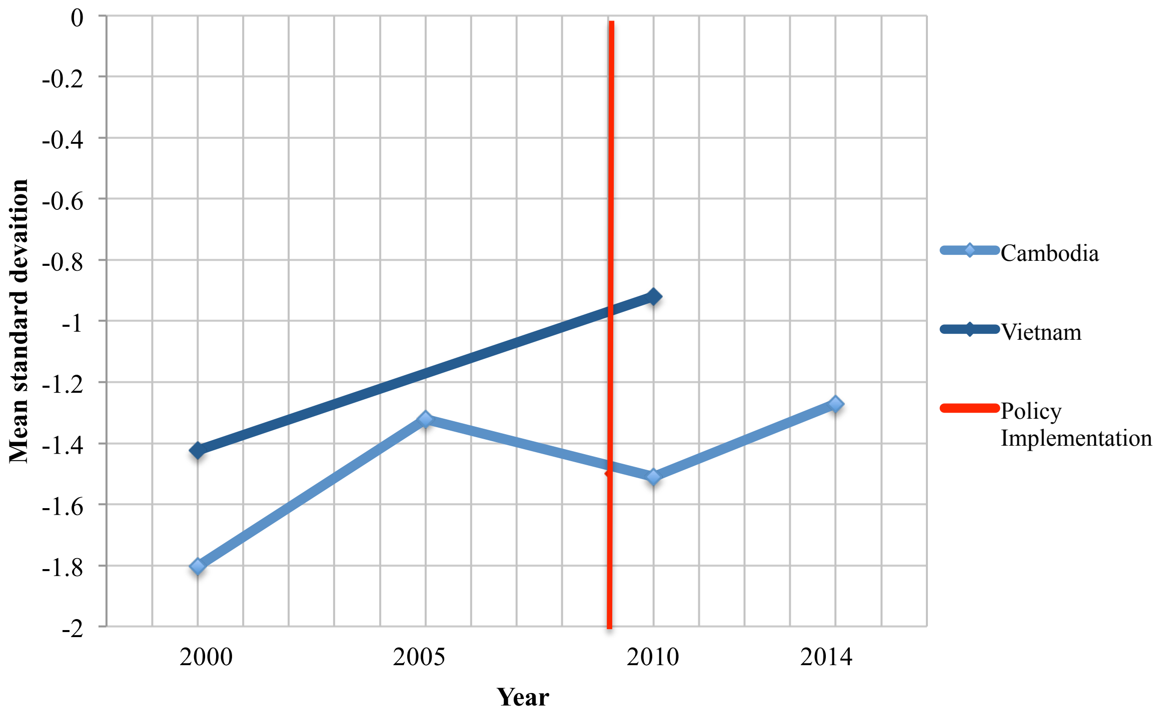

Figure 6. The mean height-for-age (standard deviations) in Cambodia and Vietnam, from 2000 to 2014. Data is only available in 2000 and 2010 for Vietnam.

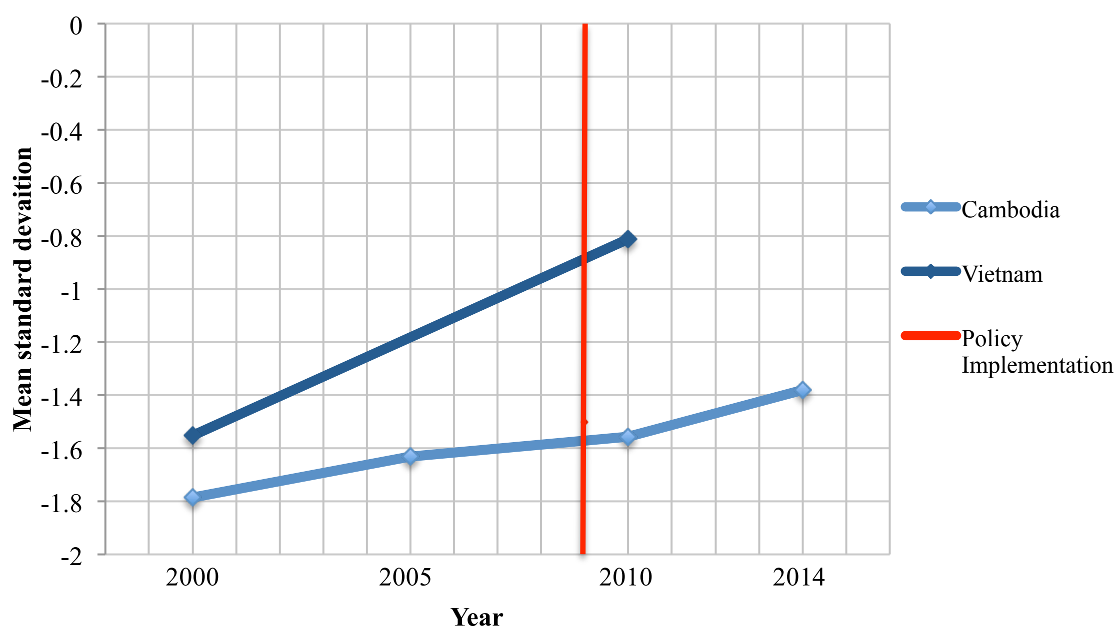

Figure 7. The mean weight-for-age (standard deviations) in Cambodia and Vietnam, from 2000 to 2014. Data is only available in 2000 and 2010 for Vietnam.

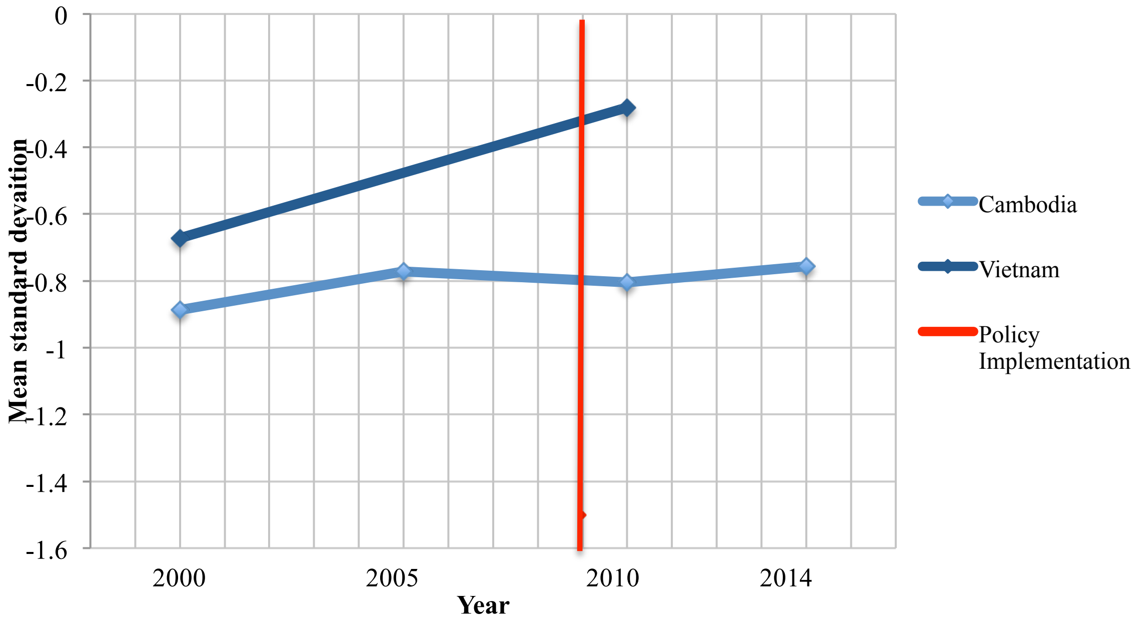

Figure 8. The mean weight-for-height (standard deviations) in Cambodia and Vietnam, from 2000 to 2014. Data is only available in 2000 and 2010 for Vietnam.

3.3.1 Height-for-age (standard deviations)

Height-for-age was analyzed first. An initial regression was run examining the relationship between height-for-age (HAZ) and treatment for Cambodian data and all data, respectively. The correlation between HAZ and treatment for Cambodian data alone was not significant, and the line was not significantly different than zero (Table 23). Conversely, the regression between treatment and all data suggested that HAZ was impacted by implementation, although the R^2 value demonstrated a very low correlation. As with the regressions performed for weight at birth, size at birth and underweight, covariates were analyzed in groups to determine significant variables for further study. First, demographic and characteristics of the mother were evaluated (Table 24, 25). The effect of the education of women on HAZ was low in Cambodia overall, and similarly, for all data (Table 24). Whether or not education had been attended and the level of education had a significant correlation to HAZ, but the R^2 value was very low overall. The effect of marriage status and age at marriage on HAZ was also negligible as a model

(R^2<0.01). Neither age at marriage or marital status was significantly correlated with HAZ as individual variables within the model. Regional characteristically such as the province of residence or living on the border of Vietnam and Cambodia showed no effect on the HAZ. Family planning characteristic, specifically, the use of contraception, showed a significant correlation to HAZ, however the overall model did not explain the variance in HAZ well, as seen in the low R^2 value. Finally, demographic characteristics such as age, sex, and age of the mother did not have a significant correlation to HAZ. Each of the demographic and the characteristics of women analyzed did not effect the significance of the treatment effect (except for the last model, demographic characteristics, in Cambodia where treatment became significant as a negative influence on HAZ). The family history, that is, the survival and deaths of child born to the same mother was not highly correlated to HAZ (Table 26). The addition of these factors, however, did cause the treatment effect to be significant for Cambodian and all data, suggesting that the factors could be strong covariate that should be include in the DR analysis.

	Coeff.	**Std. Error.**	**t**	**P>t**	**R^2**	**Prob>F**	**Root MSE**	**95% Conf Int**	
Cambodia	-0.1944	0.1852	-1.0500	0.2940	0.0001	0.2938*	11.4260	-0.5573	0.1685
All data	0.3569	0.1109	3.2200	0.0010	0.0004	0.0013**	549.6900	0.1395	0.5742

Table 23. Linear regression results for the correlation between height-for-age standard deviations and treatment for Cambodia, and all data. *F(1, 15281)=1.10 ** F(1, 29148)=10.36

	All data							Cambodia				
	Coeff	Std. Error.	t	P>t	95% Conf Int		Coeff	Std. Error.	t	P>t	95% Conf Int	
Education of women												
Treatment	0.251	0.125	2.020	0.044	0.007	0.496	-0.547	0.224	-2.450	0.014	-0.986	-0.109
Any education	0.795	0.294	2.700	0.007	0.218	1.372	0.000	-	-	-	-	-
Highest education level	0.232	0.074	3.120	0.002	.0863926	0.377	0.076	0.761	0.100	0.920	-1.415	1.567
Highest education level completed	-0.021	0.060	-0.350	0.726	-0.139	0.097	0.212	0.365	0.580	0.562	-0.504	0.928
	Number of obs=23878 R^2= 0.0025 F(4,23872)=11.94 Adj R^2= 0.0023 prob>F= 0.0000 Root MSE= 8.1697						Number of obs=11465 R^2= 0.0009 F(4,11460)=2.49 Adj R^2= 0.0005 prob>F= 0.0414 Root MSE= 11.49					
Marriage characteristics												
Treatment	-0.213	0.186	-1.150	0.251	-0.578	0.151	-0.214	0.186	-1.150	0.250	-0.579	0.150
Age at 1st marriage	0.029	0.024	1.210	0.227	-0.018	0.077	0.030	0.024	1.210	0.226	-0.018	0.077
Martial status	-0.022	0.159	-0.140	0.889	-0.333	0.289	-0.022	0.159	-0.140	0.892	-0.332	0.289
	Number of obs=15282 R^2= 0.0002 F(3, 15278)=0.85 Adj R^2= 0.0000 prob>F= 0.4641 Root MSE= 11.426						Number of obs=15278 R^2= 0.0002 F(3,15274)=0.86 Adj R^2= 0.0040 prob>F= 0.4626 Root MSE= 11.428					
Family planning												
Treatment	-0.191	0.172	-1.110	0.267	-0.529	0.146	-0.228	0.190	-1.200	0.231	-0.600	0.145
Contraception used	-0.222	0.067	-3.320	0.001	-0.353	-0.091	-0.223	0.071	-3.130	0.002	-0.362	-0.083
Child was planned	-0.010	0.119	-0.090	0.931	-0.244	0.223	-0.015	0.130	-0.110	0.910	-0.269	0.240
	Number of obs.=16837 R^2= 0.0007 F(3,16834)=3.89 Adj R^2= 0.0005 prob>F= 0.0086 Root MSE= 10.907						Number of obs=15278 R^2= 0.0007 F(3,15274)=3.64 Adj R^2= 0.0005 prob>F= 0.0122 Root MSE= 11.425					

Table 24. Results of linear regressions for the characteristics of women and height-for-age (standard deviations). The effect of 'controlling' for demographic and the characteristics of women, such education, contraception used, age, or sex, on the child's *height-for-age (standard deviations)* and the ATE was investigated through linear regressions. Regressions were performed for all data (Cambodia and Vietnam) and Cambodia only.

	All data						Cambodia					
	Coeff	Std. Error.	t	P>t	95% Conf Int		Coeff	Std. Error.	t	P>t	95% Conf Int	
Regional characteristics												
Treatment	-0.190	0.137	-1.390	0.166	-0.459	0.079	-0.195	0.185	-1.050	0.292	-0.558	0.168
Province	0.000	0.000	0.530	0.595	0.000	.0006478	0.019	0.016	1.220	0.222	-0.011	0.049
Border province	-0.244	0.100	-2.440	0.015	-0.440	-0.048	-0.260	0.190	-1.370	0.171	-0.632	0.112
Cambodia	0.864	0.149	5.800	0.000	0.572	0.155	N/A					
	Number of obs=29148 R^2= 0.0022 F(4,29143)=15.75 Adj R^2= 0.0020 prob>F= 0.0000 Root MSE= 8.4646						Number of obs=15281 R^2= 0.0003 F(3,15277)=1.35 Adj R^2= 0.0001 prob>F= 0.2552 Root MSE= 11.426					
Demographic characteristics												
Treatment	-0.163	0.168	-0.970	0.333	-0.492	0.167	-1.814	0.435	-4.170	0.000	-2.666	-0.962
Female child	-0.044	0.100	-0.440	0.659	-0.239	0.151	0.037	0.184	0.200	0.841	-0.325	0.399
Year	0.230	0.026	8.720	0.000	0.178	0.281	0.167	0.041	4.050	0.000	0.086	0.248
Child's age in yrs.	0.845	0.180	4.680	0.000	0.491	0.198	0.803	0.324	2.480	0.013	0.169	.437912
Child's age in months	-0.091	0.015	-6.120	0.000	-0.120	-0.062	-0.101	0.027	-3.800	0.000	-0.153	-0.049
Mother's age	0.045	0.034	1.310	0.190	-0.022	0.113	0.079	0.066	1.200	0.230	-0.050	0.207
Mother's age group	-0.236	0.172	-1.370	0.170	-0.573	0.101	-0.452	0.321	-1.410	0.159	-1.080	. 0.176
	Number of obs=28969 R^2= 0.0060 F(8,28960)=21.92 Adj R^2= 0.0057 prob>F= 0.000 Root MSE= 8.4712						Number of obs=15281 R^2= 0.0049 F(7,15273)=10.84 Adj R^2= 0.0045 prob>F= 0.000 Root MSE= 11.401					

Table 25. Results of linear regressions for demographic characteristics and height-for-age (standard deviations). The effect of 'controlling' demographic and women's characteristics, such education, contraception used, age, or sex, on the child's *height-for-age (standard deviations)* and the ATE was investigated through linear regressions. Regressions were performed for all data (Cambodia and Vietnam) and Cambodia only.

	All data						Cambodia					
	Coeff.	Std. Error.	t	P>t	95% Conf Int		Coeff.	Std. Error.	t	P>t	95% Conf Int	
Survival of previous children												
Treatment*	0.216	0.129	1.680	0.093	-0.036	0.468	-0.398	0.194	-2.050	0.040	-0.778	-0.018
Children ever born	-0.059	0.095	-0.620	0.538	-0.245	0.128	-0.139	0.055	-2.540	0.011	-0.247	-0.032
Surviving children	-0.035	0.112	-0.310	0.755	-0.254	0.184		0.000	-	-	-	-
# of children who have died*	0.000	-	-	-	-	-	0.015	0.237	0.060	0.949	-0.449	0.480
Ever had children who have died	-0.066	0.082	-0.810	0.417	-0.226	0.094	-0.191	0.420	-0.460	0.648	-1.014	0.631
Number of obs=25725 R^2= 0.0006 F(4, 25720)=3.98 Adj R^2= 0.0005 prob>F= 0.0031 Root MSE= 8.9584							Number of obs=15281 R^2= 0.0009 F(4. 15276)=3.37 Adj R^2= 0.0006 prob>F= 0.0000 Root MSE= 11.423					

Table 26. Results of linear regressions for children's survival in the family and height-for-age (standard deviations). The effect of the survival of other children belonging to the same mother was on the *height-for-age z-score* was evaluated through a linear regression model. Regressions were performed for all data (Cambodia and Vietnam) and Cambodia only.

An analysis of wealth indicators, such as whether a family owned a car, refrigerator, or scooter was performed (Table 27). The addition of wealth indicators into the model created co-linearity with the treatment effect, and it was excluded. The individual wealth indicators of time needed to get water, type of water available for drinking, ownership of a bicycle, a television, a scooter and more were significantly correlated with HAZ for all data. The R^2 value remained low (0.0887), however, wealth indicators explained more of the variance in HAZ then demographic and the characteristics of women at a significant level.

	Cambodia					
	Coeff.	**Std. Error.**	**t**	**P>t**	**95% Conf Int**	
treatment*	0	-	-	-	-	-
Source of drinking water	-.0704809	.0124463	-5.66	0.000	-.0948784	-.0460834
Time to get water	-.01408	.0042067	-3.35	0.001	-.022326	-.0058341
Type of toilet facility	-.1354559	.0158115	-8.57	0.000	-.1664499	-.1044619
floor material	.0347109	.0107352	3.23	0.001	.0136676	.0557543
has electricity	-.0888232	.0903205	-0.98	0.325	-.2658714	.088225
has bicycle	.4766064	.0756693	6.30	0.000	.328278	.6249349
has radio	.7472345	.0627479	11.91	0.000	.6242347	.8702343
has TV	-.2729389	.0676661	-4.03	0.000	-.4055794	-.1402983
has refrigerator	-.6045356	.141346	-4.28	0.000	-.8816049	-.3274663
has motorcycle/scooter	-.0257654	.0829818	-0.31	0.756	-.1884279	.1368972
has car/truck	1.419265	.5113233	2.78	0.006	.4169581	2.421571
Number of obs=9251 R^2= 0.0887 F(12, 9238)=74.90 Adj R^2= 0.0875 prob>F= 0.0000 Root MSE= 2.6389						

Table 27. Results of linear regressions for wealth indicators and height-for-age (standard deviations). The effect of wealth indicators, such as owning a automobile, time to water, owning a scooter, etc., on the child's *height-for-age (standard deviations*) and the ATE was evaluated through a linear regression model. Regressions were performed for Cambodia only because of data restrictions.

The relationship between indicators of childhood illness, immunization and supplementations and height-for-age were analyzed using a linear regression. For Cambodia, the implementation of the treatment was positively associated in this model with HAZ. The other variables like, having diarrhea or an ARI in the last two weeks, were not significantly correlated with HAZ for Cambodian data, excluding the vaccination for measles, which had an inverse relationship with HAZ. For all data, the treatment was significantly and positively associated with HAZ in a model including childhood illness and immunization factors. Having diarrhea or ARI were significantly negatively correlated with HAZ, and negatively affected HAZ. Similarly, having the measles vaccination or receiving Vitamin A supplementation, ever or within 6 months, were significantly correlated with HAZ. Unlike with Cambodian data, having measles was positively correlated with HAZ and having Vitamin A supplementation was also positively correlated with HAZ for all data. The other variables were not significantly correlated with HAZ. Although both models indicated the slope of line of best fit was significantly different than 0, the R^2 value demonstrated that little of the variance of HAZ is attributable to the indicators in this model. (Table 28)

	All data						**Cambodia**					
	Coeff	**Std. Error.**	**t**	**P>t**	**95% Conf Int**		**Coeff.**	**Std. Error.**	**t**	**P>t**	**95% Conf Int**	
Type of assistance at birth												
Treatment	0.822	0.094	8.740	0.000	0.637	0.007	0.560	0.133	4.200	0.000	0.298	0.822
Had diarrhea recently	-0.155	0.078	-1.990	0.047	-0.308	-0.002	-0.218	0.095	-2.300	0.022	-0.404	-0.031
Had ARI recently	-0.169	0.077	-2.200	0.028	-0.319	-0.019	-0.139	0.092	-1.520	0.130	-0.320	0.041
Sought treatment for ARI	0.089	0.073	1.210	0.227	-0.055	0.233	0.023	0.104	0.230	0.819	-0.180	0.228
Ever had a vaccination	-0.308	0.166	-1.850	0.064	-0.635	0.018	-0.066	0.202	-0.330	0.744	-0.463	0.330
Has a health card	0.110	0.094	1.170	0.242	-0.075	0.295	0.155	0.110	1.410	0.159	-0.061	0.372
Has BCG	-0.157	0.155	-1.010	0.311	-0.461	0.147	0.182	0.191	0.960	0.337	-0.191	0.557
Has polio	0.153	0.098	1.560	0.120	-0.040	0.345	0.027	0.168	0.170	0.868	-0.302	0.358
Has DPT	-0.228	0.112	-2.030	0.042	-0.448	-0.008	0.095	0.171	0.560	0.578	-0.241	0.431
Has measles	0.355	0.090	3.930	0.000	0.178	0.533	-0.371	0.131	-2.840	0.005	-0.627	-0.114
Ever had Vit. A	-0.592	0.089	-6.640	0.000	-0.767	-0.417	0.096	0.177	0.540	0.587	-0.251	0.443
Had Vit A w/in 6 months	0.457	0.078	5.880	0.000	0.305	0.610	-0.045	0.132	-0.340	0.731	-0.305	0.214
Number of obs=1747 R^2= 0.1232 F(12, 1734)=20.30 Adj R^2= -0.1171 prob>F= 0.0000 Root MSE= 0.97804							Number of obs=1079 R^2= 0.0560 F(12, 1066)=5.27 Adj R^2= 0.0454 prob>F= 0.0000 Root MSE= 1.4239					

Table 28. Results of linear regressions for determining the association between childhood illness, immunization, supplementation and height-for-age (standard deviations). The effect of illness, immunization and supplementation on the child's height-for-age(standard deviations) and the treatment effect was evaluated through a linear regression model. Regressions were performed for all data (Cambodia and Vietnam) and Cambodia only.

The covariates of birth and infant care were analyzed. The type of assistance received at birth was analyzed for its relationship with HAZ (Table 29). The presence of a physician or TBA at birth was significant for all data, while the presence of a physician or relative/friend at birth was significant for Cambodian data only. For both all data and Cambodian data, the model was not did not explain the variance in HAZ very well, with a low overall strength of relationship between specific birth factors, treatment effect, and HAZ. The treatment effect was still significant with the inclusive of birth factors in the model, however, suggesting that they could be important covariates (Table 29). The feeding and breastfeeding practices of mothers were evaluated for their relationship with HAZ (Table 30). The provision of water, fruit juice and the introduction of soft, semi-soft or hard food was correlated significantly with HAZ in Cambodia, while only the provision of water and the introduction of food were correlated with HAZ for all data. Feeding practices had a low correlation overall with HAZ, and did not change the treatment effect (Table 30). The early initiation of breastfeeding was significantly associated with HAZ. The continuation of breastfeeding at one and two years was also significantly associated with HAZ, however, these variables were inversely related to HAZ. Although the line of best fit produced by this regression was significantly different than zero, the overall model was not strongly correlated. Breastfeeding practices had no effect on treatment (Table 30).

	All data						**Cambodia**					
	Coeff	**Std. Error.**	**t**	**P>t**	**95% Conf Int**		**Coeff.**	**Std. Error.**	**t**	**P>t**	**95% Conf Int**	
Type of assistance at birth												
Treatment	-0.806	0.198	-4.070	0.000	-1.195	-0.418	-1.123	0.228	-4.930	0.000	-1.570	-0.676
Doctor	1.470	0.382	3.850	0.000	0.721	2.219	2.103	0.537	3.920	0.000	1.052	3.155
Nurse/midwife	-0.103	0.359	0.290	0.774	-0.807	0.601	-0.790	0.547	-1.440	0.149	-1.861	0.282
TBA	0.915	0.445	2.060	0.040	0.043	0.787	0.433	0.638	0.680	0.497	-0.817	1.683
Relative/friend	1.921	0.455	4.230	0.000	1.030	2.812	2.618	0.533	4.910	0.000	1.572	3.663
Other	-0.825	0.651	-1.270	0.205	-2.101	0.451	-1.224	0.792	-1.540	0.122	-2.777	0.329
No one	1.228	2.102	0.580	0.559	-2.893	5.349	0.344	2.266	0.150	0.879	-4.098	4.786
Number of obs=17308 R^2= 0.0031 F(8,17299)=6.81 Adj R^2= 0.0027 prob>F= 0.0000 Root MSE= 10.73							Number of obs=15265 R^2= 0.0041 F(8, 15256)=7.94 Adj R^2= 0.0036 prob>F= 0.0000 Root MSE= 11.383					

Table 29. Results of linear regressions for determining the association between type of assistance at birth and height-for-age (standard deviations). The effect of the type of assistance used at the child's birth, such as having a doctor present, on the child's *height-for-age (standard deviations*) and the ATE was evaluated through a linear regression model. Regressions were performed for all data (Cambodia and Vietnam) and Cambodia only.

	All data						Cambodia					
	Coeff	**Std. Error.**	**t**	**P>t**	**95% Conf Int**		**Coeff**	**Std. Error.**	**t**	**P>t**	**95% Conf Int**	
Feeding practices within 24 hours of birth												
Treatment*	0.106	0.199	0.530	0.595	-0.284	0.495	-0.209	0.281	-0.750	0.455	-0.760	0.341
Plain	-1.870	0.376	-4.970	0.000	-2.608	-1.132	-1.346	0.587	-2.290	0.022	-2.497	-0.196
Baby formula	0.380	0.283	1.340	0.180	-0.175	0.935	0.803	0.516	1.560	0.120	-0.208	1.814
Other milk	0.021	0.196	-2.720	0.915	-0.363	0.405	0.270	0.487	0.550	0.580	-0.686	1.225
Fruit juice	-0.132	0.221	-0.590	0.552	-0.566	0.302	-0.621	0.372	-1.670	0.095	-1.350	0.108
Other	-0.131	0.220	-0.600	0.551	-0.562	0.300	-0.156	0.382	-0.410	0.682	-0.905	0.592
Semi-solid or soft food	-0.998	0.272	-3.670	0.000	-1.531	-0.465	-1.810	0.494	-3.660	0.000	-2.779	-0.841
	Number of obs=12054 R^2= 0.0085 f(7,12046)=14.77 Adj R^2= 0.0079 prob>F= 0.0000 Root MSE= 9.173						Number of obs=7496 R^2= 0.0095 f(7, 7488)=10.27 Adj R^2= 0.0086 prob>F= 0.0000 Root MSE= 11.502					
Breastfeeding practices												
Treatment	-0.155	0.181	-0.860	0.393	-0.511	0.201	-0.259	0.228	-1.140	0.255	-0.706	0.188
Ever breastfeed	-0.065	3.831	-0.020	0.986	-7.575	7.445	0.001	4.180	0.000	1.000	-8.192	8.194
Early initiation of breastfeeding	0.545	0.181	3.010	0.003	0.190	0.900	0.567	0.229	2.480	0.013	0.119	1.016
Continued breastfeeding at 1 yr.	-1.274	0.334	-3.820	0.000	-1.928	-0.620	-1.340	0.397	-3.380	0.001	-2.119	-0.562
Continued breastfeeding at 2 yr.	-1.719	0.470	-3.660	0.000	-2.640	-0.797	-1.744	0.542	-3.220	0.001	-2.806	-0.682
Still breastfeeding	0.894	0.181	4.940	0.000	0.539	1.249	0.969	0.215	4.510	0.000	0.548	0.390
	Number of obs=15075 R^2= 0.0030 f(6, 15068)=7.68 Adj R^2= 0.0027 prob>F= 0.0000 Root MSE= 10.131						Number of obs=12520 R^2= 0.0028 f(6,12513)=5.92 Adj R^2= 0.0024 prob>F= 0.0000 Root MSE= 11.049					

Table 30. Results of linear regressions for feeding practices and breastfeeding practices and height-for-age (standard deviations) respectively. The effect of feeding practices within 24 hours of birth, such as providing the infant water, tinned milk or infant formula, on the child's *height-for-age (standard deviations*) and the ATE was evaluated through a linear regression model. Similarly, breastfeeding practices were evaluated for their impact on *height-for-age (standard deviations*) and the ATE. Regressions were performed for all data (Cambodia and Vietnam) and Cambodia only.

The low insignificant association between treatment and HAZ in Cambodia was not effected by most covariates. Most models explained very little of the variance of HAZ, demonstrated by the small R^2 values, but many individual variables were significantly correlated with HAZ. This indicates that the linear regression model is not well fit, although significantly different than zero in all models. These results will inform the selection of variables for the DR and NNM analyses.

3.3.2 Weight-for-age (standard deviations)

An analysis of the relationships of surveyed variables to weight-for-age (WAZ) was performed. Weight-for-age in standard deviations from the mean was utilized because of its role in the definition of wasting (which is defined as being -2SD away from the mean in weight-for-age). An initial regression was run examining the relationship between WAZ and treatment for Cambodia and all data, respectively. The correlation between WAZ and treatment for Cambodia alone was significant, although the R^2 value was low (0.0122) (Table 31). Similarly, the regression between treatment and all data suggested that WAZ was impacted by implementation, although the R^2 value demonstrated a lower correlation than that for Cambodia alone. Both relationships were significantly different than zero, however. As with the regressions performed for above for HAZ, covariates were analyzed in groups to determine significant variables for further study. Demographic and the characteristics of women were analyzed first. The education factors of women were significantly correlated for all variables for all data, although the inclusion of education factors made the treatment effect insignificant for all data. For Cambodia, attending school was collinear with the WAZ and was excluded by the software. For all data, the R^2 value showed a reasonably strong amount of the variance of WAZ was attributed to the education of women, compared to other regressions in this analysis (Table 32). The marriage characteristics of the mother had limited impact on the treatment effect, for all data and Cambodia. The age of marriage was significant for all data and Cambodia. Overall, marriage characteristics did not have a significant relationships with WAZ, and had explained the variance of WAZ very little. Family planning, such as contraception and wanting the child at that time, had limited impact on the treatment effect. A low R^2 value for both Cambodia and all data indicated that although both variables were significantly correlated with WAZ, they did not explain much of the variance (Table 32).

	Coeff.	Std. Error.	t	P>t	R^2	Prob>F	Root MSE	95% Conf Int	
Cambodia	0.2458	0.0180	13.6300	0.0000	0.0122	0.0000*	1.1056	0.2105	0.2812
All data	-0.1035	0.0174	-5.9400	0.0000	0.0018	0.0000**	1.1993	-0.1377	-0.0694

Table 31. Linear regression results for the correlation between weight-for-age standard deviations and treatment for Cambodia, and all data. *F(1, 15086)=185.84 ** F(1,19616)=35.29

	All data						**Cambodia**					
	Coeff	**Std. Error.**	**t**	**P>t**	**95% Conf Int**		**Coeff**	**Std. Error.**	**t**	**P>t**	**95% Conf Int**	
Demographic and characteristics of women												
Treatment	-0.016	0.020	-0.780	0.438	-0.055	0.024	0.130	0.021	6.150	0.000	0.089	0.172
Any education*	-0.801	0.137	-5.860	0.000	-1.069	-0.533	0.000	-	-	-	-	-
Highest education level	0.520	0.021	24.910	0.000	0.479	0.561	0.088	0.072	1.230	0.220	-0.053	0.229
Highest education level completed	-0.057	0.016	-3.640	0.000	-0.088	-0.026	0.120	0.034	3.480	0.000	0.053	0.188
Highest years attained	0.025	0.005	5.630	0.000	0.017	0.034	0.024	0.005	4.780	0.000	0.014	0.034
	Number of obs=15351 R^2= 0.1045 F(5,15345)=358.13 Adj R^2= 0.1042 prob>F= 0.0000 Root MSE= 1.1322						Number of obs=11318 R^2= 0.0335 F(4,11313)=97.94 Adj R^2= 0.0331 prob>F= 0.0000 Root MSE= 1.0795					
Marriage characteristics												
Treatment	0.237	0.018	13.110	0.000	0.202	0.273	0.238	0.018	13.130	0.000	0.202	0.273
Age at 1st marriage	0.013	0.002	5.450	0.000	0.008	0.018	0.013	0.002	5.380	0.000	0.008	0.017
Martial status	-0.009	0.015	-0.600	0.547	-0.040	0.021	-0.010	0.015	-0.630	0.531	-0.040	0.021
	Number of obs=15089 R^2= 0.0142 F(3, 15085)=72.18 Adj R^2= 0.0140 prob>F= 0.0000 Root MSE= 1.1045						Number of obs=15085 R^2= 0.0002 F(3,15081)=72.11 Adj R^2= 0.0040 prob>F= 0.000 Root MSE= 1.1045					
Family planning												
Treatment	0.054	0.018	2.980	0.003	0.019	0.090	0.231	0.019	12.460	0.000	0.194	0.267
Contraception used	0.015	0.007	2.130	0.034	0.001	0.029	-0.017	0.007	-2.490	0.013	-0.031	-0.004
Child was planned	-0.081	0.013	-6.410	0.000	-0.106	-0.056	-0.039	0.013	-3.080	0.002	-0.064	-0.014
	Number of obs=16608 R^2= 0.0038 F(3,16604)=20.87 Adj R^2= 0.0036 prob>F= 0.0000 Root MSE= 1.1469						Number of obs=15085 R^2= 0.0132 F(3,15081)=67.16 Adj R^2= 0.0130 prob>F= 0.0000 Root MSE= 1.1052					

Table 32. Results of linear regressions for characteristics of women and weight-for-age (standard deviations). The effect of 'controlling' for the characteristics of women, such education, contraception used,

age, or sex, on the child's *weight-for-age (standard deviations)* and the ATE was investigated through linear regressions. Regressions were performed for all data (Cambodia and Vietnam) and Cambodia only.

Demographic characteristics were analyzed, first, the regional characteristics. Although they had no impact on the significance of the treatment effect, the province of residence, living on a border province and living in Cambodia were all significantly correlated with WAZ. Living on the Cambodian-Vietnam border and being Cambodian had a negative relationship with WAZ. Low r^2 values indicated the model did not explain much of the variance of WAZ (Table 33). Other demographic characteristics like age, sex and age of the mother were evaluated. The age and sex of the child was significantly correlated with WAZ, but the age of the mother was not, both for Cambodian data and for all data. R^2 of 0.1412 for all data and 0.1019 for Cambodian data suggested these models explained more of the variance in WAZ, compared to other categorical regressions models in this study. The effect of past survival and deaths of children born to the same mother were also associated with WAZ in a weak model (Table 34). Whether there were children who died previously and the number of children who died were correlated significantly for all data, but not for Cambodian data only. The R^2 values indicated a weak overall explanation of the variance within WAZ by survival and death rates (Table 34). An analysis of wealth indicators was performed (Table 35). The addition of wealth indicators into the model created co-linearity with the treatment effect, which was excluded. Only possession of a television was correlated for all data. The R^2 value was very low, indicating wealth factors were not highly correlated with WAZ. Overall, the model allows the determination of initial relationships and the investigation of the effects of categories on WAZ.

	All data						Cambodia					
	Coeff	Std. Error.	t	P>t	95% Conf Int		Coeff	Std. Error.	t	P>t	95% Conf Int	
Regional characteristics												
treatment	0.246	0.019	13.090	0.000	0.209	0.282	0.248	0.018	13.730	0.000	0.212	0.283
Province	0.003	0.001	5.520	0.000	0.002	0.005	-0.004	0.002	-2.460	0.014	-0.007	-0.001
Border province	-0.048	0.019	-2.560	0.010	-0.084	-0.011	-0.260	0.190	-1.370	0.171	-0.632	0.112
Cambodia	-0.764	0.033	-23.430	0.000	-0.828	-0.700	N/A					
	Number of obs=19616 R^2= 0.0819 F(4,19611)=437.54 Adj R^2= 0.0817 prob>F= 0.0000 Root MSE= 1.1502						Number of obs=15088 R^2= 0.0131 F(3,15084)=66.55 Adj R^2= 0.0129 prob>F= 0.0000 Root MSE= 1.1052					
Demographic characteristics												
treatment	-0.715	0.023	-31.580	0.000	-0.760	-0.671	-0.101	0.041	-2.480	0.013	-0.181	-0.021
Female child	-0.031	0.016	-1.970	0.048	-0.063	0.000	-0.034	0.017	-1.960	0.050	-0.067	0.000
year	0.035	0.004	8.730	0.000	0.027	0.043	0.035	0.004	9.030	0.000	0.027	0.042
Child's age in yrs.	0.151	0.028	5.430	0.000	0.097	0.206	0.127	0.030	4.220	0.000	0.068	0.186
Child's age in months	-0.029	0.002	-12.500	0.000	-0.033	-0.024	-0.029	0.002	-11.500	0.000	-0.033	-0.024
mother's age	-0.005	0.006	-0.830	0.405	-0.016	0.006	-0.009	0.006	-1.480	0.138	-0.021	0.003
mother's age group	0.015	0.028	0.540	0.588	-0.039	0.070	0.025	0.030	0.840	0.402	-0.033	0.083
	Number of obs=19448 R^2= 0.1412 F(8,19439)=399.56 Adj R^2= 0.1409 prob>F= 0.000 Root MSE= 1.1108						Number of obs=15088 R^2= 0.1019 F(7,15080)=244.54 Adj R^2= 0.01015 prob>F= 0.000 Root MSE= 1.0544					

Table 33. Results of linear regressions for demographic characteristics and weight-for-age (standard deviations). The effect of 'controlling' for demographic characteristics, such age, or sex, on the child's *weight-for-age (standard deviations)* and the treatment effect were investigated through linear regressions. Regressions were performed for all data (Cambodia and Vietnam) and Cambodia only.

	All data						Cambodia					
	Coeff.	Std. Error.	t	P>t	95% Conf Int		Coeff.	Std. Error.	t	P>t	95% Conf Int	
Survival of previous children												
treatment*	0.131	0.019	6.760	0.000	0.093	. .1694388	0.160	0.019	8.540	0.000	0.124	0.197
Children ever born	-0.078	0.005	-15.400	0.000	-0.088	-0.068	-0.062	0.005	-11.600	0.000	-0.072	-0.051
Surviving children*	0.000	-	-	-	-	-	0.000	-	-	-	-	-
# of children who have died	-0.145	0.016	-9.140	0.000	-0.176	-0.114	0.007	0.023	0.320	0.745	-0.038	0.052
Ever had children who have died	0.355	0.012	29.530	0.000	0.332	0.379	-.0552446 -	. .0406442	-1.360	0.174	0.135	0.024
Number of obs=19448 R^2= 0.0864 F(4, 19443)=459.78 Adj R^2= 0.0862 prob>F= 0.0000 Root MSE= 1.1456							Number of obs=15088 R^2= 0.0271 F(4. 15083)=105.15 Adj R^2= 0.0269 prob>F= 0.0000 Root MSE= 1.0973					

Table 34. Results of linear regressions for children's survival in the family and weight-for-age (standard deviations). The effect of the survival of other children belonging to the same mother was on the *weight-for-age z-score* was evaluated through a linear regression model. Regressions were performed for all data (Cambodia and Vietnam) and Cambodia only.

	Cambodia					
	Coeff.	Std. Error.	t	P>t	95% Conf Int	
Treatment*	0.0000	-	-	-	-	-
Source of drinking water	0.0033	0.0053	0.6300	0.5310	-0.0070	0.0137
Time to get water	0.0021	0.0019	1.0700	0.2870	-0.0017	0.0059
Type of toilet facility	-0.0365	0.0189	-1.9200	0.0540	-0.0736	0.0007
Floor material	-0.0579	0.0250	-2.3200	0.0210	-0.1068	-0.0089
Has electricity	-0.0132	0.1069	-0.1200	0.9020	-0.2229	0.1964
Has bicycle	-0.0023	0.0488	-0.0500	0.9630	-0.0980	0.0934
Has radio	0.1474	0.0540	2.7300	0.0060	0.0416	0.2532
Has TV	0.0251	0.0685	0.3700	0.7130	-0.1091	0.1594
Has refrigerator	-0.2083	0.6156	-0.3400	0.7350	-1.4154	0.9987
Has motorcycle/scooter	0.1084	0.0705	1.5400	0.1240	-0.0298	0.2467
Has car/truck	0.1731	0.4366	0.4000	0.6920	-0.6830	1.0291
Number of obs=2643 R^2= 0.0093 F(11, 2631)=2.25 Adj R^2= 0.0052 prob>F= 0.0101 Root MSE= 1.1957						

Table 35. Results of linear regressions for wealth indicators and weight-for-age (standard deviations). The effect of wealth indicators, such as owning a automobile, time to water, owning a scooter, etc., on the child's weight-for-age (standard deviations) and the treatment effect was evaluated through a linear regression model. Regressions were performed for all data (Cambodia and Vietnam) and Cambodia only.

The relationship between indicators of childhood illness, immunization and micronutrient supplementations and weight-for-age were analyzed using a linear regression. For Cambodia, the implementation of the treatment was positively associated in the model with WAZ. The other variables were not significantly correlated with WAZ for Cambodian data. For all data, the treatment was significantly and positively associated with WAZ in a model including childhood illness and immunization factors. The other variables were not significantly correlated with WAZ. In a linear model, recent illness, treatment of recent illnesses, past immunizations and micronutrient supplementations were not correlated individually with current WAZ. (Table 36)

	All data						**Cambodia**					
	Coeff	**Std. Error.**	**t**	**P>t**	**95% Conf Int**		**Coeff.**	**Std. Error.**	**t**	**P>t**	**95% Conf Int**	
Type of assistance at birth												
Treatment	0.381	0.088	4.32	0.000	0.208	0.554	0.459	0.1028	4.47	0.000	0.257	0.661
Had diarrhea recently	-0.220	0.0699	--3.15	0.002	-0.357	-0.082	-0.209	0.0732	-2.86	0.004	-0.353	-0.065
Had ARI recently	-0.051	0.069	-0.74	0.457	-0.187	0.084	-0.067	0.071	-0.94	0.346	-0.206	0.0724
Sought treatment for ARI	0.0467	0.0736	0.64	0.525	--0.097	0.191	0.0131	0.0802	0.16	0.870	-0.144	0.1707
Ever had a vaccination	-0.151	0.149	-1.01	0.313	-0.445	0.142	-0.175	0.1560	-1.12	0.261	-0.481	0.1308
Has a health card	0.113	0.083	1.35	0.177	-0.051	0.277	0.104	0.0853	1.22	0.221	-0.063	0.271
Has BCG	0.173	0.139	1.24	0.214	-0.100	0.446	0.2175	0.147	1.48	0.139	-0.071	0.506
Has polio	0.0178	0.108	0.16	0.869	-0.194	0.230	-0.019	0.130	-0.15	0.884	-0.274	0.236
Has DPT	0.083	0.111	0.75	0.454	-0.135	0.303	0.166	0.132	1.26	0.209	-0.093	0.425
Has measles	-0.231	0.094	-2.45	0.014	-0.417	-0.0461	-0.311	0..1001	-3.08	0.002	-0.508	-0.113
Ever had Vit. A	0.0039	0.101	0.04	0.969	-0.196	0.204	-0.149	0.136	-1.09	0.275	-0.417	0.119
Had Vit A w/in 6 months	-0.076	0.0861	-0.89	0.375	-0.245	0.0925	0.021	0.102	0.21	0.833	-0.179	0.222
Number of obs=1181 R^2= 0.0439 F(12, 1168)=4.47 Adj R^2= 0.0341 prob>F= 0.000 Root MSE= 0.1.0842							Number of obs=1079 R^2= 0.0495 F(12, 1066)=4.36 Adj R^2= 0.0388 prob>F= 0.0000 Root MSE= 1.0984					

Table 36. Results of linear regressions for determining the association between childhood illness, immunization, supplementation and weight-for-age (standard deviations). The effect of illness, immunization and supplementation on the child's weight-for-age(standard deviations) and the treatment effect was evaluated through a linear regression model. Regressions were performed for all data (Cambodia and Vietnam) and Cambodia only.

Characteristics of the birth of the child and infant care practices were analyzed. The effect of assistance at birth on WAZ was examined. The presences of a doctor, midwife or nurse, and relative or friend were all significantly correlated for Cambodia only. The presence of no one at birth was also significantly, inversely correlated to WAZ for Cambodian data (Table 37). The presence of a physician, TBA, and relative or friend was significantly correlated for all data. The R^2 values remained low, indicated birth assistance explained very little of the variance in WAZ (Table 37). Most variables for liquids given to child 24 hours after birth were significant in Cambodian data and for all data. The R^2 value, of 0.1420 for all data and 0.1913 for Cambodian data only, suggested that the feeding practices explained more of the variance in WAZ than other models. Breastfeeding practices were also found to be significant individually as variables, although a lower R^2 for the regression suggested breastfeeding practices were less relevant in explaining most of the variance than feeding practices on WAZ (Table 38). The relationship between birth, infant feeding practices and WAZ, respectively, suggests that these variables explain some of the variance seen in WAZ and should be included in future analysis.

	All data						**Cambodia**					
	Coeff	**Std. Error.**	**t**	**P>t**	**95% Conf Int**		**Coeff.**	**Std. Error.**	**t**	**P>t**	**95% Conf Int**	
Type of assistance at birth												
treatment	-0.073	0.021	-3.530	0.000	-0.114	-0.033	0.025	0.022	1.140	0.254	-0.018	0.068
Doctor	0.706	0.042	16.950	0.000	0.624	0.787	0.559	0.052	10.830	0.000	0.458	0.660
Nurse/midwife	0.059	0.040	1.500	0.135	-0.018	0.137	0.189	0.053	3.600	0.000	0.086	0.293
TBA	-0.191	0.050	-3.860	0.000	-0.288	-0.094	0.020	0.061	0.320	0.749	-0.101	0.140
Relative/friend	0.103	0.049	2.090	0.037	0.006	0.200	0.136	0.052	2.640	0.008	0.035	0.238
other	0.090	0.070	1.280	0.202	-0.048	0.228	0.123	0.076	1.620	0.105	-0.026	0.272
no one	-0.382	0.222	-1.720	0.085	-0.816	0.053	-0.213	0.040	-5.340	0.000	-0.291	-0.135
Number of obs=16598 R^2= 0.0721 F(8,16589)=158.99 Adj R^2= 0.0708 prob>F= 0.0000 Root MSE= 1.1079							Number of obs=15073 R^2= 0.0403 F(8, 15064)=79.07 Adj R^2= 0.0398 prob>F= 0.0000 Root MSE= 1.0898					

Table 37. Results of linear regressions for determining the association between type of assistance at birth and weight-for-age (standard deviations). The effect of the type of assistance used at the birth of the child, such as having a doctor present, on the child's *weight-for-age (standard deviations)* and the treatment effect was evaluated through a linear regression model. Regressions were performed for all data (Cambodia and Vietnam) and Cambodian data only.

	All data						Cambodia					
	Coeff	**Std. Error.**	**t**	**P>t**	**95% Conf Int**		**Coeff**	**Std. Error.**	**t**	**P>t**	**95% Conf Int**	
Feeding practices within 24 hours of birth												
treatment*	0.053	0.026	2.040	0.042	0.002	0.103	0.308	0.027	11.470	0.000	0.255	0.361
Plain	-0.435	0.049	-8.840	0.000	-0.532	-0.339	-0.202	0.056	-3.580	0.000	-0.313	-0.091
Baby formula	0.357	0.037	9.660	0.000	0.285	0.430	0.482	0.049	9.750	0.000	0.385	0.579
Other milk	0.623	0.026	24.430	0.000	0.573	0.673	0.103	0.047	2.220	0.027	0.012	0.195
Fruit juice	0.173	0.029	6.020	0.000	0.117	0.230	-0.030	0.036	-0.850	0.396	-0.100	0.039
Other	-0.047	0.029	-1.640	0.101	-0.103	0.009	-0.077	0.036	-2.110	0.035	-0.149	-0.006
Semi-solid or soft food	-0.869	0.035	-24.500	0.000	-0.939	-0.800	-1.094	0.047	-23.060	0.000	-1.187	-1.001
	Number of obs=11876 R^2= 0.1420 f(7,11868)=280.58 Adj R^2= 0.1415 prob>F= 0.0000 Root MSE= 1.1861						Number of obs=7399 R^2= 0.1913 f(7, 7391)=249.72 Adj R^2= 0.1905 prob>F= 0.0000 Root MSE= 1.0942					
Breastfeeding practices												
treatment	-0.006	0.021	-0.280	0.781	-0.047	0.035	0.250	0.023	10.920	0.000	0.205	0.295
Ever breastfeed	-0.608	0.429	-1.420	0.157	-1.450	0.234	-0.746	0.416	-1.790	0.073	-1.562	0.069
Early initiation of breastfeeding	0.278	0.021	13.140	0.000	0.237	0.320	0.064	0.023	2.800	0.005	0.019	0.109
Continued breastfeeding at 1 yr.	-0.560	0.038	-14.930	0.000	-0.634	-0.487	-0.586	0.040	-14.770	0.000	-0.664	-0.508
Continued breastfeeding at 2 yr.	-0.833	0.053	-15.750	0.000	-0.936	-0.729	-0.783	0.054	-14.460	0.000	-0.889	-0.676
SBF1	0.548	0.021	26.170	0.000	0.507	0.589	0.526	0.022	24.440	0.000	0.484	0.568
	Number of obs=13889 R^2= 0.0696 f(6, 13882)=173.05 Adj R^2= 0.0692 prob>F= 0.0000 Root MSE= 1.1352						Number of obs=12372 R^2= 0.0692 f(6,12365)=153.28 Adj R^2= 0.0688 prob>F= 0.0000 Root MSE= 1.0994					

Table 38. Results of linear regressions for feeding practices and breastfeeding practices and weight-for-age (standard deviations) respectively. The effect of feeding practices within 24 hours of birth, such as providing the infant water, tinned milk or infant formula, on the child's weight-for-age (standard deviations) and the treatment effect was evaluated through a linear regression model. Similarly, breastfeeding practices were evaluated for their impact on weight-for-age (standard deviations) and the treatment effect. Regressions were performed for all data (Cambodia and Vietnam) and Cambodia only.

3.3.3 Weight-for-height (standard deviations)

The final anthropometric indicator recommended by the WHO under consideration is weight-for-height, which indicates whether the child is underweight. As with height-for-age (3.7.1) and weight-for-age (3.7.2) above, regressions were performed to investigate the relationship between weight-for-height and other variables. Initial regressions between treatment and weight-for-height (WHZ) indicated a significant correlation, but the R^2 value was very low (Table 39). The analysis between WHZ and treatment for all data was significant, although the R-squared indicated a very little of the variance of WHZ was attributed to treatment alone.

	Coeff.	**Std. Error.**	**t**	**P>t**	**R^2**	**Prob>F**	**Root MSE**	**95% Conf Int**	
Cambodia	0.0500	0.0172	2.9000	0.0040	0.0006	0.0038*	1.0575	0.0162	0.0838
All data	-0.1622	0.0162	-10.0300	0.0000	0.0051	0.0000**	1.1123	-0.1939	-0.1305

Table 39. Linear regression results for the correlation between weight-for-height standard deviations and treatment for Cambodian data, and all data. *F(1, 15090)=8.40 ** F(1,19577)=100.59

Regressions of the characteristics of women and demographic data had little impact on the significance of the treatment effect (Table 39, 40). Education variables of women had a significant impact on WHZ in all data, but no significant impact in Cambodian data, except for years of schooling completed at the highest level. The impact of marriage characteristics were not significant on WHZ. The use of contraception was significant for Cambodian data, but not in regressions for all data (Table 40). Whether a child was wanted or not was significant for all data, but not in Cambodian data only. R^2 values for models of the education of women, marriage characteristics and family planning did not explain much of the variance of WHZ. The regional characteristics were not significantly correlated for Cambodian data only, but the variables were significantly correlated to WHZ in regressions with all data (Table 40). The treatment effect stayed significant for both regressions. The impact of demographic characteristics, like sex and age, varied between regressions for all data and for Cambodian data only (Table 41). The age of the child in months and the age of the women were significant for both, but the sex of the child was not significantly correlated with WHZ for Cambodia and all data. R^2 values indicated that regional and demographic models explained little of the variance of WHZ overall. The history of the family, survival of previous children born to the same mother indicated a significant correlation for all variables in the regression using all data, and a no significant correlations for Cambodian data only (Table 42).

	All data						Cambodia					
	Coeff	**Std. Error.**	**t**	**P>t**	**95% Conf Int**		**Coeff**	**Std. Error.**	**t**	**P>t**	**95% Conf Int**	
Education of women												
treatment	-0.093	0.019	-4.770	0.000	-0.131	-0.055	0.005	0.020	0.230	0.818	-0.035	0.045
any education*	-0.743	0.132	-5.610	0.000	-1.003	-0.483	0.000	-	-	-	-	-
highest education level	0.348	0.020	17.250	0.000	0.308	0.387	0.062	0.069	0.890	0.372	-0.074	0.198
highest education level completed	-0.067	0.015	-4.380	0.000	-0.096	-0.037	0.044	0.033	1.330	0.185	-0.021	0.110
Highest years attained	0.013	0.004	2.890	0.004	0.004	0.021	0.010	0.005	2.010	0.045	-.0002426	0.020
	Number of obs=15319 R^2= 0.0496 F(5,15313)=159.96 Adj R^2= 0.0493 prob>F= 0.0000 Root MSE= 1.0903						Number of obs=11321 R^2= 0.0058 F(4,11316)=16.38 Adj R^2= 0.0054 prob>F= 0.0000 Root MSE= 1.0433					
Marriage characteristics												
treatment	0.049	0.017	2.810	0.005	0.015	0.083	0.049	0.017	2.820	0.005	0.015	0.083
Age at 1st marriage	0.003	0.002	1.210	0.227	-0.002	0.007	0.003	0.002	1.160	0.248	-0.002	0.007
Martial status	0.013	0.015	0.900	0.369	-0.016	0.042	0.013	0.015	0.890	0.375	-0.016	0.042
	Number of obs=15093 R^2= 0.0007 F(3, 15089)=3.64Adj R^2= 0.0005 prob>F= 0.0122 Root MSE= 1.0572						Number of obs=15089 R^2= 0.0007 F(3,15085)=3.60 Adj R^2= 0.0005 prob>F= 0.0128 Root MSE= 1.0573					
Family planning												
treatment	-0.064	0.017	-3.720	0.000	-0.098	-0.030	0.040	0.018	2.250	0.025	0.005	0.074
Contraception used	-0.003	0.007	-0.490	0.623	-0.016	0.010	-0.023	0.007	-3.560	0.000	-0.036	-0.011
Child was planned	-0.050	0.012	-4.210	0.000	-0.074	-0.027	-0.023	0.012	-1.920	0.055	-0.047	0.001
	Number of obs=16591 R^2= 0.0016 F(3,16587)=8.83 Adj R^2= 0.0014 prob>F= 0.0000 Root MSE= 1.084						Number of obs=15089 R^2= 0.0017 F(3,15085)=8.35 Adj R^2= 0.0015 prob>F= 0.0000 Root MSE= 1.057					

Table 40. Results of linear regressions for characteristics of women and weight-for-height (standard deviations). The effect of 'controlling' for the characteristics of women, such education, and contraception used, or marriage status on the child's *weight-for-height (standard deviations)* and the treatment effect were investigated through linear regressions. Regressions were performed for all data (Cambodia and Vietnam) and Cambodia only.

	All data						Cambodia					
	Coeff	**Std. Error.**	**t**	**P>t**	**95% Conf Int**		**Coeff**	**Std. Error.**	**t**	**P>t**	**95% Conf Int**	
Regional characteristics												
treatment	0.050	0.018	2.800	0.005	0.015	0.085	0.050	0.017	2.890	0.004	0.016	0.084
Province	0.002	0.001	2.950	0.003	0.001	0.003	0.002	0.001	1.530	0.127	-0.001	0.005
Border province	-0.029	0.018	-1.660	0.097	-0.064	-0.011	0.005	0.018	-1.700	0.089	-0.065	0.005
Cambodia	-0.481	0.031	-15.430	0.000	-0.542	-0.420	N/A					
	Number of obs=19579 R^2= 0.0395 F(4,19574)=201.11 Adj R^2= 0.0393 prob>F= 0.0000 Root MSE= 1.093						Number of obs=15092 R^2= 0.0009 F(3,15082)=4.33 Adj R^2= 0.0007 prob>F= 0.0046 Root MSE= 1.10574					
Demographic characteristics												
treatment	-0.534	0.022	-24.100	0.000	-0.577	-0.490	-0.129	. .0402985	-3.190	0.001	-0.208	-0.050
Female child	0.004	0.016	0.260	0.796	-0.026	0.035	0.010	0.017	0.580	0.561	-0.023	0.043
Year	0.018	0.004	4.500	0.000	0.010	0.025	0.017	0.004	4.550	0.000	0.010	0.025
Child's age in yrs.	0.067	0.027	2.450	0.014	0.013	0.120	0.056	0.030	1.860	0.062	. -.0028939	0.114
Child's age in months	-0.012	0.002	-5.530	0.000	-0.017	-0.008	-.0129765 -.00	0.002	-5.280	0.000	-0.018	-0.008
mother's age	-0.012	0.006	-2.130	0.033	-0.023	-0.001	-0.012	0.006	-2.060	0.040	-0.024	-0.001
mother's age group	0.039	0.027	1.440	0.150	-0.014	0.092	0.037	0.030	1.250	0.211	-0.021	0.095
	Number of obs=19413 R^2= 0.0532 F(8,19404)=136.30 Adj R^2= 0.0528 prob>F= 0.000 Root MSE= 1.0836						Number of obs=15092 R^2= 0.0244 F(7,15084)=244.54 Adj R^2= 0.0239 prob>F= 0.000 Root MSE= 1.045					

Table 41. Results of linear regressions for demographics and weight-for-height (standard deviations). The effect of 'controlling' for demographic and the characteristics of women, such province of residence, age, or sex, on the child's weight-for-height (standard deviations) and the treatment effect were investigated through linear regressions. Regressions were performed for all data (Cambodia and Vietnam) and Cambodia only.

	All data						**Cambodia**					
	Coeff.	**Std. Error.**	**t**	**P>t**	**95% Conf Int**		**Coeff.**	**Std. Error.**	**t**	**P>t**	**95% Conf Int**	
Survival of previous children												
Treatment*	0.001	0.019	0.040	0.966	-0.036	0.037	0.018	0.018	0.980	0.326	-0.018	0.053
Children ever born	-0.115	0.013	-9.050	0.000	-0.139	-0.090	-0.021	0.021	-1.020	0.309	-0.062	0.020
Surviving children*	0.077	0.015	5.070	0.000	0.047	0.106	-0.006	0.022	-0.290	0.773	-0.049	0.037
# of children who have died	0.000	-	-	-	-.	-	0.000	-	-	-	-.	-
Ever had children who have died	0.234	0.011	20.400	0.000	0.212	0.257	0.006	0.039	0.150	0.881	-0.071	0.082
Number of obs=194113 R^2= 0.0390 F(4, 19408)=196.94 Adj R^2= 0.0388 prob>F= 0.0000 Root MSE= 1.0916							Number of obs=15092 R^2= 0.0031 F(4. 15087)=11.85 Adj R^2= 0.0029 prob>F= 0.0000 Root MSE= 1.0562					

Table 42. Results of linear regressions for children's survival in the family and weight-for-height (standard deviations). The effect of the survival of other children belonging to the same mother was on the *weight-for-height z-score* was evaluated through a linear regression model. Regressions were performed for all data (Cambodia and Vietnam) and Cambodia only.

After demographic, women and family characteristics were evaluated, the relationship between wealth indicators and WHZ was examined through linear regressions (Table 43). The model for wealth indicators indicated that very little of the variance in WHZ was attributed to the wealth characteristics, for Cambodian data only (R^2=0.0048, p>F=0.3168) . Only ownership of a television was significantly correlated the WHZ in regressions (Table 43). The coefficient for the relationship between the treatment and WHZ, for all data, in the model including wealth scores was excluded by the program for having no association. The variance among WHZ standard deviations was not well explained by wealth indicators, according to this regression. The wealth indicators were only available before and after implementation for Cambodia, so no results from all data were able to be determined.

	Cambodia					
	Coeff.	Std. Error.	t	P>t	95% Conf Int	
Treatment*	0	-	-	-	-	-
Source of drinking water	0.0030	0.0052	0.57	0.567	-0.007	0.013
Time to get water	-0.001	. 0.002	-0.44	0.657	-0.005	0.003
Type of toilet facility	-0.001	0.0189	-0.06	0.948	- 0.038	. 0.036
Floor material	-0.039	0.0249	-1.58	0.114	-0.088	0.009
Has electricity	-0.011	0.1068	-0.11	0.916	-0.221	0.198
Has bicycle	-0.052	0.0487	-1.09	0.278	-0.148	0.0427
Has radio	0.1611	0.0539	2.99	0.003	0.055	0.267
Has TV	0.0074	0.0684	0.11	0.913	-0.1267	0.142
Has refrigerator	0.3184	0.6150	0.52	0.605	-0.887	1.524
Has motorcycle/scooter	-0.042	0.0704	-0.60	0.548	-0.180	0.095
Has car/truck	-0.141	0.4362	-0.33	0.745	-0.997	0.713
Number of obs=2643 R^2= 0.0048 F(11, 2631)=2.25 Adj R^2= 0.0006 prob>F= 0.3168 Root MSE= 1.1948						

Table 43. Results of linear regressions for wealth indicators and weight-for-height (standard deviations). The effect of wealth indicators, such as owning a automobile, time to water, owning a scooter, etc., on the child's *weight-for-height (standard deviations)* and the treatment effect was evaluated through a linear regression model. Regressions were performed for Cambodian data only, as consistent data for each variable for each year was not available from MCIS Vietnam.

The relationship between indicators of childhood illness, immunization and micronutrient supplementations and weight-for-height were analyzed using a linear regression. For Cambodia, the implementation of the treatment was positively associated in the model with WAZ. The other variables were not significantly correlated with WHZ for Cambodian data. For all data, the treatment was not significantly associated with WHZ in a model, including for childhood illness and immunization factors, and the linear regression line-of-best-fit was not significantly different from 0. The other variables were not significantly correlated with WHZ. In a linear model, recent illness, treatment of recent illnesses, past immunizations and micronutrient supplementations were not correlated with current WHZ. (Table 44)

	All data						Cambodia					
	Coeff	**Std. Error.**	**t**	**P>t**	**95% Conf Int**		**Coeff.**	**Std. Error.**	**t**	**P>t**	**95% Conf Int**	
Type of assistance at birth												
Treatment	0.0734	0.0795	0.92	0.356	-0.083	0.229	0.2205	0.0914	2.41	0.016	0.041	0.400
Had diarrhea recently	-0.1144	0.0631	-1.81	0.070	-0.238	0.0093	-0.0965	0.0651	-1.48	0.139	-0.224	0.031
Had ARI recently	0.0626	0.0626	1.00	0.318	-0.060	0.185	0.0361	0.0632	0.57	0.567	-0.087	0.160
Sought treatment for ARI	0.0552	0.0664	0.83	0.406	-0.075	0.185	-0.0010	0.0713	-0.01	0.989	-0.141	0.139
Ever had a vaccination	-0.1903	0.1352	-1.41	0.160	-0.455	0.0750	-0.1906	0.1388	-1.37	0.170	-0.463	0.0817
Has a health card	0.0302	0.0756	0.40	0.689	-0.118	0.178	0.0116	0.0759	0.15	0.878	-0.137	0.160
Has BCG	0.1494	0.1257	1.19	0.235	-0.097	0.396	0.1280	0.1307	0.98	0.328	-0.128	0.384
Has polio	0.0277	0.0976	0.28	0.776	-0.163	0.219	-0.0540	0.1157	-0.47	0.640	-0.281	0.173
Has DPT	0.0014	0.1008	0.01	0.989	-0.196	0.199	0.1445	0.1175	1.23	0.219	-0.086	0.375
Has measles	-0.0527	0.0852	-0.62	0.536	-0.220	0.114	-0.0962	0.0897	-1.07	0.284	-0.272	0.0797
Ever had Vit. A	-0.0206	0.0919	-0.22	0.823	-0.201	0.159	-0.2855	0.1213	-2.35	0.019	-0.524	-0.047
Had Vit A w/in 6 months	-0.0558	0.0777	-0.72	0.473	-0.208	0.0967	0.0798	0.0909	0.88	0.380	-0.098	0.258
Number of obs=1182 R^2= 0.0084 F(12, 1182)=0.83 Adj R^2= -0.0018 prob>F= 0.6228 Root MSE= 0.97804							Number of obs=1080 R^2= 0.0151 F(12, 1067)=1.36 Adj R^2= 0.0040 prob>F= 0.0000 Root MSE= 0.9773					

Table 44. Results of linear regressions for determining the association between childhood illness, immunization, supplementation and weight-for-height (standard deviations). The effect of childhood illness and immunizations on the child's weight-for-height (standard deviations) and the treatment effect was evaluated through a linear regression model. Regressions were performed for all data (Cambodia and Vietnam) and Cambodia only.

The birthing process and infant feeding practices, including breastfeeding, were also evaluated for their relationship to WHZ. The type of assistance available at birth was not highly related, unlike WAZ, and the only significant variable for Cambodian data was the presence of a doctor (Table 45). In the regression with all data, the presence of a doctor, a relative/friend or other (uncoded) was significantly correlated with WHZ, although the presence of a relative/friend at birth had an inverse relationship with WHZ z-scores (Table 45). R^2 values for type of assistance at birth model showed very little variance of WHZ was attributable to assistance at birth. Feeding practices had a significant correlation to WHZ in Cambodia if the child was given water, baby or infant formula, or was introduced to soft or semi-soft foods. The introduction of any liquid 24 hours after birth, and the introduction of foods were all significantly correlated with WHZ in regressions with all data. Early initiation of breastfeeding was significantly correlated with WHZ in regression with all data (Table 46). Continued breastfeeding at one and two years was significantly negatively associated with WHZ in both all data and only Cambodian data only regressions. R^2 values for feeding practices regressions showed very little variance of WHZ was attributable to either feeding practices or breastfeeding practices.

	All data						**Cambodia**					
	Coeff	**Std. Error.**	**t**	**P>t**	**95% Conf Int**		**Coeff.**	**Std. Error.**	**t**	**P>t**	**95% Conf Int**	
Type of assistance at birth												
treatment	-0.096	0.020	-4.780	0.000	-0.136	-0.057	-0.029	0.021	1.340	-0.181	-0.070	0.013
Doctor	0.392	0.040	9.700	0.000	0.313	0.472	0.277	0.050	5.540	0.000	0.179	0.374
Nurse/midwife	-0.056	0.038	-1.460	0.145	-0.132	0.019	-0.017	0.051	-0.330	0.745	-0.116	0.083
TBA	-0.101	0.048	-2.090	0.036	-0.195	-0.006	-0.011	0.059	-0.190	0.850	-0.128	0.105
Relative/friend	0.025	0.048	0.530	0.596	-0.069	0.119	0.010	0.050	0.200	0.840	-0.088	0.10
Other	0.133	0.069	1.940	0.052	-0.001	0.267	0.135	0.073	1.840	0.066	-0.009	0.279
No one	-0.053	0.214	-0.250	0.804	0.474	-0.367	0.031	0.213	0.140	0.886	-0.388	0.449
Number of obs=16581 R^2= 0.0198 F(8,16572)=41.79 Adj R^2= 0.0193 prob>F= 0.0000 Root MSE= 1.0739							Number of obs=15077 R^2= 0.0055 F(8, 15068)=10.48 Adj R^2= 0.0050 prob>F= 0.0000 Root MSE= 1.0548					

Table 45. Results of linear regressions for determining the association between type of assistance at birth and weight-for-height (standard deviations). The effect of the type of assistance used at the child's birth, such as having a doctor present, on the weight-for-height (standard deviations) of the child and the treatment effect was evaluated through a linear regression model. Regressions were performed for all data (Cambodia and Vietnam) and Cambodian data only.

	All data						Cambodia					
	Coeff	Std. Error.	t	P>t	95% Conf Int		Coeff	Std. Error.	t	P>t	95% Conf Int	
Feeding practices within 24 hours of birth												
Treatment*	-0.053	0.025	-2.09	0.037	-0.103	-0.003	0.118	0.027	4.25	0.000	0.063	0.173
Plain	-0.278	0.048	-5.70	0.000	-0.374	-0.182	-0.135	0.058	-2.31	0.021	-0.249	-0.020
Baby formula	0.148	0.036	4.05	0.000	0.076	0.220	0.10	0.0513	6.04	0.000	0.209	0.411
Other milk	0.419	0.025	16.63	0.000	0.370	0.469	0.045	0.0483	0.93	0.352	-0.049	0.139
Fruit juice	0.083	0.028	2.94	0.003	0.027	0.139	-0.013	0.036	-0.36	0.720	-0.085	0.059
Other	-0.046	0.028	-1.65	0.100	-0.102	0.008	-0.035	0.037	-0.93	0.353	-0.109	0.039
Semi-solid or soft food	-0.529	0.035	-15.05	0.000	-0.598	-0.460	-0.671	0.049	-13.63	0.000	-0.767	-0.574
	Number of obs=11836 R^2= 0.0612 f(7,11828)=110.21 Adj R^2= 0.0607 prob>F= 0.0000 Root MSE= 1.1709						Number of obs=7400 R^2= 0.0716 f(7, 7392)=81.41 Adj R^2= 0.0707 prob>F= 0.0000 Root MSE= 1.1363					
Breastfeeding practices												
Treatment	-0.088	0.0203	-4.33	0.000	-0.127	-0.0482	0.0693	0.0223	3.11	0.002	0.025	0.113
Ever breastfeed	0.082	0.4155	0.20	0.842	-0.7318	0.897	-0.006	0.405	-0.02	0.987	-0.801	0.788
Early initiation of breastfeeding	0.152	0.0205	7.45	0.000	0.112	0.19	0.0182	0.0223	0.81	0.416	-0.0256	0.062
Cont'd breastfeeding at 1 yr.	-0.334	0.0363	-9.18	0.000	-0.405	-0.262	-0.354	0.0386	-9.17	0.000	-0.4304	-0.2787
Cont'd breastfeeding at 2 yr.	-0.664	0.0511	-12.99	0.000	-0.764	-0.564	-0.655	. 0.053	-12.43	0.000	-0.759	-0.552
Currently breastfeeding	0.334	0.020	16.47	0.000	0.294	0.373	0.335	0.021	16.01	0.000	0.294	0.377
	Number of obs=13872 R^2= 0.0310 f(6, 13865)=73.92 Adj R^2= 0.0306 prob>F= 0.0000 Root MSE= 1.0987						Number of obs=12375 R^2= 0.0287 f(6,12368)=60.81 Adj R^2= 0.0282 prob>F= 0.0000 Root MSE= 1.0723					

Table 46. Results of linear regressions for feeding practices and breastfeeding practices and weight-for-height (standard deviations) respectively. The effect of feeding practices within 24 hours of birth, such as providing the infant water, tinned milk or infant formula, on the child's *weight-for-height (standard deviations)* and the treatment effect was evaluated through a linear regression model. Similarly, breastfeeding practices were evaluated for their impact on weight-for-height (standard deviations) and the treatment effect. Regressions were performed for all data (Cambodia and Vietnam) and Cambodia only.

Similar to other nutritional indicators of interest, WHZ is a highly complex indicator. The application of linear regressions can allow researchers to determine if variables are significantly correlated, but because of the large number of variables that affect WHZ, categorical models did not explain a large amount of the variance of WHZ.

3.4 DOUBLY ROBUST ESTIMATOR: IPWRA

A review of the results from the basic regression analysis (Sections 3.2 and 3.3), using weight at birth (g), being underweight at birth (<2500g), being very small at birth, weight-for-age, height-for-age and weight-for-height z scores, demonstrates the very problem that the doubly robust estimator and nearest-neighbour matching technique hope to address. The statistical significance of covariates and the indicators but the fact that variables were run individually made it difficult to draw meaningful conclusions about the overall impact of the treatment on the nutrition indicators of interest. The linear and logistic regressions, however, allow a basic understanding into relationships between covariates that assist the discussion of the results of the DR estimator and the nearest neighbour matching estimator. First, the variable selection process for this DR estimator is explained, followed by a specific list of covariates used in each DR estimator for each nutritional indicator. The results of the DR estimator are presented. The DR estimator was applied to Cambodian data alone, and then data from both Cambodia and Vietnam, for each nutritional indicator, respectively. Each result indicates the use of the DR to estimate the treatment effect on each of the six nutritional indicators; there are twenty-four estimations of the ATE or ATET, for Cambodian data or all data, using the DR estimator.

The DR estimator uses two models, an outcome model and a treatment model, as introduced in Chapter 1. Including a large number of variables that are unrelated to both the treatment and outcome can introduce bias into the DR estimator, but some debate remains about the best method for variable selection. The inclusion of covariates related to the outcome and treatment is suggested to be an appropriate method, with emphasis on selection of covariates that are more related to the outcome than associated with the treatment[87,88]. The statistical relationship between the nutritional indicator of interest and confounding factors needs to be backed in scientific literature for proper interpretation of the results[64]. For the DR estimator, variables were first selected for an outcome model. These are variables that were correlated to the nutritional indicator in Section 3.2 and 3.3 or have been introduced in Chapter 1 as already scientifically proven correlated to nutritional status. For example, the presence of a TBA at birth was significantly associated with weigh at birth, and the presence of trained individuals at birth is also correlated to better health outcomes for the baby in the literature[47]. The age of the children, the age of the mother and gender have also commonly been found to be associated with childhood malnutrition in the literature, and were included[56,91]. These variables are included in the outcome model. The variables selected for the treatment model are variables that would be different, on average, between the treatment and non-treatment group, in an attempt to control for preexisting differences in the two populations. In this case, the variables investigated above that could be considered covariates between Cambodian and Vietnam populations were included. For example, the average education level between Cambodian and Vietnamese women is different, and therefore women who are less educated in this data set are more likely to have the treatment (Table X). By controlling for the education of women in both the treatment and outcome models, a less biased estimator can be produced. This selection process was completed for all the covariates for both an outcome and treatment model.

To evaluate weight at birth (g) with a DR estimator, variables were selected that had been assessed in the linear regression model (Section 3.2.1) or which had been proven to effect outcome in another peer reviewed study. For the outcome model, the education of mother, age of marriage of mother, surviving siblings, type of assistance at birth, if antenatal care was provided, if a caesarian section was performed and sex of the child were all included. For the treatment model, to control for covariates that would introduce bias due to preexisting differences in the populations, the education level of mothers, age at marriage, contraception used, family history, the age of women, province of residence, wealth factor index score, age of child, recent diarrhea or acute respiratory infections of the child, breastfeeding practices, and infant feeding practices were included. The same variables were used as controls in DR estimates of the ATE of underweight (<2500g) and 'very small' at birth. For the WHO anthropometric measures, similar covariates were used in the outcome model. Additional variables were included in the treatment model, as WHZ, WAZ, and HAZ can all be affected by practices such as feeding and breastfeeding practices, and recent illnesses. The DR estimates were performed for Cambodia alone to compare Cambodia before treatment to after treatment, while controlling for preexisting differences in the population, for example, in the educated vs. less educated population, or between provinces. Another DR regression for all data was performed to use Vietnam as the untreated population, and control for differences between the populations of these two countries to get a more unbiased estimate of the treatment effect.

The DR estimation for weight at birth confirmed the linear regression results of a negative effect of the 'treatment' on weight at birth (g) for Cambodian data and Cambodian and Vietnamese data. The decrease was 78.91 g, from an average of 3212.6g for untreated for Cambodian data, and 79.36g from an average of 3212.88g for all data (Table 47). This suggested that the treatment decreased weight at birth by two percent of the mean approximately. The average treatment effect on the treated (ATET) showed a smaller decrease of approximately 73g and 60g, for Cambodian data and all data, respectively. This suggests implementation of the policy actually had a less substantial effect on weight at birth for Cambodians only, than suggested by the ATE. The DR estimation of the effect of treatment on being born underweight at birth was not significant for Cambodian data and all data. The DR estimator for being identified as 'very small' at birth similarly was insignificant for ATE and ATET. Although the negative effect of the ATE and ATET on the proportion of children underweight at birth and identified as very small at birth indicates that the treatment would be decreasing the number of children in these harmful categories, a positive impact of the treatment, the insignificant results mean no conclusions can be drawn from these two variables.

	Coeff.	Robust Std. Err.	z	p>|z|	95% Conf. Int.		POM	Outcome model	Treatment model
	Weight at birth (g)								
	ATE								
Cambodia	-78.921	21.70	-3.64	0.000	-121.45	-36.389	3213.6	Linear	Logit
All data	-79.326	22.94	-3.46	0.001	-124.29	-34.357	3212.8	Linear	Logit
	ATET								
Cambodia	-73.180	26.112	-2.80	0.005	-124.36	-22.000	3210.6	Linear	Logit
All data	-62.114	13.023	-4.77	0.000	-87.640	-36.589	3199.5	Linear	Logit
	Underweight at birth								
	ATE								
Cambodia	-0.0154	0.0130	-1.18	0.239	-0.0410	0.0102	0.1546	Linear	Logit
All data	-0.0194	0.0136	-1.43	0.154	-0.0463	0.0073	0.1591	Linear	Logit
	ATET								
Cambodia	-0.0225	0.0159	-1.42	0.155	-0.0536	0.0085	0.1557	Linear	Logit
All data	-0.0296	0.0167	-1.77	0.077	-0.0625	0.0031	0.1628	Linear	Logit
	'Very small' at birth								
	ATE								
Cambodia	-0.0026	0.0030	-0.88	0.380	-0.0085	0.0033	0.03093	Linear	Logit
All data	-0.0035	0.0029	1.20	0.231	0.0093	0.0022	0.03115	Linear	Logit
	ATET								
Cambodia	-0.0019	0.0030	-0.63	0.526	-0.0079	0.0041	0.02551	Linear	Logit
All data	-0.0022	0.0031	-0.75	0.455	-0.0083	0.0037	0.02585	Linear	Logit

Table 47. The results from a DR regression analysis of size and weight at birth. Using a IPWRA model to estimate the ATE and ATET for continuous variable weight at birth (g) and discrete variables of being born underweight (<2500g) or being 'very small' at birth. The POM for the untreated sample is recorded for reference

The DR estimation for HAZ confirmed the linear regression results of a negative effect of the treatment on HAZ for Cambodian data and all data, but results were only significant for Cambodian data. None of the DR estimations for the ATET on HAZ were statistically significant at $p<0.05$. The DR estimator showed a negative, statistically significant treatment effect on WAZ. There was a ATE decrease of 12.3% of the untreated mean z-score for Cambodian data, and a ATE decrease of 12.9% of the untreated mean z-score for all data for weight-for-age was determined. The ATET on WAZ was not significant for Cambodian data, or all data. The ATE effect on WHZ in

Cambodian data was a decrease of 0.1628SD, a decrease of 22.8% of the untreated mean. For all data, the ATE effect was a decrease of 23.8% of the untreated mean. Both ATE were significant (p<0.001). The ATET on WHZ was not significant for Cambodian data or all data. (Table 47)

	Coeff.	Robust Std. Err.	z	p>|z|	95% Conf. Int.		POM	Outcome model	Treatment model
	Height-for-age (standard deviations)								
	ATE								
Cambodia	-0.1595	0.062	-2.31	0.021	-0.2951	-0.0238	-1.248	Linear	Logit
All data	-0.1255	0.065	-1.91	0.056	-0.2541	0.003	-1.381	Linear	Logit
	ATET								
Cambodia	-0.1021	0.086	-1.18	0.239	-0.2721	0.0678	-1.093	Linear	Logit
All data	-0.1079	0.087	-1.24	0.216	-0.2788	0.0630	-1.088	Linear	Logit
	Weight-for-age (standard deviations)								
	ATE								
Cambodia	-0.1692	0.064	-2.63	0.008	-0.2951	-0.0433	-1.3711	Linear	Logit
All data	-0.1771	0.064	-2.74	0.006	-0.3036	-0.0505	-1.364	Linear	Logit
	ATET								
Cambodia	-0.1478	0.091	-1.62	0.105	-0.3263	0.0306	-1.2137	Linear	Logit
All data	-0.1605	0.093	-1.72	0.085	-0.3430	0.0219	-1.2010	Linear	Logit
	Weight-for-height (standard deviations)								
	ATE								
Cambodia	-0.1698	0.062	-2.70	0.007	-0.2928	-0.0467	-0.7442	Linear	Logit
All data	-0.1757	0.063	-2.78	0.005	-0.2994	-0.0520	-0.7378	Linear	Logit
	ATET								
Cambodia	-0.1417	0.085	-1.66	0.097	-0.3088	0.02551	-0.6521	Linear	Logit
All data	-0.1542	0.086	-1.78	0.075	-0.3241	0.01555	-0.6394	Linear	Logit

Table 47. The results from a DR regression analysis of anthropometric measures of nutrition status. Using an IPWRA model to estimate the ATE and ATET for continuous variables of HAZ, WAZ and WHZ. The POM for the untreated sample is recorded for reference.

The IPWRA analysis results suggest the implementation of the policy had an overarching negative impact on anthropometric measures and weight at birth, and an insignificant impact on underweight children and on children identified as very small. The ability to draw conclusions from the IPWRA DR model is somewhat limited as certain variables, could not be included because of the similarity to the treatment variable, as mentioned above in the discussion of the selection of variables. The inability to include the year in the model, because of its similarity to treatment, means that the results of the DR model only can be described in terms of before and after policy implementation.

Evaluation of the nutrition status indicators with an NNM model will allow matching on multiple binary variables, including the year.

3.5 NEAREST-NEIGHBOUR MATCHING ESTIMATOR

A NNM estimator was implemented because of its ability to possibly reduce bias in the estimation of ATE and ATET, compared to the DR estimator. The NNM model was adjusted to remove large-sample bias that the continuous covariates introduced into the estimator, such as wealth index factor score[68,70]. First, the process for selecting variables that individuals from Cambodia and Vietnam will be matched on is explained. The results from the NNM estimator are then presented for ATE and ATET, for each of the six nutritional indicators. Each result indicates the use of the NNM technique to determine treatment effect on one of the nutritional indicators; there are twelve estimations of the ATE or ATET using the NNM technique.

The variable selection to define matching criteria between untreated and treated groups is similar to that of the DR estimator, but relies less on the previously determined relationship between the outcome and covariates. The results from the earlier linear and logistic regressions are used in the discussion of the introduction of bias into the estimator (Chapter 4), but not in variable selection. Variables that were found to be unassociated were still included in the matching criteria because, although they may increase variance, exclusion of a potentially important confounder can be increase bias significantly[87]. Best practices suggest that variable selection should be done based on previous research and scientific understanding of an effect of the covariate on the outcome, and that it is better to include too many covariates than exclude a significant one[89]. Individuals who were treated, from Cambodia after 2009, were matched with up to ten individuals who were not treated, from Vietnam. The matching was based on women's education, wealth quintile, type of assistance at birth, sex of the child, breastfeeding and infant feeding practices, recent childhood illness, age of the child and age of the mother, province and whether they lived in a province bordering Vietnam. Further details on covariates, included comparison of means over time and between countries can be found in Section 3.5 to 3.9. The NNM method computed the ATE by creating an outcome for the data point if it had received the opposite treatment based on a weighed function of covariates that match it to a similar un-treated data point.

The ATE on weight at birth was a decrease of 41.2 g, although this decrease was not significant. The number of children who were identified as very small at birth was decreased by the treatment (p=0.004). The ATE on the proportion of children who were very small at birth was not significant. The ATE on HAZ was significant and showed a decreased of 0.25SD. The ATE on WAZ was significant and showed a decrease of 0.247 SD. Similarly, the ATE on WHZ was -0.2802SD. Overall, the NNM estimator seemed to confirm the results of the IPWRA model. The ATE on the three anthropometric measures was significantly negative. The ATE on the number of children who were 'very small' at birth was insignificant, as was the ATE on weight at birth. Finally, the ATE of the proportion of children who were underweight at birth decreased, significantly. The ATET was also calculated for the six nutritional indicators using the NNM model. The model found most of the ATET to be insignificant at p<0.05, except the ATET on WHZ, which was determined to be a significant decrease of 0.166SD. Overall, the NNM model demonstrated similar results to the unadjusted linear and logistic regressions and to the IPWRA model. (Table 49)

	Coeff.	Robust Std. Err.	z	p>|z|	95% Conf. Int.		Obs
ATE							
Weight at birth	-41.200	27.064	-1.520	0.128	-94.244	11.844	12399
Underweight	-0.051	0.018	-2.870	0.004	-0.854	-0.016	12401
'Very small at birth'	-0.005	0.004	-1.150	0.249	-0.012	0.003	18400
HAZ	-0.250	0.075	-3.220	0.001	-0.391	-0.095	1950
WAZ	-0.292	0.064	-4.560	0.000	-0.418	-0.167	1950
WHZ	-0.256	0.061	-4.170	0.000	-0.377	-0.136	1950
ATET							
Weight at birth	-61.055	31.534	-1.940	0.053	-122.861	0.750	12399
Underweight	-0.005	0.004	-1.150	0.249	-0.012	0.003	12401
'Very small at birth'	-0.004	0.005	-0.910	0.365	-0.013	0.005	18400
HAZ	-0.005	0.085	-0.060	0.954	-0.172	0.162	1950
WAZ	-0.114	0.074	-1.550	0.121	-0.258	0.030	1950
WHZ	-0.166	0.075	-2.210	0.027	0.031	-0.019	1950

Table 49. Estimates of the ATE and ATET on nutritional indicators using a NNM model. The NNM model matches based on a selection of covariates and matches a treated individual with a non-treated (control) individual with the same characteristics. The NNM then compares the two means between these individuals of the dependent variable to determine the ATE or the ATET.

3.6 DEMOGRAPHICS AND POPULATION CHARACTERISTICS

Initial analysis used demography and population characteristics to determine the differences between Vietnam and Cambodia that could affect the interpretation of results. The average age of the children surveyed in Cambodia was 29.1 months, overall. In Vietnam, the average age of the children surveyed was 28.0 months. Average age of the women surveyed in Cambodia overall was 30.0 years. The average age of the women surveyed in Vietnam was slightly higher at 31.1. The average age at marriage in Cambodia was 20.0, overall and the median was 19. Of all the years, 2014 had the highest average age of 20.1 year at first marriage in Cambodia. In Vietnam, the average age across all years was 20.6 year and the median was 20. The highest average age at first marriage in Vietnam was 21.0 years, recorded in 2010.

Of the population, overall 13433 people were found to be living in provinces bordering Vietnam. In 2000, 3714 people lived in provinces on the Vietnam border and 5120 did not. In 2005, 3332 people lived in border provinces, while 4958 did not. In 2010, 3421 lives along the Vietnam border, while 4811 did not. In 2014, 4199 did not live in provinces that bordered Vietnam and 2966 did (Table 50).

Province	2000	2005	2010	2014	Overall
Banteay mean chey	462	402	396	300	1560
Kampong cheaam	475	343	408	402	1628
Kampong chhnang	678	456	532	329	1995
Kampong speu	516	470	425	396	1807
Kampong Thom	519	441	427	347	1734
Kandal	420	365	392	318	1495
Kratie	341	488	495	471	1795
Phnom pen	306	349	420	435	1510
Prey veng	397	384	376	326	1483
Pursat	577	369	416	388	1750
Siem reap	517	536	448	380	1881
Svay reing	410	313	364	320	1407
Takeo	529	392	378	297	1596
Otdar mean chey	58	488	395	382	1323
Battambang & Krong palin	512	425	376	329	1642
Kampot & Krong kep	343	403	352	294	1392
Krong preah sihanouk & Kaoh kong	671	431	434	403	1939
Preah vihear & Steung teng	304	591	542	510	1947
Mondol kirir & Rattanak kiri	799	644	656	538	2637

Table 50. The geographic composition of population distribution in Cambodia. Provinces Kampong Cham, Kampot, Mondol Kiri, Kratie, Prey Veng, Rattanak Kiri, Svay Reng, Takeo, Kep all share a border with Vietnam.

Women in Vietnam were much more likely to be educated at all levels, for all years, and on average for all data compared to women in Cambodia (Table 51). Women in Vietnam were also much more likely to be educated at all compared to women in Cambodia (Table 51).

	Education level	2000	2005	2010	2014	Overall
Cambodia	No education	0.37	0.37	0.22	0.14	0.26
	Primary	0.51	0.51	0.53	0.49	0.52
	Secondary	0.12	0.12	0.24	0.32	0.20
	Higher	0.00	0.00	0.02	0.04	0.01
Vietnam	No education	0.17	*	0.10	0.09	0.10
	Primary	0.29	*	0.22	0.19	0.25
	Secondary	0.42	*	0.46	0.44	0.39
	Higher	0.12	*	0.23	0.28	0.26

Table 51. Education level of women in Cambodia and Vietnam between 2000 and 2014. The proportion of women who completed the corresponding level of education in Cambodia and Vietnam is shown for each year, and then for all data overall. Data from 2006 from Vietnam was unavailable.

3.7 BIRTH AND INFANT CARE CHARACTERISTICS

Aspects of the birthing process were used as covariates because of their proposed effect on the dependent variables of interest. The type of assistance received at birth was investigated as a covariate. Women could response to the survey indicating the person who was assisting with or present at the birth of the child, such as a doctor, midwife or nurse, or traditional birth attendant. The proportion of women who responded per type of assistance was determined (Table 52). From before implementation of the policy to after, Cambodia increased in births attended by physicians, midwifes or nurse and relatives or friends and decreased in the births attended by other (uncoded) and no one (Table 52). This suggests that Cambodia is increasing in properly attended births, however, Vietnam increased by a higher percent for both the physician and midwife/nurse category, suggesting more of their births are properly supervised, leading to lower child and maternal mortality[92]. Table 53 demonstrates the proportion of births assisted by each type of person other the year, and on average over all years. In Cambodia, midwife and traditional birth attendant (TBA) were the most common for all years but 2010, where a physician becomes more common than a midwife. In Vietnam, physicians and midwife/nurses are the most common. DiD analysis suggested an increase rate of doctors present at birth after the implementation of the policy, compared to Vietnam. An increased DiD suggest higher rates of change for the presence of a midwife/nurse at birth, although this was less in magnitude compared to Vietnam. (Table 54)

	Cambodia				Vietnam			
	2000	2005	2010	2014	2000	2005	2010	2014
Physician/doctor	0.017	0.051	0.100	0.141	0.288	0.651	0.784	0.850
Midwife/Nurse	0.278	0.361	0.625	0.838	0.330	0.331	0.533	0.755
Traditional Birth Attendant	0.716	0.616	0.312	0.129	0.199	0.087	0.039	0.021
Relative or friend	0.005	0.050	0.057	0.032	0.149	0.122	0.047	0.065
Other	0.058	0.005	0.003	0.001	0.058	0.026	0.034	0.003
No one	0.003	0.002	0.001	0.000	0.036	0.001	0.002	0.004

Table 52. The proportion and distribution of type of assistance received at birth in Cambodia and Vietnam, between 2000 and 2014, and overall. Women responded to the type of assistance received at birth, and could indicate more than one category, for example, the presence of a doctor and midwife or nurse.

	Cambodia					**Vietnam**				
	2000	2005	2010	2014	Overall	2000	2006	2010	2014	Overall
Doctor	0.016	0.047	0.091	0.124	0.068	0.281	0.535	0.545	0.502	0.506
Midwife /nurse	0.259	0.333	0.570	0.735	0.466	0.322	0.272	0.371	0.446	0.381
TBA	0.666	0.569	0.284	0.113	0.418	0.194	0.071	0.027	0.012	0.041
Relative/ friend	0.005	0.046	0.052	0.028	0.032	0.146	0.101	0.033	0.038	0.055
Other	0.054	0.004	0.003	0.001	0.016	0.057	0.021	0.024	0.002	0.016

Table 53. Proportion of birth assisted by category type, of births that were specifically assisted by at least one category.

	Births assisted by:					
	A doctor	A midwife/ nurse	A TBA	A relative/ friend	Other	No one
Cambodia	0.008	0.130	-0.083	-0.070	0.051	0.000
Vietnam	-0.297	0.220	0.094	0.044	0.001	0.037
DiD	0.304	-0.090	-0.177	-0.114	0.050	-0.038

Table 54. The DiD analysis for the types of assisted births in Cambodia and Vietnam. The DiD calculation uses Equation 6 to compare the rate of change before implementation to the rate of change after implementation.

Another aspect of birth and infant care is breastfeeding and feeding practices. Breast milk is the perfect food for infants, containing all nutrients require for optimal development and protective antibodies, and proper breastfeeding is key to reducing morbidity and mortality rates in children[93]. The feeding practices of mothers 24 hours after birth were recorded in the DHS and MICS surveys and were analyzed (Table 55). From before and after implementation the proportion of mothers who gave their children liquids other than breastmilk in the 24 hours after birth, decreased in Cambodia, due to a decrease in water, fruit juice and other (uncoded) being offered. However, the proportion of babies who were given baby formula or tinned, powdered or another form of milk increased by approximately 7 percent in Cambodia before and after implementation of the policy (Table 55). Vietnam saw small increases in all liquids expect fruit juice, and unfortunately a lack of data collected on the giving of baby/infant formula in 2006 made that statistic incomparable (Table 56). DiD estimates for the change in the proportion of children receiving liquids 24 hours after birth indicated that Cambodia had increasing rates of inappropriate feeding for all categories after implementation (Table 56). The rate of inappropriate feeding in Vietnam decreased from before to after implementation for all categories (excluding baby formula which could not be determined due to lack of data) (Table 56).

	Cambodia				Vietnam			
	2000	2005	2010	2014	2000	2005	2010	2014
Given plain water	0.877	0.942	0.969	0.917	0.967	0.863	0.775	0.779
Given baby formula	-	0.165	0.141	0.366	0.036	0.047	0.087	0.143
Given tinned/powdered/other milk	0.250	0.469	0.586	0.545	0.046	0.044	0.086	0.156
Given fruit juice	0.150	0.415	0.225	0.237	0.265	0.056	0.094	0.210
Other	0.157	0.038	0.240	0.065	0.271	0.054	0.116	0.157
Given soft, semi-solid or solid food	-	0.883	0.811	0.376	0.898	0.733	0.761	0.752

Table 55. The proportion of type of liquid or food given to the child 24 hours after birth in Cambodia and Vietnam, between 2000 and 2014. Women responded to the type of liquid they had given their child 24 hours after birth.

	Children received the below 24 after birth:				
	Water	Baby formula	Milk	Fruit juice	Other
Cambodia	0.1068323	0.0450477	0.0715048	0.324623	0.25739436
Vietnam	-0.1164514	*	-0.2606185	-0.2521387	-0.0561646
DiD	0.2232837	*	0.3321233	0.5767617	0.31355896

Table 56. The DiD analysis for the types of liquid children received 24 hours after birth in Cambodia and Vietnam. The DiD calculation uses Equation 6 to compare the rate of change before implementation to the rate of change after implementation. The milk category includes tinned, powdered, and other types of milk.
* Indicates missing data

Breastfeeding practices were also evaluated because of their impact on nutritional status of the child, especially during the time when stunting can occur, that is, from 0 to 24 months. The number of women who ever breastfed was determined (Table 57). The change in the number of women who had ever breastfed before and after implementation was analyzed, using various time point comparisons. On average, before and after 2009, the number of women who had ever breastfed decreased in Cambodia and increased in

Vietnam (in very small percentages, approximately one percent or less) (Table 57). The DiD analysis for women ever having breastfed determined that the rate of change decreased from before and after implementation in Cambodia and Vietnam, and the rate decreased more in Vietnam (Table 58).

	2000	2005	2010	2014
Cambodia	0.956	0.968	0.950	0.951
Vietnam	0.953	0.177	0.218	0.215

Table 57. The number and distribution of the women who have ever breastfed in Cambodia and Vietnam, from 2000 to 2014.

	Ever have breastfed	Early initiation of breastfeeding	Continued breastfeeding at one year	Continued breastfeeding at 2 years
Cambodia	-0.009471	-0.3051102	-0.0085388	-0.0177295
Vietnam	-0.0369775	*	0.01279	-0.0007425
DiD	0.0275065	*	-0.0213288	-0.016987

Table 58. The DiD analysis for breastfeeding practices in Cambodia and Vietnam. The DiD calculation uses Equation 6 to compare the rate of change before implementation to the rate of change after implementation. * Indicates missing data

Early initiation of breastfeeding has also been found to be associated with more robust nutritional and health outcomes, providing ideal nutrients, and immunological protection[75]. The number and distribution of women who initiated breastfeeding was determined, however, data was unavailable for 2006 for Vietnam, affecting the rest of the analysis (Table 59). In Cambodia, the difference between the average before and the average after implementation showed an increase in women initiating early breastfeeding. From 2000 to 2014 in Vietnam the rate of early initiation increased, however, between 2010 and 2014, the rate decreased by seven percent (Table 59). Other variables associated with breastfeeding have been found to impact nutritional status. Continued breastfeeding at one year, with the proper introduction of complementary foods, is recommended by WHO/UNICEF[75]. The continued breastfeeding of children at two years is recommended by the WHO[76]. The proportion of children who were still breastfeeding when their child was one year (12 to 14 month) was calculated, and overall there are very few mothers who continue breastfeeding at one year (Table 60). The change in the average proportion of mothers continuing to breastfeed at one year before implementation to after implementation showed a small decrease in Cambodia and a small increase in Vietnam

(Table 60). The DiD analysis supported this result (Table 58). The overall proportion of mothers still breastfeeding at 20 to 23 months was lower than at one year (Table 60). The number of women who continued breastfeeding at two years decreased a small amount in Cambodia and increased a small amount in Vietnam, results that were confirmed by a DiD analysis for before and after implementation (Table 60, Table 58).

	2000	2005	2010	2014
Cambodia	0.152	0.472	0.782	0.797
Vietnam	0.261	-	0.886	0.816

Table 59. The proportion of the women who initiated breastfeeding within 1 hour after birth in Cambodia and Vietnam, from 2000 to 2014. The number of women who initiated breastfeeding or brought the baby to their breast within one hour (inclusive) of birth. Data was not available for 2006 in Vietnam

	2000	2005	2010	2014
Continued breastfeeding at one year				
Cambodia	0.062	0.065	0.063	0.057
Vietnam	0.043	0.060	0.058	0.089
Continued breastfeeding at two years				
Cambodia	0.028	0.042	0.032	0.029
Vietnam	0.005	0.017	0.016	0.027

Table 60. The proportion of the women who continued breastfeeding at one and two years in Cambodia and Vietnam, from 2000 to 2014. Continued feeding at one year is the number of women who were still breastfeeding with a child aged 12 to 14 months. Continued feeding at two years is the number of women who were still breastfeeding with a child aged 20 to 23 months.

Data demonstrated improvements in Cambodia in the number of properly supervised births; proper feeding practices 24 hours after birth, early initiation of breastfeeding, and continued breastfeeding at one year but decreased continued breastfeeding at two years. These results suggest Cambodia is progressing in the right direction but not at the same rate as Vietnam. Further, DiD analyses indicated Cambodia frequently decreased in the rate of progression for breastfeeding and feeding practices after the implementation of the policy.

3.8 CHILDHOOD ILLNESS: INCIDENCE AND TREATMENT

Another covariate of nutritional status and a metric of interest to the NNS is the proper treatment of childhood illness. Diarrhea causes 17% of deaths among children under five years of age, and acute respiratory infections account for 19% of deaths for children under five[3]. Both the DHS and MICS have data available for diarrheal illness and symptoms of acute respiratory illness (a fever paired with a cough). The proportion and distribution of children who had diarrhea in the past two weeks prior to survey was calculated (Table 61). The percentage of children who were reported to have diarrhea in the past two weeks ranged from 20 to 12 percent in Cambodia, and from 11 to 9 percent in Vietnam. There was a decrease in the proportion of children before and after implementation, on average, in both Cambodia and Vietnam (Table 61). A DiD analysis suggested the rate of change before implementation was larger than the rate of change after implementation in Cambodia, however, the DiD showed an increase in rate of change in Vietnam after implementation (Table 62). The proportion of children who received oral rehydration therapy (ORT) to treat diarrheal illness, the first step in management of severe diarrhea recommended by the WHO[94], was measured for Cambodia and Vietnam (Table 63). The proportion of children whose recent diarrhea was treated with ORT increased, in both Cambodia in Vietnam, on average after implementation compared to on average before implementation (Table 63). DiD demonstrates, however, that the rate of change of the proportion of children receiving ORT before implementation was larger than after, in both Cambodia and Vietnam (Table 62). The average treatment over 2000 to 2014 was also investigated in Cambodia, although data was not available for all years. Children were most likely to be given an antibiotic pill or syrup after ORT (33.3%), or given another pill or syrup that was not an antibiotic, antimotility drug or zinc tablet (22.1%) (Table 64). The 'other' pill could indicate improper treatment of diarrhea, since antibiotics, antimotility and zinc supplementation are all recommended by the WHO after ORT[94].

	2000	2005	2010	2014
Cambodia	0.203	0.190	0.146	0.123
Vietnam	0.111	0.070	0.073	0.095

Table 61. The proportion of children who had diarrhea in the past two weeks at the time of the survey in Cambodia and Vietnam, from 2000 to 2014.

	Incidence of diarrhea in the past two weeks	ORT	ARI
Cambodia	-0.0094773	-0.0716909	0.0183439
Vietnam	0.0631033	-0.0432029	0.1694403
DiD	-0.0725806	-0.028488	-0.1510964

Table 62. The DiD analysis for the incidence and treatment of common childhood illnesses in Cambodia and Vietnam. The DiD calculation uses Equation 6 to compare the rate of change before implementation to the rate of change after implementation.

	2000	2005	2010	2014
Cambodia	0.168	0.227	0.358	0.345
Vietnam	0.073	0.193	0.434	0.511

Table 63. The proportion of children who had received oral rehydration therapy to treat the recent diarrheal disease of the survey in Cambodia and Vietnam, from 2000 to 2014.

	Proportion of children	Obs.
Given antibiotic pill or syrup	0.334	4989
Given an antimotility *	0.011	1978
Given zinc*	0.043	1978
Given other pill or syrup (not Ab, antimotility or zinc)*	0.221	1978
Given unknown pill or syrup*	0.305	1978
Given an injected Ab**	0.027	3562
Given a non-Ab injection*	0.005	1978
Given an unknown injection*	0.021	1978
Given an IV treatment**	0.015	3562
Given herbal medicine/home remedy	0.039	4989
Given other treatment	0.023	4989

Table 64. Treatment of diarrheal disease in Cambodia from 2000-2014 (overall). The proportion of responders who indicated that the child had received this particular treatment was recorded. Data was only available for certain years, where * indicates data only available from 2010 and 2014 and ** indicates data only available from 2000, 2010 and 2014.

Another common cause of childhood illness was investigated as a covariate. The number of children who had both a cough and fever at the same time, indicative symptoms of a respiratory infection, ranged from 28% to 15% in Cambodia from 2000 to 2014. High rates of acute respirator infection (ARI) were seen in Vietnam for all four years (Table 65). The average proportion of children with ARI before implementation was higher than the average proportion of children with ARI after implementation in both Cambodia and Vietnam (Table 65). DiD analysis indicated that the rate of decrease was larger after implementation in Cambodia and Vietnam, with the DiD of Vietnam approximately tenfold that of Cambodia (Table 61). The average proportion of children who received a specific treatment and whose parents/caregivers sought advice for ARI was tabulated (Table 65). On average, the most common treatment was a pill or syrup, and aspiring and antimalarial treatments were the least common. The most common locales from which to seek advice for an ARI were a community health centre, a shop and a private pharmacy. Overall, 70% of caregivers/parent sought advice for the ARIs of their children.

	2000	2005	2010	2014
Cambodia	0.290	0.264	0.167	0.160
Vietnam	0.813	0.658	0.538	0.552

Table 65. The proportion of children who had symptoms indicative of acute respiratory infection (fever, cough) in the past two weeks in Cambodia and Vietnam, from 2000 to 2014.

	Proportion of children	Obs.
Caregivers/parents sought advice for ARI	0.700	8391
From a government hospital	0.038	8340
From a community health centre	0.185	3331
From other public health centre	0.002	8303
From private hospital	0.019	8331
From private pharmacy	0.140	8472
From a shop	0.224	9348
From traditional healer	0.005	8322
From other private medical sector	0.014	8350
From other	0.010	8311
Treated with pill/syrup	0.529	4527
Treated with injection	0.080	4527
Treated with aspirin	0.001	7482
Treated with ibuprofen	0.010	4527
Treated with antimalarial	0.003	7529

Table 66. Treatment of ARI in Cambodia from 2000-2014 (overall). The type of facility where advice was sought by the caregiver/parent was determined, and the proportion of each was determine on average. The proportion of responders who indicated that the child had received this particular treatment was recorded.

The incidence and treatment of diarrheal and respiratory disease in Cambodia is a key component of the NNS. For both diseases, the incidence rates fell, but Vietnam had a larger decrease in the change before and after implementation. The slower progression of

Cambodia in the proper treatment and management of childhood illness after implementation could be due to multiple covariates, which are investigated further below.

3.9 IMMUNIZATION AND SUPPLEMENTATION IN CHILDREN

Another objective of the NNS strategy was to increase the prevalence of micronutrient supplementation and immunization. Immunization data was available over time for; BCG (Bacillus Calmette-Guerin), the vaccine used to prevent tuberculosis; the poliovirus vaccination, either as IPV (Inactivated Poliovirus Vaccine) intramuscularly or as OPV (Oral Poliovirus Vaccine) to prevent polio; the DPT (diphtheria, pertussis, and tetanus) vaccine to prevent diphtheria, whooping cough and tetanus; and the measles vaccine. Data for the DPT vaccine was not available for 2010 in Cambodia nor for 2000 to 2006 in Vietnam (Table 67). The introduction of the pentavalent vaccine, which replaced DPT, in low-income countries around the same time further complicates this variable and the results of DPT are presented with caution.

The percentage of children who had ever received any vaccine ranged from 56 to 87 percent in Cambodia, and from 88 to 94 percent in Vietnam (Table 67). The average percentage of children who had ever received any vaccination was larger after the implementation of the policy in Cambodia, but decreased in Vietnam (Table 67). DiD analysis, however, demonstrated that the rate of change from after implementation compared to before decreased in Cambodia, and was also smaller in magnitude than in Vietnam (Table 67). The proportion of children with vaccination or health cards increased in Cambodia and decreased in Vietnam (Table 67). The DiD analysis indicated an increased in rate of change of children with health cards in Cambodia after implementation, but of smaller magnitude than Vietnam (Table 68).

From before to after implementation, the average proportion of children who received the BCG vaccine increased by 17% in Cambodia and by 1 percent in Vietnam (Table 67). The DiD analysis, however, indicates that the rate of increase of Cambodian children receiving BCG was greater in before implementation than after implementation in Cambodia. The proportion of children in Cambodia and Vietnam who received a 3-

series polio vaccination increased, as well as the proportion that received the measles vaccine, in Cambodia and Vietnam (Table 67). DiD analysis indicated that the rate of increase in children receiving both these vaccines decreased after implementation (Table 68).

Finally, vitamin A supplementation was analyzed. The proportion of children who received vitamin A supplementation ever in Cambodia ranged from 0.29 to 0.66, while the proportion of children who received vitamin A supplementation in the last six months in Cambodia ranged from 0.28 to 0.63. In Vietnam, rates of vitamin A supplementation were much higher overall (0.72 to 0.99) and the proportions of those who have received it in the last six months were also greater (0.60 to 0.66) (Table 67). The proportion of vitamin A supplementation ever and within the last six month increased on average before and after implementation, in Vietnam and Cambodia. The result of a DiD analysis indicates that the rate of change, between time points, of vitamin A supplementation was greater after implementation in Cambodia. DiD for other vitamin A supplementations at 6 month all show greater increases before implementation, although Cambodia had a rate of lesser magnitude before compared to Vietnam (Table 68).

	Cambodia				Vietnam			
	2000	2005	2010	2014	2000	2006	2010	2014
Ever had a vaccination	0.564	0.796	0.784	0.873	0.886	0.936	0.940	0.859
Have had a health card	0.862	0.833	0.886	0.942	1.000	0.824	0.823	0.889
Received BCG vaccine	0.605	0.869	0.897	0.933	0.927	0.955	0.958	0.947
Received three-series polio vaccine	0.396	0.627	0.742	0.782	0.446	0.586	0.613	0.731
Received three-series DPT vaccine	0.353	0.624	-	0.786	-	-	0.653	0.461
Received measles vaccine	0.427	0.626	0.683	0.718	0.528	0.851	0.892	0.653
Received vitamin A supplements ever	0.295	0.116	0.672	0.662	0.722	0.793	0.939	0.998
Received vitamin A supplements in the last six month	0.277	0.410	0.619	0.629	0.603	0.652	0.779	0.664

Table 67. The proportion and distribution of immunization and supplementation characteristics in Cambodia and Vietnam, between 2000 and 2014, and overall.

	Ever received vaccination	Ever had vacc. card	Received BCG	Received 3-step polio	Received measles	Received vitamin A suppl.	Received vitamin A within 6 months
Cambodia	-0.143	0.085	-0.228	-0.191	-0.164	0.170	-0.122
Vietnam	-0.131	0.242	-0.038	-0.021	-0.561	-0.012	-0.164
DiD	-0.012	-0.157	-0.190	-0.170	0.397	0.182	0.041

Table 68. The DiD analysis for immunization and supplementation factors in Cambodia and Vietnam. The DiD calculation uses Equation 6 to compare the rate of change before implementation to the rate of change after implementation.

Descriptive statistics were presented for each of the covariates above to determine trends in the data. Descriptive statistics help to frame the interpretation of the results of the analyses of the dependent variables of interest, that is, the nutritional indicators.

3.10 SUMMARY OF RESULTS

Descriptive statistics framed the problem faced by indicating general trends in the data, made it difficult to draw meaningful conclusion about the effect of the policy on the changes being seen in the nutritional variables of interest and covariates. Women in Vietnam, for example, were much more likely to be more highly educated than women in Cambodia. Birthing and infant care descriptive statistics suggested that Cambodia was making improvements in the number of properly supervised births, proper feeding 24 hours after birth, early initiation of breastfeeding, continued breastfeeding at one year and decreased continued breastfeeding at one year. For diarrheal disease, the incidence of disease fell at a lower rate in Cambodia compared to Vietnam, similarly to the rate of treatment of the disease with ORT. The data on immunization and supplementation presented similar stories: the raw proportion of children receiving vaccinations, health cards, and supplements increased, but at a slower pace after the implementation of the NNS, and in smaller magnitude compared to Vietnam. The descriptive statistics suggest that Cambodia is progressing in the right direction, but DiD analysis suggests that Vietnam is progressing at a faster rate than Cambodia in recent years, findings which correspond to that of other current research.

Unadjusted linear and logistic regressions highlighted the difficulty in explaining complex variables like nutritional status and its related nutritional indicators. The analysis of weight at birth suggests that birth weight is decreasing in Cambodia, compared to past averages. Further, descriptive statistics and t-test suggests that mean weight at birth of Cambodian children is decreasing at a significant rate compared to Vietnam. Maternal malnutrition rates continue to be higher in Cambodia and this finding is consistent with research that suggests babies born to malnourished mothers are more likely to underweight [71,95]. Similar to weight at birth, most regression models run with the covariates were poor at predicting weight at birth, being born very small or being born underweight. Regressions were performed to analyzed the relationship between WAZ, HAZ, WHZ and covariates. The low insignificant association between treatment and HAZ in Cambodia was not affected by most covariates. Most models explained little of the variance in the three anthropometric factors, demonstrated by the R^2 value, but many individual variables were significantly correlated with HAZ. The correlation between WAZ and treatment for Cambodian data alone was significant, and most variables were uncorrelated with WAZ in models with other covariates. A similar result was found in the WHZ analysis, where the necessity of running variables individually made it difficult to draw conclusions about the overall impact of the policy on the nutritional indicators. The variance in the significance of treatment effect and relationship between the treatment dummy variable and each of the anthropometric variables made it difficult to determine the effect of the treatment. The linear and logistic regressions of Section 3.2 and Section 3.3 were primarily useful in selection criteria for variables for the DR analysis of Section 3.4.

The results of the IPWRA analysis suggest the implementation of the policy had a negative impact on anthropometric measures and weight at birth. To incorporate more variables of interest in a different estimator, the NNM model was used to evaluate the impact of the policy on the nutritional status indicators. The NNM model found similar results as the IPWRA analysis, again suggesting that the treatment had a negative effect on most of the nutritional indicators of interest. The results suggest that there was a significant negative impact of the policy, although the impact was very small.

CHAPTER 4: DISCUSSION

4.1 EVALUATING THE SUCCESS OF THE NNS

Overall, the results of this study suggest that the nutritional status indicators were negatively impacted by the implementation of the policy in 2009; however, it is clear from other research Cambodia is progressing in a positive direction with the goals laid out in the NNS. The success of Cambodia in meeting each of the objectives of Key Result 1, that is, reducing PEM and micronutrient deficiencies in young children and the reasons why the NNS may have had a negative or no impact on the progression of these indicators is discussed. The suitability of the methodology is discussed, followed by the limitations of conclusions, due to modeling, data, or extraneous factors.

Objective 1.1, the increased rate of immediate and early initiation of breastfeeding, was increased from 2010 to 2014, but not at a rate faster than Vietnam. The feeding practices, including breastfeeding practices, had significant correlations with WHZ, WAZ and HAZ, although the regression models overall explained very little of the variance of these three indicators. This could be due, in part, although a reduction in the giving of pre-lacteal feeds was found, an increase in breast-milk substitutes from 2000 to 2010 was found[93]. The positive impact of reducing pre-lacteal feeds, but increasing breast milk substitutes may be why overall, feeding practices did not have a large impact on the nutritional indicators. Breastfeeding is one of the most cost effective interventions to improve health and immune function, however, increasing use of breastmilk substitutes, like baby formula, increase the risk of morbidity and mortality in children[93]. Between 2000 and 2005, public health campaigns focused on early childhood feeding practices, and the use of baby formula did not increase among children below six months of age[93]. A lack of resources caused the campaign to stop, and this caused a sharp increased inappropriate use of breastmilk substitutes between 2005 and 2010. Although Cambodia reduced the proportion of inappropriate feeding practices and increased recommended breastfeeding practices, such as the early initiation of breastfeeding, the effect of the policy seemed to slow progression, possibly due to lack of resources at the NNP and the discontinued communication campaign[50,93]. Further resources need to be contributed to the communication campaign for a larger, significant impact of breastfeeding and feeding practices on nutritional status later in life. The promotion of breastfeeding and WHO best practices in public and private hospitals also need to occur. The advertising and marketing of breastmilk substitutes should also be required to comply with the International Code of Marking Breast-milk Substitutes (WHO) in order to reduce the number of more affluent women buying substitutes because of increased access to them[93]. These changes could positively affect the impact of a future policy.

Objective 1.2 focused on increasing the rates of complimentary feeding of children (6 to 23 months of age), with goals of increasing energy and nutrient density. The evaluation of complementary feeding practices demonstrated that the introduction of soft, semi-food, or other food was significantly correlated with HAZ and WHZ, in an inverse relationship. This is most likely caused by the introduction of foods too early in a child's life. The WHO recommends exclusive breastfeeding for the first six months of a child's life, with the introduction of complementary foods beginning at this age. Similar to the negative impact of the policy on HAZ and WHZ in Cambodia, a study from Haiti found the promotion of complementary feeding practices contributed to growth faltering in children under 2 years and dietary diversity and adequate macromolecules were not achieved as complementary feeding was introduced[96]. To improve the impact of policy on complementary feeding practices and on nutritional status indicators later in life, a number of strategies could be employed by the NNP. Developmentally- and age-appropriate, nutrient-dense foods are recommended based on breastfeeding status, in guides produced by the WHO and Pan-American Health Organization. The reproduction of country specific English and Khmer language guides could help improve counseling available from health care professionals[96–98]. Research from other low-income countries suggests that complimentary feeding can be useful when tied to messages of dietary diversity, to promotion of micronutrient rich vegetables and animal source foods[96]. The NNS document indicates that there was no communication strategy focused on complementary feeding at the time of implementation (In 2012, however, a strategy was launched by the United Nations Millennium Development Goals Achievement Fund and

USAID)[50,99]. The effects of an ongoing communication strategy could have a positive impact on complementary feeding practices in Cambodia if the communication focused on the implementation of complementary feeding in conjunction with an increase in dietary diversity, meal frequency and with the implementation of a healthy diet plan[96].

The goal of Objective 1.3 was to increase the rates of appropriate care and feeding of sick children, and Objective 1.9 also attempted to increase the treatment of diarrheal disease with zinc. In 2000, half of deaths of children under five in developing countries were attributed to diarrhea, respiratory illness, malaria, and measles, although many of these deaths were associated with another disease, malnutrition[3]. Analysis in this study demonstrated that rates of diarrhea and ARI decreased, and appropriate treatment such as ORT, or seeking care for a respiratory infection increased, but by lower overall rates when compared to those in Vietnam. The number of children who received zinc as a treatment for diarrhea increased from 2% to 6%, from 2010 to 2014, but data was not available before 2010. Regression models indicated that a significant negative correlation was seen between having diarrhea and the three anthropometric indicators, HAZ, WAZ and WHZ. Having had the measles vaccine and Vitamin A supplementation within the last six months seemed to be positively correlated with HAZ. The regressions suggested that having a diarrheal disease and some immunizations were negatively correlated with the nutritional indicators of interest. The relationship between malnutrition and deficient immune function is well studied, and the two can, conversely, affect each other[100]. For example, the presence of parasitic worms can increase the risk of malnutrition, leading to increased susceptibility to diarrheal diseases[49]. The need for Cambodia to create a policy that continues to addresses childhood illness is highlighted by the results of this study, and is consistent with other research[48,55,91]. The WHO Integrated Management of Childhood Illness, along with health care specific manuals, can provide a starting basis for communication strategies and guides to improve the proper treatment of diarrhea in Cambodia[94,100]. The results of this study reaffirm the need for Cambodia to address childhood illness if it is to efficiently decrease childhood undernutrition.

Objective 1.4, that is, improving the management of severely malnourished children at facility and community levels, was not analyzed through regressions, due to the lack of data available in the survey. Current literature and NGO reports, however, provide some insight into the progress of improving the management of severely malnourished children at the facility and community level. At the time of policy implementation, community health centres followed the IMCI, but severe malnutrition cases of undernutrition were referred to hospitals because of a lack of equipment and supplies[24,50]. For micronutrient deficiencies, health centres supply Vitamin A and iron/folate therapeutically or prophylactically to women and children. The interpersonal communication skills and the counseling capacity of the staff of community health care centres were, however, found to be low[50]. The lack of progress from implementation of the policy in the community and facility management of malnutrition of children contributed to the need for other NGOs to create programs and communication strategies. Recent reports show UNICEF has begun an in-community screening program for malnourished and severely malnourished children, including community facilities or health centres that have now been equipped with therapeutic food, that will improve the management of nutrition in these children within the community[101]. This screening program was started in 2015, at the end of the lifetime of the policy, so it is unlikely to have helped the NNS reach this target.

Objective 1.5, improving the management of nutrition/feeding of HIV-positive children, including counseling of HIV positive pregnant women and mothers was also not evaluated in this study due to lack of data. Although there was a lack of recent initiatives from the NNP that could be found targeting this objective, there are a number of NGOs that offer nutritional counseling services to HIV infected mothers.

Objective 1.6 focused on increasing the coverage of vitamin A supplementation and Medendazole distribution. Medendazole is a deworming drug given to treat intestinal parasites. Data, however, was not available for deworming rates for before and after the implementation of the policy. The following evaluation of Objective 1.6 will therefore, focus solely on the coverage of Vitamin A supplementation in children. The proportion of vitamin A supplementation, ever and within the last six months, increased on average in Cambodia, and a DiD analysis indicated that the rate of change of vitamin A supplementation was greater after implementation in Cambodia. DiD for vitamin A supplementations within six months indicated greater increases before implementation. The NNS states that the NNP has difficulty managing supplements and stocks at health centres, pharmacies and hospitals, because of the low number of staff. Cambodia may see greater success in achieving this goal in the future using an approach that limits direct involvement from members of the NNP, compared to the improvements seen from 2009 to 2014 due to the NNS. A recent review suggests that biofortified vitamin A-rich sweet potatoes can be an effective method for increasing maternal and child vitamin A intake[90]. Agricultural programs targeted at mothers, such as home gardens, can slightly improve vitamin A intake, and vitamin A status[90]. Both of these reviewed programs would see an increase in Vitamin A status, and would reduce the need for supplementation, lowering the responsibilities of staff at the NNP.

Among low-income countries, the highest prevalence of anemia is in South Asia[71]. Objective 1.7 sought to reduce the rate of anemia and zinc deficiency in young children. This was not evaluated through regression analysis due to lack of data availability across all years for both countries, however, the descriptive statistics that are available can give an image of trends over time. Sixty-three percent of children were anemic, with only 2% being severely anemic in 2000[71]. In 2005, the rate of anemia stayed approximately the same, and the number of severely anemic children decreased to one percent[72]. In 2010, the number was reduced to 55 percent, with a slight increase to 56 percent in 2014. The NNS hoped to decrease anemia in children to 52 percent in 2010, and 42 percent in 2015, goals that it did not achieve. Overall, the largest change was seen between 2005 and 2010, not in the years following the implementation of the policy.

The NNS also hoped to increase the proportion of houses using adequately iodized salt to meet a target of 95% in 2014. Reports indicate the percentage of households using adequately iodized salt increased from 28% in 2004, to 70% in 2011, due to legislation and regulations introduced during this time[102]. Iodine is essential for the synthesis of thyroid hormones and cell replication, necessary for proper brain development as neural cells rapidly divide in utero and infancy[1]. The solution for iodine deficiencies is easily implemented; the NNP hoped to target the salt manufacturers to ensure iodization at production. In 2010, UNICEF stopped providing salt producers with the raw material to iodize their salt, and a recent study found that iodization of salt has also decreased due to a lack of monitoring and legislation[102]. Objective 1.8 was clearly not met. Instead of meeting its objective of having 95% of salt being adequately iodized, salt iodization - decreased to 92% of salt being inadequately iodized[102].

In summary, although the nutritional status of children increased overall in Cambodia from 2000 to 2014, most of the objectives of Key Result 1were not met. Further, the overall analysis for the six nutritional indictors indicated a negative, although small, effect of the policy on the nutritional status of children as a whole. Indicators for certain objectives were not available in the survey data, but were available in the literature. The same level analysis and testing could not be done for those only in the literature as those that were available in the DHS and MICS data, and they could not be incorporated into final DR and matching models. Increased rates of immediate and early initiation of breastfeeding and exclusive breast-feeding until six months were achieved after the implementation of the policy. Increased rates of appropriate complementary feeding of infants and young children (6-23 months of age) were achieved, although the increased rate of complementary feeding was negatively correlated with anthropometric factors, suggesting requirements of complementary feeding, such as increases in nutrient and calorically dense foods were not met. Increased rates of feeding of, and appropriate care for sick children were met, as measured through diarrhea and ARI treatment, including an increase of treatment of diarrheal disease with zinc, and incidence reduction. These factors were negatively correlated with anthropometric measures, again highlighting the need for integrated strategies to target malnutrition and these diseases. Improvements in the management of severely malnourished children at facility and community levels, and in the management of nutrition/feeding of HIV-positive children, including through the counseling of HIV positive pregnant women and mothers was discussed. Results in the literature suggest improvements, unrelated to the policy, are taking place through the efforts of NGOs. Increased rates of vitamin A supplementation were seen nationally, than in Vietnam, and at a higher rate for children who had ever received a Vitamin A supplement, after the implementation of the policy. The NNS did not, however, meet the goal of reduced anemia by 2014, with lower rates of change occurring after the policy implementation. Similarly, the proportion of households using adequately iodized salt decreased by 2014 when compared to 2010.

Despite meeting some of the objectives of Key Result 1, the results of the present analysis indicate that the implementation of the NNS policy has had negative effect on this achievement, and that the improvements seen in the nutritional status of children in Cambodia were likely due to other factors.

The economic growth seen by Cambodia from 2000 to 2014 may have impacted the general well-being and health outcomes of its citizens. The GDP per capita in Cambodia grew from $300 to $1100, in current US dollars, during the fourteen year period[10]. The DiD analysis of most variables that were important indicators of success for the NNS demonstrated Vietnam had an increased rate of improvement after the policy, when compared to Cambodia. Although the GDP per capita in Vietnam increased more in magnitude, the percent of GDP per capita growth was greater for Cambodia for all years studied. This suggests that the increase in nutritional status indicators in Vietnam after the implementation was not due to a greater change in GDP per capita[10]. Before implementation, when Cambodia had higher rates of change in nutritional status indicators, a higher percent of government expenditure was spent on health. Further, after implementation, when Vietnam saw higher rates of change in nutritional status indicators, governmental percent of expenditure on health care was higher than in Cambodia. This suggests that the overall advancement in the nutritional status of children in Cambodia was due to improvement in economic conditions and increased spending on health. However, decreased percent of government expenditure on health could have affected results of this study, that is, the negative effect of the policy as found in the DR and matching models. Any improvements in childhood health, however, due not appear to be attributable to the policy itself, which seemed to have an improbably large mandate for an understaffed department.

The lack of significant positive impact of the NNS policy on the nutritional status of children in Cambodia could be the result of numerous reasons. The NNP itself covers an overview of specific challenges they faced as an organization. Primarily, the NNP describes itself as "vastly understaffed and overstretched" [50]. The program, as of 2009, had a staff of thirteen people who were responsible for "policy development, planning, coordination, supervision, evaluation, curriculum development, training, development of communication and financial program management"[50]. Staff were mainly physicians, none of who had any graduate level training in nutrition and the NNP states that inadequate skills, and inexperience in managing complex nutrition interventions, were a challenge for implementation of the policy. Additionally, the NNP cites low uptake of government health services, possible due in part to the communication skills and counseling capacity of health care staff, described as 'low'[50]. A shortage in health staff, specifically midwives, limits the ability of Cambodia to improve at rates comparable to those of Vietnam in the area of infant nutrition. Eighteen percent of health centers in Cambodia, for example, lack a midwife[50]. The policy may not have produced a measurable effect on the nutritional indicators because of practical difficulties implementing substantive goals to achieve the objectives of the policy.

4.2 SUITABILITY OF THE ECONOMIC MODELS

Multiple regressions were used in the methodology to create a strong analysis. Some models proved to be more suitable and accurate in the assessment of observational, epidemiological data. Descriptive analysis illuminated trends in the data and was useful for evaluating if the goals of Key Result 1 had been met on a basic level. Descriptive statistics determined decreasing proportions of underweight and very small at birth children, and smaller negative standard deviations for weight-for-age, weight-for-height, and height-for-age. Further, results on feeding and breastfeeding practices, childhood illness, immunizations, and supplementations informed discussion on the NNS achieving its goals in the future. Linear and logistic regressions of the nutritional indicators proved unsuitable for producing conclusions about the effect of the policy because similar variables were run, creating high numbers of collinear variables. The high number of binary related variables meant that all variables could not be run at once on the software. The regressions between categorically group covariates, the treatment and the indicator of interest only provided information about the relationship between the variables. Because of the complex nature of variables included by multiple factors, like nutrition, none of the models explained a lot of the variance in the indicators of interest. The separation of variables meant that conclusions could not be drawn about the overall effect of the policy on nutritional indicators. Linear and logistic regressions, along with current scientific literature, informed the variable selection, as data driven approaches to variable selection have been found to be useful in application of DR and other matching estimators[59].

The DR estimator provided a more accurate estimate of the impact of the NNS on the nutritional indicators of interest, modeling the treatment and outcome effects to help negate unmeasured confounding variables and differences between populations. The NNM estimator was the most suitable, as it attempted to solve the missing information problem of observation data through matching. Due to the lack of a large number of continuous variables, the bias adjustment proposed by Abadie and Imbens (2006) were used within appropriate parameters[69]. The use of PSM in evaluating policies should be further investigated, but it was less suitable than the NNM in this case, due to the high number of binary variables that created propensity scores that were too large or, conversely, too small to be matched. The NNM model included up to the nearest ten neighbours in the opposite treatment group, which increases the suitability of the model. There remains some dispute about the appropriate selection of variables for matching estimators. Brookhart and van der Laan (2006) recommend the incorporation of all variables to reduce bias, while a more recent study by Patrick et al (2011) suggests that covariates should only be selected based on their association with outcome[59,88]. Although the NNM and PSM models are typically used in more concrete evaluations of less complex outcomes, such as in pharmacoepidemiology, the NNM and PSM estimators are also suited to evaluating observational population data to inform policy where there is quality data available for the population[59]. The matching models were especially suitable for examining data from two populations. Further analysis should be done that incorporates other indicators of nutritional status, such as incidence of anemia, or presence of iodized salt. Similarly, as more data becomes available for comparator countries, such as Lao PDR, which is more demographically similar to Cambodia, further analysis could be completed comparing outcomes across multiple countries.

4.3 LIMITATIONS

The main limitation of the evaluation of the policy was the data itself. Analysis of secondary data can introduce bias through problems of data collection and input that the researcher may not even be aware of. In the present evaluation, the differences between the DHS and MICS data lead to difficulties recoding responses in order that the coded answers would match. The MICS data had variation in and of itself, in that different responses for the same variable were also coded differently over the years. The lack of the depth and breadth of the MICS database, when compared to the enormous number of variables available in the DHS database, limited the number of nutritional indicators, when variables like anemia, presence of iodized salt, etc. could have been included if Cambodian data only had been considered. Although both surveys are structured to reduce bias and be representative of national indicators, differences in data collection, also affect the conclusions that can be drawn from analysis[71,74].

Another key limitation in drawing conclusions from the analysis is the use of observational data for two populations. Although the statistical analysis attempted to control and negate differences between populations, the multitude of confounding factors that could have affected nutritional indicators in Vietnam during the time of the study would also affect the interpretation of the results. For example, the differences in wealth of the two countries complicated analyses. As discussed, although Cambodia and Vietnam had a similar GDP per capita in 2000, Vietnam's GDP per capita was double that of Cambodia's by the end of the study. The percentage growth of GDP per capita experienced by Cambodia was, however, greater than Vietnam during 2000 to 2014. Despite increasing GDP per capita, the percent of government expenditure on health decreased in Cambodia, however, compared to increases in expenditure in Vietnam. The effects of household wealth were controlled for through the incorporation of wealth indicators in the analysis, but the far-reaching effects of government expenditure on health and absolute GDP per capita could impact nutritional status indicators. Further analysis could be completed that incorporates weighted factors for health spending, GDP per capita, and GDP growth over each of the years to negate this effect, although covariates that affect the treatment model (in this case, whether one was in Cambodia after 2009) have been shown to increase bias within the matching estimators.

In any study that analyzes secondary data, there will be the possibility of unknown bias from data collection and input. Further, the analysis of observational data in two populations makes it nearly impossible to control for all confounding factors, so models must be used that approximate treatment effects. The selection of variables for these models is debated within literature and the multitude of variables that affect a complex outcome like nutritional status increase the difficulty in covariate selection.

CHAPTER 5: CONCLUSIONS

The impacts of childhood malnutrition are well studied; malnutrition negatively affects physical and cognitive growth and development, immune function, and mortality in children, and is correlated with the development of chronic diseases, decreased productivity and work performance, and reduced lifetime earnings in adulthood[19,103].Cambodia continues to have high rates of malnutrition, with 32% of Cambodian children under the age of 5 categorized as stunted, 10 percent described as wasted, and 24 percent as underweight[1]. The NNS was implemented in 2009 by the NNP to address these challenges. Summary of the descriptive data suggests the objectives of Key Result 1 were achieved as Cambodia improved most nutritional markers from 2000 to 2014. When comparing changes to those occurring in Vietnam over the same period, Cambodian achievements in reducing childhood malnutrition became less clear. A comparison of descriptive statistics suggested Vietnam was experiencing greater improvements, as measured by nutrition indicators, during the period the NNS policy was in effect in Cambodia. Linear and logistic regressions for the six nutritional status indicators, weight at birth, being 'very small' at birth, being underweight at birth, HAZ, WAZ and WHZ demonstrated complex relationships between nutrition status indicators and covariates. Regressions provided more information about the impact of the policy on meeting the goals of the NNS and allowed for the selection of variables for the next analytic model. The DR estimator, IPWRA, results suggested the implementation of the policy had a negative impact on anthropometric measures and weight at birth. The NNM estimator was applied for further analysis. The NNM model found similar results as the IPWRA analysis, confirming that the treatment had a small negative effect on most of the nutritional indicators of interest. Exerts from the NNS report about the lack of staffing and staff experience managing large scale programs provide context as to why a positive effect from the policy was not observed. The nutritional status of the children of Cambodia is progressing, however, the current analysis would indicate that this positive trend is occurring independently of implementation of the NNS in 2009.

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APPENDIX A: Recode Book

WEALTH/SOCIOECONOMIC STATUS INDICATORS

WS1 Source of drinking water

1	piped into dwelling
2	piped into yard/plot
3	public tap/standpipe
4	tube well of borehole
5	protected well
6	unprotected well
7	protected spring
8	unprotected spring
9	river/dam/lake pond/stream/canal/irrigation channel
10	rainwater
11	tanker truck/water vendor
12	bottled water
13	other
.	missing/not de jure resident

ws2 Time to get to water source

0	water on premises
0-99	number of minutes to get to water source
.	missing/ not de jure resident

WS3 Type of toilet facility

1	flushed to piped sewer system*
2	flushed to septic tank
3	flushed to pit latrine (water seal type)
4	flushed to somewhere else
5	flushed to don't know where
6	ventilated improved pit latrine
7	pit latrine with slab
8	pit latrine without slab/open pit
9	no facility/bush/field
10	composting toilet
11	hanging toilet/latrine
12	bucket toilet
13	other
.	missing/not de jure resident

*in 2000 Vietnam, only a code for flush to sewage system/septic tank

WS4 Main floor material

1	earth/sand/clay/dung*
2	wood planks
3	palm/bamboo**
4	parquet or polished wood
5	vinyl or asphalt strips
6	ceramic tiles
7	cement tiles***
8	cement
9	floating house/houseboat****
10	other
.	missing/not de jure resident

*dung was a category in 2000 Vietnam, so it was included in earth/sand/clay category of other years
**in 2000 Vietnam, this category did not include palm
*** Vietnam did not have this category for all years
**** Vietnam did not have this category for all years

ws5 Has electricity

0	no
1	yes
.	missing/not de jure resident

ws6 Has bicycle

0	no
1	yes
.	missing/not de jure resident

ws7 Has radio

0	no
1	yes
.	missing/not de jure resident

ws8 Has motorcycle/scooter

0	no
1	yes
.	missing/not de jure resident

ws9 Has television

0	no
1	yes
.	missing/not de jure resident

ws10 Has car/truck

0	no
1	yes
.	missing/not de jure resident

ws11 Has refrigerator

0	no
1	yes

.	missing/not de jure resident

stool How the youngest child's stool is disposed of

1	children use toilet/latrine
2	thrown into toilet/latrine
3	thrown outside the yard
4	buried in the yard
5	Not disposed off/left on the ground
6	other
.	missing/not de jure resident

<u>WOMEN'S INDICATORS & BIRTH INDICATORS</u>

educ1 Has any education

0	no
1	yes
.	missing

educ2 Highest educational level

0	no education
1	primary education
2	secondary education
3	higher education (technical, college, university, beyond secondary)
.	missing/not de jure resident

educ3 Highest level of education completed

0	no education
1	primary education incomplete
2	primary education completed
3	secondary education incomplete
4	secondary education completed
5	higher eduction
.	missing/not de jure resident

educ4 Highest grad completed at that level

0-11	grades completed at that level
.	missing/ no education

agewom Age of the woman in years

x	age of woman in completed years
.	missing

agegroup Age of the woman in 5-year age groups

20-24	age between
25-29	
30-34	
35-49	
.	missing

ceb Total number of children ever born

0-11	number of children born
.	missing/ no children born

cdied Have had children who are dead

0	No children have died
1	At least one child has died
.	missing/ no children

cdead Number of children who have died

0-*x*	Number of children who have died
.	missing/ no children

csurv Number of surving children

0-*x*	Current number of surviving children
.	missing/ no children

contracept Contraception used

0	not using
1	using
.	missing

*Vietnam only had pill, IUD and withdrawal as options

bc Currently using some kind of contraception

0	Currently not using any type of contraception
1	Using some form of contraception
.	missing

mar Current martial status

0	never married
1	married
2	living together
3	widowed
4	divorced*
.	missing

*Vietnam doesn't have a divorced category

agemar Age at first marriage

0-*x*	Age at first marriage
.	not married/child/missing

birth1 Received assistance from a (medical) doctor at birth of child

0	No, doctor was not present
1	Yes, doctor was present
.	missing

birth2 Received assistance from a nurse or midwife at birth of child

0	No, nurse/midwife was not present
1	Yes, nurse/midwife was present
.	missing

birth3 Received assistance from a traditional birth attendant at birth of child

0	No, TBA was not present
1	Yes, TBA was present
.	missing

birth4 Received assistance from a relative/friend at birth of child

0	No, relative/friend was not present
1	Yes, relative/friend was present
.	missing

birth5 Received assistance from other at birth of child

0	No, other was not present
1	Yes, other was present
.	missing

birth6 Received assistance from no one at birth of child

0	Someone was present at birth
1	Yes, no one was present at birth
.	missing

wab2500 Child weighed 2500g or less at birth (underweight) (recalled or recorded)

0	No
1	Yes
.	missing

wab3000 Child weighed 3000g or less at birth (small) (recalled or recorded)

0	No
1	Yes
.	missing

wab Weight of the child at birth in grams (recalled or recorded)

xxxx	Weight of child at birth in g
.	missing

scabsmall Child was identified as very small at birth by mother upon recall on a scal of 1 to 5 (see **scab**)

0	No, child was identified as size other than very small compared to average
1	Yes, child was identified as very small compared to average
.	missing

scab Size of the child on a scale, as reported by the mother

1	Much smaller than average
2	Smaller than average
3	Average
4	Larger than average
5	Much larger than average
.	missing

wanted Wanted most recent pregnancy at that time

1	Yes, wanted the pregnancy then (at that time)
2	Wanted pregnancy later
3	Did not want any more children
.	missing

antenatal Number of antenatal visits by a medical professional/traditional birth attendant

0	received no antenatal visits
1-*x*	Number of antenatal visits

.	missing

placedel Place of delivery of child

1	respondent's home
2	other home
3	TBA's/midwife's home
4	central/national hospital
5	provincial hospital
6	district hospital
7	health centre
8	khum clinic/health post
9	military hospital
10	other hospital/public sector
12	private hospital
13	private clinic
15	other private clinic
16	other
.	missing

caes Was the child delivered by caesarian section

0	No, child was not delivered by caesarean section
1	Yes, child was delivered by caesarian section (emergency or choice)
.	missing

FEEDING INDICATORS

fed1 The child was given plain water within 24 hours of birth

0	No, child was not given plain water within 24 hours of birth
1	Yes, child was given plain water within 24 hours of birth
.	missing

fed1a Number of times child was given plain water within 24 hours of birth

0	Child was not given plain water within 24 hours of birth
1-6	Number of times child was given plain water within 24 hours of birth
7	Child was given plain water 7 or more times within 24 hours of birth
.	missing

fed2 The child was given commercially produced baby formula within 24 hours of birth

0	No, child was not given baby formula within 24 hours of birth
1	Yes, child was given baby formula within 24 hours of birth
.	missing

fed2a Number of times child was given baby formula within 24 hours of birth

0	Child was not given baby formula within 24 hours of birth
1-6	Number of times child was given baby formula within 24 hours of birth
7	Child was given baby formula 7 or more times within 24 hours of birth
.	missing

fed3 The child was given powdered/tinned milk within 24 hours of birth

0	No, child was not given powdered/tinned milk within 24 hours of birth
1	Yes, child was given powdered/tinned milk within 24 hours of birth
.	missing

fed3a Number of times child was powdered/tinned milk within 24 hours of birth

0	Child was not given powdered/tinned milk within 24 hours of birth
1-6	Number of times child was given powdered/tinned milk within 24 hours of birth
7	Child was given powdered/tinned milk 7 or more times within 24 hours of birth
.	missing

fed4 The child was given fruit juice within 24 hours of birth

0	No, child was not given fruit juice within 24 hours of birth
1	Yes, child was given fruit juice within 24 hours of birth
.	missing

fed4a Number of times child was fruit juice within 24 hours of birth

0	Child was not given fruit juice within 24 hours of birth
1-6	Number of times child was given fruit juice within 24 hours of birth
7	Child was given fruit juice 7 or more times within 24 hours of birth
.	missing

fed5 The child was given other liquid within 24 hours of birth

0	No, child was not given other liquid within 24 hours of birth
1	Yes, child was given other liquid within 24 hours of birth
.	missing

fed5a Number of times child was other liquid within 24 hours of birth

0	Child was not given other liquid within 24 hours of birth
1-6	Number of times child was given other liquid within 24 hours of birth
7	Child was given other liquid 7 or more times within 24 hours of birth
.	missing

fed7 The child ate semi-solid or soft food yesterday

0	No, child was did not eat semi-solid or soft food yesterday
1	Yes, child ate semi-solid or soft food yesterday
.	missing

fed7a Number of times child ate semi-solid or soft food yesterday

0	Child did not eat semi-solid or soft food yesterday
1-6	Number of times child ate semi-solid or soft food yesterday
7	Child ate semi-solid or soft food 7 or more times yesterday
.	missing

ebf Has the women ever breastfed any of her children

0	No
1	Yes
.	missing

eibf Did the women put the child to her breast within one hour of birth (early initiation of breastfeeding)

0	No
1	Yes
.	missing

bf1y Continued breastfeeding at one year (12-15 months inclusive)

0	No
1	Yes
.	missing

bf2y Continued breastfeeding at one year (20-23 months inclusive)

0	No
1	Yes
.	missing

TREATMENT OF ILLNESS AND IMMUNIZATION INDICATORS

im1 Child has ever received a vaccination

0	No, child has never received a vaccination
1	Yes, child has received a vaccination
.	missing

im2 Child has a health card/vaccination card

0	No, child has never received a vaccination
1	Yes, health card was seen by surveyors
2	Yes, health card was not seen by surveyors
3	No longer has
.	missing

im2a Child has a health card/vaccination card

0	No, child does not have a health card/vaccination card
1	Yes, child has a health card/vaccination (seen or not seen)
.	missing

im3 Child has received the bcg vaccine

0	No, child did not receive the BCG vaccine
1	Yes, child received the BCG vaccine
.	missing

im3a Year that child received the BCG vaccine

xxxx	Year that child received BCG vaccine
.	missing

im4 Child has received the three-part polio vaccine

0	No, child did not receive the polio vaccine three times
1	Yes, child received the polio vaccine three times
.	missing

im4a Year that child received the first polio vaccine

xxxx	Year that child received first polio vaccine
.	missing

im4b Year that child received the second polio vaccine

xxxx	Year that child received second polio vaccine
.	missing

im4c Year that child received the third polio vaccine

xxxx	Year that child received third polio vaccine
.	missing

im5 Child has received the three-part DPT vaccine

0	No, child did not receive the DPT vaccine three times
1	Yes, child received the DPT vaccine three times
.	missing

im5a Year that child received the first DPT vaccine

xxxx	Year that child received first DPT vaccine
.	missing

im5b Year that child received the second DPT vaccine

xxxx	Year that child received second DPT vaccine
.	missing

im5c Year that child received the third DPT vaccine

xxxx	Year that child received third DPT vaccine
.	missing

im6 Child has received the measles vaccine

0	No, child did not receive the measles vaccine
1	Yes, child received the measles vaccine
.	missing

im5a Year that child received the measles vaccine

xxxx	Year that child received measles vaccine
.	missing

im7 Child has received the three-part tetra/penta vaccine

0	No, child did not receive the tetra/penta vaccine three times
1	Yes, child received the tetra/penta vaccine three times
.	missing

im7a Year that child received the first tetra/penta vaccine

xxxx	Year that child received first tetra/penta vaccine
.	missing

im7b Year that child received the second tetra/penta vaccine

xxxx	Year that child received second tetra/penta vaccine
.	missing

im7c Year that child received the third tetra/penta vaccine

xxxx	Year that child received third tetra/penta vaccine
.	missing

vitA Child received a vitamin A supplement ever

0	No, child did not receive vitamin A supplement ever
1	Yes, child received a vitamin A supplement
.	missing

vitA6 Child received vitamin A supplement within the last 6 months

0	No, child did not receive vitamin A within the last 6 months
1	Yes, child received a vitamin A supplement within the 6 months
.	missing

ors1 Given oral rehydration to treat recent diarrhea

0	No, child did not OR to treat diarrhea
1	Yes, child received OR to treat diarrhea

.	missing

ors2 Given a pre-packaged oral rehydration liquid to treat recent diarrhea

0	No, child did not received a pre-packaged OR to treat diarrhea
1	Yes, child received a pre-packaged OR to treat diarrhea
.	missing

hdr Had diarrhea within past two weeks

0	No, child did not have diarrhea within the past two weeks
1	Yes, child had diarrhea within the past two weeks
.	missing

td1 Child was given antibiotic pill/syrup to treat recent diarrhea

0	No, child did not received antibiotic pill/syrup to treat recent diarrhea
1	Yes, child received antibiotic pill/syrup to treat recent diarrhea
.	missing

td2 Child was given an antimotility to treat recent diarrhea

0	No, child did not received antimotility to treat recent diarrhea
1	Yes, child received antimotility to treat recent diarrhea
.	missing

td3 Child was given zinc to treat recent diarrhea

0	No, child did not received zinc to treat recent diarrhea
1	Yes, child received zinc to treat recent diarrhea
.	missing

td4 Child was given other pill/syrup to treat recent diarrhea

0	No, child did not received other pill/syrup to treat recent diarrhea
1	Yes, child received other pill/syrup to treat recent diarrhea
.	missing

td5 Child was given unknown pill/syrup to treat recent diarrhea

0	No, child did not received unknown pill/syrup to treat recent diarrhea
1	Yes, child received unknown pill/syrup to treat recent diarrhea
.	missing

td6 Child was given an injected antibiotic to treat recent diarrhea

0	No, child did not received injected Ab to treat recent diarrhea
1	Yes, child received injected antibiotic to treat recent diarrhea
.	missing

td7 Child was given a injection, not an antibiotic, to treat diarrhea

0	No, child did not received a injection, not an antibiotic, to treat diarrhea
1	Yes, child received a injection, not an antibiotic, to treat diarrhea
.	missing

td8 Child was given an unknown injection

0	No, child did not received an unknown injection to treat recent diarrhea
1	Yes, child received an unknown injection to treat recent diarrhea

.	missing

td9 Child was given an intravenous treatment to treat recent diarrhea

0	No, child did not received intravenous treatment to treat diarrhea
1	Yes, child received intravenous treatment to treat diarrhea
.	missing

td10 Child was given herbal medicine/home remedy to treat recent diarrhea

0	No, child did not received herbal medicine/home remedy to treat recent diarrhea
1	Yes, child received herbal medicine/home remedy to treat recent diarrhea
.	missing

td11 Child was given other treatment to treat recent diarrhea

0	No, child did not received other treatment to treat recent diarrhea
1	Yes, child received other treatment to treat recent diarrhea
.	missing

hARIr Had symptoms suggestive of an acute respiratory infection (ARI) within the past two weeks

0	No, child did have symptoms of ARI within the past two weeks
1	Yes, child had symptoms of ARI within the past two weeks
.	missing

ari1 Caregivers/parents sough advice for symptoms of a ARI

0	No, caregivers/parents sough advice for symptoms of a ARI
1	Yes, caregivers/parents sough advice for symptoms of a ARI
.	missing

ari2 Sought advice/treatment from a government hospital (national, provincial or district)

0	No, advice was not sough from a government hospital
1	Yes, advice/treatment was sought from a government hospital
.	missing

ari3 Sought advice/treatment from a community health centre/khum centre

0	No, advice was not sought from a community health centre
1	Yes, advice was sough from a community health centre
.	missing

ari4 Sought advice/treatment from other public health centre

0	No, advice was not sought from another public health centre
1	Yes, advice was sough from another public health centre
.	missing

ari5 Sought advice/treatment from a private hospital

0	No, advice was not sought from a private hospital
1	Yes, advice was sought from a private hospital
.	missing

ari6 Sought advice/treatment from a private pharmacy

0	No, advice was not sought from a private pharmacy

1	Yes, advice was sought from a private pharmacy
.	missing

ari7 Sough advice/treatment from a shop

0	No, advice was not sought from a shop
1	Yes, advice was sought from a shop
.	missing

ari8 Sought advice/treatment from a traditional healer/practitioner

0	No, advice was not sought from a traditional healer/practitioner
1	Yes, advice was sought from a traditional healer/practitioner
.	missing

ari9 Sought advice/treatment from other private medical sector person/centre

0	No, advice was not sought from another private medical person/centre
1	Yes, advice was s sought from another private medical person/centre
.	missing

ari10 Sought treatment from other

0	No, advice was not sought from other
1	Yes, advice was s sought from other
.	missing

ari11 Given pill/syrup to treat ARI symptoms (fever/cough)

0	No, child was not given pill/syrup to treat symptoms
1	Yes, child was given pill/syrup to treat symptoms
.	missing

ari12 Given injection to treat ARI symptoms (fever/cough)

0	No, child was injection to treat symptoms
1	Yes, child was given injection to treat symptoms
.	missing

ari13 Given aspirin to treat ARI symptoms (fever/cough)

0	No, child was not aspirin to treat symptoms
1	Yes, child was given aspirin to treat symptoms
.	missing

ari14 Given ibuprofen to treat ARI symptoms (fever/cough)

0	No, child was not given ibuprofen to treat symptoms
1	Yes, child was ibuprofen to treat symptoms
.	missing

ari15 Given an antimalarial to treat ARI symptoms (fever/cough)

0	No, child was not given antimalarial to treat symptoms
1	Yes, child was given antimalarial to treat symptoms
.	missing

CHILDREN'S DEMOGRAPHICS AND NUTRITIONAL STATUS INDICATORS

agemon1 Age of the child in months

0-*59*	Age of the child in completed months
.	missing

agey Age of the child in years

0-*x*	Age of the child in completed years
.	missing

sex1 Sex of the child

0	Male
1	Female
.	missing

weight Weight of the child in kg to 1 decimal

xx.x	Weight of the child in kg
.	missing/weight not measured

height Height of the child in centimeters (1 decimal)

xx.x	Height of the child in centimeters
.	missing/weight not measured

hap Percentile of child's height/age

xx.xx	Percentile of child's height/age (DHS/UNICEF)
.	missing/ not measured

haz Standard deviations from the mean of child's height/age (z-score)

x.xx	Z-score of height/age (DHS/UNICEF)
.	missing/ not measured

ham Percent of reference median of child's height/age (DHS/UNICEF)

xx.xx %	Percent of reference median (DHS/UNICEF)
.	missing/ not measured

wap Percentile of child's weight/age

xx.xx	Percentile of child's weight/age (DHS/UNICEF)
.	missing/ not measured

waz1 Standard deviations from the mean of child's weight/age (z-score)

x.xx	Z-score of weight/age (DHS/UNICEF)
.	missing/ not measured

wam1 Percent of reference median of child's weight/age (DHS/UNICEF)

xx.xx %	Percent of reference median (DHS/UNICEF)
.	missing/ not measured

whp Percentile of child's weight/height

xx.xx	Percentile of child's weight/height (DHS/UNICEF)
.	missing/ not measured

whz Standard deviations from the mean of child's weight/height (z-score)

x.xx	Z-score of weight/age (DHS/UNICEF)
.	missing/ not measured

whm Percent of reference median of child's weight/height (DHS/UNICEF)

xx.xx %	Percent of reference median (DHS/UNICEF)
.	missing/ not measured

bmi Body Mass Index (BMI) standard deviations from new WHO mean

x.xx	Z-score of BMI (WHO)
.	missing/ not measured

DUMMY & GENERAL VARIABLES

camb Dummy variable

0	Vietnam
1	Cambodia

year Year of data survey

2000	Vietnam/Cambodia
2005	Cambodia
2006	Vietnam
2010	Vietnam/Cambodia
2014	Vietnam/Cambodia

province Province or region of Cambodia/Vietnam

border Dummy variable for provinces/regions that fall along the Cambodia/Vietnam border

0	No, province/region does not fall along Vietnam/Cambodia land border
1	Yes, province/region does fall along Vietnam/Cambodia land border