



norden

Nordic School of Public Health
NHV

**Birth weight and growth during the first two
years of life: a study in urban and rural
Vietnam**

Nguyen Thu Huong

**Doctoral thesis at the Nordic School of Public Health NHV
Gothenburg, Sweden
2014**

Previously published papers were reprinted with permission from the publishers.
Published by Nordic School of Public Health NHV, Sweden
Printed by Billes Tryckeri AB, Sweden
Cover picture: With permission from NHV
© Nguyen Thu Huong, 2014
ISBN 978-91-86739-65-2
ISSN 0283-1961

To my family

ABSTRACT

Background: Differences in health and living conditions between urban and rural settings can be seen as an important example of gaps between population groups. Birth weight and child growth are important predictors for the future health of a person and at aggregate level, for the public health of a population.

The general aim of this thesis is to describe and discuss birth weight, physical growth and breastfeeding of children, as well as associated factors, from birth to 24 months of age in urban and rural areas of Vietnam, thus contributing to the evidence base for health strategy and policy.

Methods: Two Health and Demographic Surveillance Sites in Hanoi were used; urban Dodalab and FilaBavi in the rural part. To study rural birth weight 1999 to 2010 information was obtained for 10,114 newborn in FilaBavi. To study urban rural growth disparities 2008-2010, 1,466 children were followed for two years after birth with measurements of weight and length. A study of breastfeeding included 2,572 mothers followed for one year after delivery. Background information about households and mothers was taken from routine surveys in the two sites.

Results: The mean birth weight in FilaBavi remained stable at about 3,100 grams, over the 12 years studied despite rapid economic and technological development. At the individual level we found birth weight to be associated with household economy and the education of mothers. In the urban rural comparison, the mean birth weight for urban boys and girls were 3,298 and 3,203 g as compared with 3,105 and 3,057 g for the rural infants. Children in the urban area grew faster than those in the rural area. There were markedly higher frequencies of stunting in the rural area compared with the urban. The initiation of breastfeeding during the first hour of life was more frequent in the urban area. Exclusive breastfeeding during the first three months of age was more commonly reported in the rural than in the urban area. Both birth weight and child growth were statistically significantly and positively associated with economic conditions and mother's education.

Conclusion: The results of the studies presented in this thesis show that there are large and important differences in child birth weight, child growth and infant breastfeeding between urban and rural areas. There are also major differences between the areas with respect to education and economic resources. All predictors of child birth weight and growth discussed are directly or indirectly associated with the social and economic conditions.

Globalization and urbanization means obvious risks for increasing gaps between as well as within the rural and urban areas. Large discrepancies in a society will lead to serious public health problems in all segments of the population, not only the underprivileged.

Key words: Birth weight, child growth, breast feeding, urban rural discrepancy, Vietnam

LIST OF PAPERS

This thesis is based on the following paper:

Paper I: Huong Thu Nguyen, Bo Eriksson, Toan Khanh Tran, Chuc Thi Kim Nguyen, Henry Ascher. Birth weight and delivery practice in a Vietnamese rural district during 12 year of rapid economic development. BMC Pregnancy and Childbirth 2013, 13:41

Paper II: Huong Thu Nguyen, Bo Eriksson, Liem Thanh Nguyen, Chuc Thi Kim Nguyen, Max Petzold, Göran Bondjers, Henry Ascher. Physical growth during the first year of life. A longitudinal study in rural and urban areas of Hanoi, Vietnam. BMC Pediatrics 2012:12:26

Paper III: Huong Thu Nguyen, Bo Eriksson, Max Petzold, Göran Bondjers, Toan Khanh Tran, Liem Thanh Nguyen, Henry Ascher. Factors associated with physical growth of children during the first two years of life in rural and urban areas of Vietnam. BMC Pediatrics 2013, 13: 149.

Paper IV: Huong Nguyen Thu, Bo Eriksson, Toan Tran Khanh, Max Petzold, Göran Bondjers, Chuc Nguyen Thi Kim, Liem Nguyen Thanh, Henry Ascher. Breastfeeding practices in urban and rural Vietnam. BMC Public Health 2012: 12:964

ABBREVIATIONS

ANC	Antenatal care
BMI	Body Mass Index
CHC	Commune Health Centre
CS	Caesarean section
FP	Fractional Polynomials
DHS	Demographic and Health Survey
HDSS	Health and Demographic Surveillance Site
IMR	Infant Mortality Rate
IUGR	Intrauterine growth retardation
LBW	Low birth weight
MoH	Ministry of Health
NCHS	National Centre for Health Statistics
SD	Standard deviation
SRB	Sex Ratio at Birth
USD	US dollar
UNICEF	UN International Children's Emergency Fund
WHO	World Health Organization

CONTENT

ABSTRACT	iv
LIST OF PAPERS	v
ABBREVIATIONS	vi
CONTENT	vii
PREFACE.....	viii
1. Introduction	1
1.1. Birth weight	3
1.2. Child growth and factors associated with child growth	4
1.3. Breastfeeding and factors associated with breastfeeding	6
2. Research questions and aims	9
2.1. Research questions of the studies	9
2.2. General aim of the research	9
2.3. Specific aims.....	9
3. The research contexts	10
3.1. Demography, social and economic conditions in Vietnam	10
3.2. Healthcare system in Vietnam.....	11
3.3. Preventive health care, mortality and morbidity of children in Vietnam	13
3.4. Legislation and cultural context in Vietnam.....	14
3.5. Urbanization and migration	15
4. Methods	16
4.1. Study setting	16
4.3. Concepts, definitions and variables	19
4.4. Statistical analysis.....	21
4.5. Ethical consideration	22
5.1. Birth weight and delivery practice in a Vietnamese rural district, Ba Vi during 12 years of rapid economic development (Paper I).....	23
5.2. Urban and rural birth weight (Paper II and paper III)	25
5.5. Stunting.....	33
5.6. Breastfeeding of infants in rural and urban areas	34
6. Discussion.....	37
6.1. Birth weight and delivery practice in FilaBavi from 1999 to 2010.....	37
6.2. Differences in birth weight between rural and urban areas	39
6.3. Differences in child growth in rural and urban areas	40
6.4. Differences in breastfeeding of infants in rural and urban areas	43
6.5. Method discussion	45
7. Conclusion.....	49
8. Recommendations	49
9. Future research	49
ACKNOWLEDGEMENTS	51
REFERENCES	53

PREFACE

I graduated as a paediatrician in 1992 at Hanoi Medical University. Then I decided to continue to study medicine at Master's level in Hanoi Medical University and completed studies at a Master's level in Paediatrics in 1996. Luckily then I had the chance to work in the National Hospital of Paediatrics, Hanoi. Our hospital, which was constructed using a donation by the Swedish Government and the Swedish people, is the biggest paediatric hospital in Vietnam. There I was able to make contacts with some Swedish doctors, which led me to love Swedish people and their country. Every day I have seen and treated children at our hospital for diarrhea and pneumonia due to malnutrition. In 2007, I participated in a cooperative workshop organized by the Hanoi Medical University and the Nordic School of Public Health about research in epidemiology and health systems research in Dong Da district, Hanoi. I came to believe that morbidity and mortality due to some diseases will decrease if we focus on the primary healthcare system in the community. After discussions with Professor Bo Eriksson and Professor Nguyen Thi Kim Chuc, I decided in 2008 to apply for registration as a PhD student in the Nordic School of Public Health. My thesis is about following children from birth to 24 months of age measuring birth weight, physical growth and studying factors associated to growth in rural and urban areas. With the support of my supervisors and other co-authors, I drafted, revised and submitted four papers and wrote a cover story. The research training that I have gone through these years has further increased my interest in the systematic search for knowledge of the particular public health problem related to children's health in Vietnam. After this thesis has been defended I hope to continue following all children, who were involved in my research as long as possible and work both in community studies and in clinical work to improve child health and healthcare in Vietnam.

1. Introduction

This thesis is concerned with the physical growth of children in urban and rural Vietnam studied through observations of birth weight, weight and length growth during the first two years of life and associated possibly influencing factors.

Birth weight and child growth are important predictors for the future health of a person and at aggregate level, for the public health of a population. Abnormal growth in utero and during infancy can have immediate negative effects but may also lead to adverse health effects later in life e.g. as expressed in the Barker hypothesis [1]. Suboptimal growth during fetal life and infancy can influence weight gain in childhood and increase risk of hypertension, coronary heart disease and type II diabetes later in life [2, 3]. These diseases are today major public health challenges, established in high income countries and emerging in many low and middle income countries. Epidemiological transition from communicable to non-communicable diseases, or to a combination of both, poses a major public health problem involving the whole or large groups of a population [4, 5]. Recent studies in Vietnam indicated that the country is moving in this direction [5].

The growth of children is a complex process that depends on many interacting factors including both genetic and environmental factors. Particularly important are the prenatal and postnatal nutritional status of the mother and infant factors such as birth weight, diet and infections. These factors are in turn and to different degrees determined by socioeconomic, cultural and biologic conditions [6].

The conceptual framework for this thesis (figure 1) is based on the one given for malnutrition by Black et al [7], however modified for the present situation. The factors included are at three levels, termed basic, underlying and immediate. In the original model the term “cause” is used. It has been changed here to “factor”. Discussions of causality in a strict sense are likely to be highly complicated for growth and are beyond the scope of this thesis. There is extensive literature about child growth, breastfeeding and related issues. Much of the basic information is found in the reports, publications and homepages of international organizations like World Health Organization (WHO) and United Nations International Children’s Emergency Fund (UNICEF).

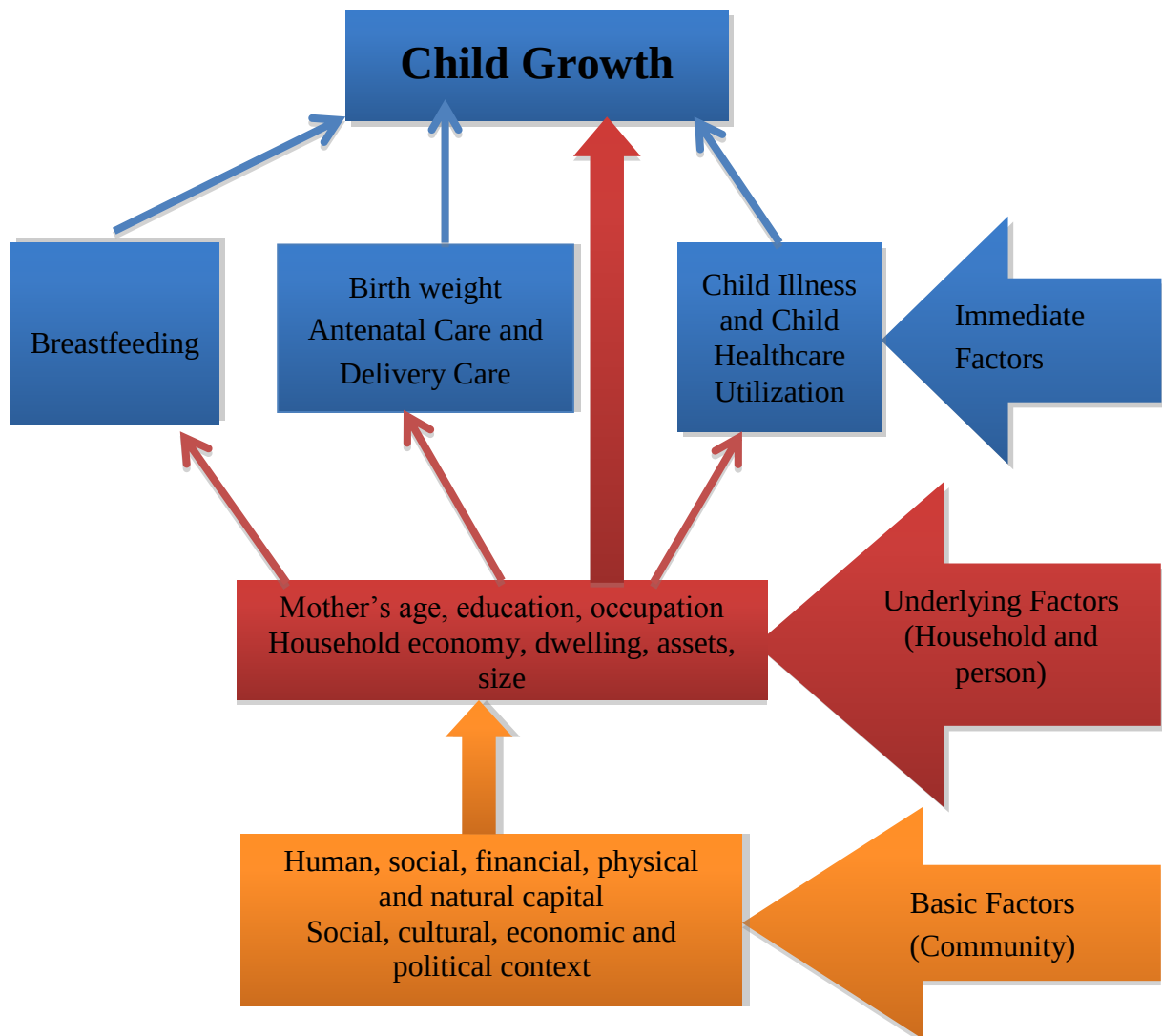


Figure 1. Conceptual framework of this study

The most important *basic factors* possibly indirectly influencing child growth are the general social, cultural, economic and political contexts. These are fundamental for establishing human, social, financial, physical and natural capital: all determinants for living conditions and distinctively different between urban and rural contexts.

Underlying factors are primarily the characteristics of persons and households. For persons, the traditional demographic factors like age of the mother and, to some extent, the father are of interest. Education and occupation of parents, particularly of the mother, can also be expected to be of importance [8, 9]. Children with mothers who have higher education have shown better growth (lower prevalence of stunting, underweight, obesity and overweight) [8]. At the household level, economy, dwelling characteristics, assets and size, numbers of adults and children, are key factors [9, 10]. Satisfactory personal and household social and economic resources are needed as underlying factors to create conditions and interest for health promotive choices and behavior.

Immediate factors directly influence child growth at the individual level. The birth weight of a child is the result of intrauterine growth as well as the nutritional conditions and gestational age at birth. It also reflects the mother's health, nutritional status and behavior during pregnancy including e.g. use of antenatal care and smoking. After birth, nutritional practices, primarily breastfeeding, and child illness are likely to influence growth.

The present studies consider three specific immediate factors: antenatal care, breastfeeding and child illness. Education about nutrition and counselling provided in Antenatal Care (ANC) during pregnancy can help to reduce the risk of anemia, increase gestational weight gain and improve birth weight [11]. The counseling provided during antenatal care can also promote the mother's willingness to register their babies early in under-five clinics, which possibly promotes good child growth [12].

To obtain good public health of a population the gaps between individuals and groups of individuals must be reasonable as stated in the Ottawa charter document [13]. Differences between urban and rural settings can be seen as very important examples of gaps between groups in a population. Differences in birth weight and growth of infants between urban and rural areas have not been described earlier in Vietnam and associations between growth and child, mother and household factors are largely unexplored.

1.1. Birth weight

Birth weight is a central element in the conceptual framework. It shows the weight after the intrauterine growth of the child and is the starting point for the continued growth after delivery. The mean birth weight varies over time and between different contexts. Mean birth weight is normally from about 3,000 g to 3,500 g. The birth weight variation expressed as standard deviation is 10-15% of the mean birth weight [14]. In any context studied so far there is a difference between boys and girls, the latter having lower mean weight and length [14-17]. Low Birth Weight (LBW) has been defined by WHO as weight at birth less than 2,500 g (5,5, pounds) [18].

LBW may be due to prematurity, intrauterine growth retardation (IUGR) or both [18]. Preterm birth is defined as childbirth occurring with less than 37 completed pregnancy weeks or 259 days of gestation [18, 19]. About 9.6% of all births (12.9 million) in the world were preterm in 2005. Approximately 85% of these children were born in Africa and Asia. Only about 0.5 million preterm births occurred in Europe and equally many in North America, while 0.9 million occurred in Latin America and the Caribbean [19]. Preterm birth has increased over time because of increasing numbers of induced preterm births and preterm delivery of artificially conceived multiple pregnancies. The reasons for induced preterm births include pre-eclampsia or eclampsia, and IUGR. There are also multiple reasons for a child having spontaneous preterm delivery such as infection [20]. Risk factors for spontaneous preterm births include a previous preterm birth, low maternal body-mass index, short cervical length and a raised cervical-vaginal fetal fibronectin concentration [20].

IUGR is defined as being born with a birth weight under the 10th percentile of the birth-weight-for-gestational-age reference curve. Approximately 30 million newborns annually

are born with IUGR. Almost 75% are in Asia, mainly in South-central Asia, 20% in Africa, and 5% in Latin America [21]. Fetal growth is dependent on genetic, placental and maternal factors. IUGR is normally considered to be a result of genetic disorders, placental insufficiency, chronic maternal disease, infection, poor maternal nutrition, substance abuse (smoking, alcohol, drugs), multiple gestation and low social and economic status [22].

Several genetic and environmental factors are known to influence the intrauterine growth of a fetus and hence the birth weight. Studies have shown that variations of genetic factors (fetal and parental components) account for 30-80% of the birth weight variance [23-25] and that the remaining part could be explained by environmental effects [24, 25]. Differences between population groups with respect to such factors can therefore lead to differences in birth weight between countries, ethnic groups [14-17] as well as different social and economic contexts. Demographic, social and economic conditions are also known to be determinants for birth weight [14-16].

A study of newborn at Fujian Provincial Maternal and Children Hospital, China investigated some factors related to low birth weight, including women's height, number of prenatal examination, abnormal non-stress test, week of gestation when the first examination was performed, sex (boy) preference and abnormal family history. Awareness of health information appeared to be a protective factor, suggesting that low birth weight could to some extent be prevented during pregnancy [26]. A study in Norway showed that height and weight of both mother and father were associated with variation in birth weight [23]. Another study in the United Kingdom showed that maternal weight was associated with child birth weight. Paternal weight did so as well but less strongly [27].

Smoking has been shown to be a very important single negative factor associated to low birth weight [28]. In a study in London, the difference between the means in birth weight comparing non-smokers and smokers of one to 14 cigarettes a day was 140 g [28]. Another study in the USA showed that the proportion of LBW babies was 6.4% among non-smokers, 9.5% among light smokers, 11.7% among moderate and heavy smokers, i.e. a dose response relation [29].

LBW is a public health problem in many countries, where as much as 15 % of births result in LBW babies [30]. Ninety-six percent of all LBW babies are born in low income, developing countries [18]. LBW infants are at much higher risk of early death than infants with normal weight at birth [31]. Infants with LBW put on weight more rapidly than infants who were heavier at birth and can risk overweight [32]. Reducing LBW incidence is one of the major goals in “A World Fit for Children”, the Declaration and Plan of Action adopted at the United Nations General Assembly Special Session on Children in 2002 [18].

1.2. Child growth and factors associated with child growth

1.2.1. Weight and length growth of children

The growth of infants after the perinatal period is the most rapid in human life [33]. Normal infants, born at full term, increase their length 50% and triple their weight in the first 12 months. After that, children increase about 10-13 cm during the second year, 7.5-10 cm during the third year and thereafter 5-6 cm per year until puberty [33].

Different growth charts are available to monitor the nutritional state of children from 0-5 years of age. The most important are those from National Centre for Health Statistic, USA (NCHS) first presented 1977, Centre for Disease Control and Prevention USA (CDC) from 2000 and the World Health Organization (WHO) first presented 2006.

In the 1977 charts from NCHS, with children followed from 2 to 18 years, all social classes are included but only white middle class individuals are included in another follow-up from 0 to 36 months [34].

The CDC growth charts from 2000 consist of revised versions of the growth charts developed by the NCHS in 1977 with the addition of new Body Mass Index (BMI) -for-age charts. Americans of different ethnicity between 0 to 20 years old were included [34].

The WHO Multicentre Growth Reference Study was undertaken between 1997 and 2003 to generate new growth charts for assessing growth and development of infants and young children around the world. The MGRS collected primary growth data and related information from approximately 8,500 children with widely different ethnic backgrounds and cultural settings (Brazil, Ghana, India, Norway, Oman and the USA). The new growth curves were constructed to provide an international standard representing the best possible physical growth for all children from birth to five years of age and to establish the breastfed infant as the norm for growth and development [35].

There are three key dimensions of child growth defined from weight, length and age of the child according to WHO [36].

1. Stunting- children with height for age below the mean - 2 Standard Deviations
2. Underweight- children with weight for age below the mean - 2 Standard Deviations
3. Wasting- children with weight for height below the mean - 2 Standard Deviations

More than 300 household surveys have been completed in the Demographic Health Surveys (DHS) project in 90 countries since 1984 collecting information on different health topics for nationality representative samples with one strong focus on children and women [37, 38]

Results from 21 different national DHS show that the wasting in infants younger than 6 months is a considerable public health problem. The wasting prevalence of infants ranged from 1.1 to 15% using NCHS or from 2.2 to 34.1% with the WHO growth chart as standard [39]. Wasting due to some disease before 6 months often continue for the same reason after 6 months [39]. According to WHO, the median prevalence of stunting among children aged five or younger in low and middle-income study countries was 27.3% for girls and 31.3% for boys [40]. Forty seven percent of Indian children under five year of age are moderately or severely malnourished. At least half of all infant deaths are related to malnutrition, often associated with infectious diseases [41]. Assessing growth is common in pediatric care all over the world [42].

1.2.2. Factors associated with child growth

According to UNICEF, birth weight is an indicator of a newborn's chances for survival, growth, long-term health and psychosocial development [30]. Infants with low birth weight

put on weight more rapidly than infants who were heavier at birth and can risk overweight [32]. A study to investigate risk factors of protein energy malnourishment among 0-5 year old children in Oman found that low birth weight, higher birth order and sibling with history of underweight were risk factors [43]. A longitudinal study from birth to 3 years of age in United State found that the prevalence of asthma varied by birth weight category: 6.7% in children 2500 g or more at birth, 10.9% in children 1500 to 2499 g at birth, and 21.9% in children less than 1500 g at birth [44]. Associations between birth weight and coronary artery disease in adulthood were seen in a case-control study in Italy in 2009, different in male and female. In females, LBW was more common than in control. In males high birth weight was more common [45].

Relations between child growth and the immediate factors focused in this study were seen in previous studies. Birth weight can influence growth of children in different directions, e.g. later overweight is more frequent in children with birth weight less than 2500 gram [46] or LBW infants can have difficulties to achieve the NCHS standard weight or length at 12 months [47].

The duration of breastfeeding was found to be associated with height for age among children in their first two years of life in Zambia [48]. Exclusive breastfeeding of infants tended to give faster growth regarding both weight and length during the first 6 months of life compared to a weaned group and a group of partially breastfed children, but without increasing the risk for later obesity [49]. A systematic review of 61 published studies showed that breastfeeding was associated with reduced risk of obesity, compared with formula feeding [50].

Some studies have shown associations between morbidity, mainly due to infectious disease, and growth of infants. A study in India found that there was a marked negative relationship between diarrhoea and physical growth of the child. Each day of illness due to diarrhoea was estimated to produce a weight deficit of 20-40 grams [51]. Another study in Brazil estimated that diarrhoea reduced the increases in weight and length by averages of 13.4 g and 0.132 mm per day with disease [52]. Diarrhoea during the first year increased the risk of low BMI for age, weight for length and weight for age in Vietnam [53]. Data from Indonesia showed no significant association between morbidity and growth during the first 6 months of life. However, between 6 and 11 months of age, acute respiratory infection was significantly associated with incremental weight loss [54].

1.3. Breastfeeding and factors associated with breastfeeding

Breastfeeding, exclusive and partial, is a natural way of feeding newborn, infants and small children. The major WHO recommendations are early (first hour of life) initiation of breastfeeding and exclusive breastfeeding for the first 6 months of life, with continued breastfeeding through the second year of life [55].

The short term benefits of breastfeeding for infants are widely acknowledged [56-60]. Breastfeeding has been found to reduce the occurrence of postpartum bleedings, breast cancer and ovarian cancer of mothers. Benefits for the economy of families and environment have been reported [56]. Breastfeeding can also decrease the incidence and

severity of infectious diseases and post neonatal infant death [56]. A study conducted in the United States on 1,204 infants, who died between 28 days and 1 year from causes other than congenital anomaly or malignant tumor and 7,740 children who were still alive at 1 year concluded that breastfeeding was associated with a 21% reduction of risk for post neonatal death. Longer breastfeeding was associated with even lower risk [57]. A prospective Scottish study of a cohort of children (mean age 7.3 years) suggested that the introduction of solid foods before 15 weeks was associated with increased respiratory symptoms and excess fatness [58]. Not breastfeeding resulted in an increased risk of death by diarrhea compared with exclusive breastfeeding among infants 0-5 months of age and to any breastfeeding among children aged 6-23 months [59]. Infants who continue exclusive breastfeeding for 6 months appear to have a significantly reduced risk of gastrointestinal infection and no deficit in growth [60].

A systematic review of the long term effects of breastfeeding [61] found evidence of long-term effects of breastfeeding on lower mean blood pressure, lower total cholesterol and higher intelligence test scores. The prevalence of overweight or obesity and type-2 diabetes was also lower in the breastfeeding group [61]. On the other hand no effect of prolonged and exclusive breastfeeding on height, adiposity, or blood pressure was observed in a randomized study of Belarusian young school children [62]. Also there was no evidence of causal effects of breastfeeding on BMI and blood pressure in a study aimed at understanding the confounding structure of breastfeeding by socio-economic position in the British Avon Longitudinal Study of Parents and Children or the Brazilian Pelotas 1993 cohorts [63]. In the largest randomized breastfeeding trial ever conducted, researchers provided strong evidence that prolonged and exclusive breastfeeding improves children's cognitive development [64].

Despite this quite strong evidences the WHO recommendations are not followed very well: in 2007, a national survey in USA reported that 26% of all women who had children aged 0 to 5 years, did not give any breastfeeding to their children [65]. In a study of five Asian countries 2002 to 2005, exclusive breastfeeding of infants younger than 6 months was reported to be 30.7% in Timor-Leste, 33.7% in Philippine, 38.9% in Indonesia and 60.1% in Cambodia. The fifth country, Vietnam, reported 15.5% [66].

Associations between delayed initiation of breastfeeding, discarding of colostrum and lack of knowledge about these aspects were found in Bangladesh [67]. A study of Vietnamese women in Australia suggested that the proportion of early initiation of breastfeeding was low due to negative views on colostrum. Only 25.7% thought that colostrum was healthier for babies than formula, 64.9% said that it was equally healthy and 40% gave their babies formula milk in the hospital [68].

The use of Caesarean section (CS) as delivery method has in some studies been seen to increase the risk for not breastfeeding [69, 70]. After surgery, babies are often taken away from the mother. Mothers might also worry about side effects of medicines like antibiotics which may pass to their babies through the breast milk [69]. Marketing of formula milk has been shown to generally affect the breastfeeding behaviors of mothers. Mothers are given the impression that formula milk is as good as, or better than, breast milk [71].

Education of mothers and families, especially fathers, as well as healthcare professionals regarding the benefits of breastfeeding were positive factors for the choice to breastfeed by mothers in the United States [72]. Non-exclusively breastfeeding mothers had less education than exclusively breastfeeding mothers [69, 73]. Husband and senior member of the family, as the maternal mother, could influence the decision [69]. Health care professional can have considerable influence on the decision of breastfeeding. Mothers who deliver at home do less breastfeeding than mothers who deliver in Commune Health Centre [69].

Mothers' return to work has been found to be one of the reasons for not breastfeeding [72, 74]. Mothers were more likely to breastfeed longer than six months if they delayed their return to work [72]. The maternity leave regulation is thus an important factor of influence for breastfeeding in a country [75]. Before May 2013, the maternity leave was only 4 months in Vietnam [76].

The reasons for giving complementary food was discussed in China, where the belief is that it improves weight gain and leads to healthier babies [77]. A Chinese tradition is that friends and relatives come to visit the mother and child after delivery. The most popular gift is infant milk formula. This can be a reason for the extensive use of early formula milk in China [70].

Improved socioeconomic conditions both at the individual and community level were found to be negative factors for exclusive breastfeeding in some Asian countries such as the Philippines, Indonesia and Timor – Leste. Infants in households with wealth index indicating middle or rich status showed a higher risk for early stopping of exclusive breastfeeding [78].

2. Research questions and aims

2.1. Research questions of the studies

The following research questions led to the studies presented and discussed in this thesis:

- Has the birth weight changed systematically over the period 1999-2010 in a rural area of Hanoi?
- If there are trends in birth weight, how do these relate to the socioeconomic development?
- Has delivery practices changed over the same time period in the area?
- Are there differences in birth weight, physical growth and breastfeeding patterns between children in the urban and rural areas of Hanoi, Vietnam?
- What underlying and immediate factors are associated with birth weight and physical growth?
- Are the associations between growth and underlying and immediate factors different between the rural and urban areas?
- To what extent can differences in household socioeconomic conditions, mother's education, use of ANC, child characteristics, breastfeeding and infant illness explain birth weight and growth variation between and within the two sites?

2.2. General aim of the research

To describe and discuss birth weight, physical growth from birth to 24 months of age and breastfeeding of children, as well as associated factors, in urban and rural areas of Vietnam, thus contributing to the evidence base for health strategy and policy.

2.3. Specific aims

- To study trends in birth weight as well as birth and delivery practices over the time period 1999-2010 in the rural FilaBavi Health and Demographic Surveillance Site (HDSS) related to social and economic development.
- To describe and compare birth weight and growth in weight and length during the first two years of life in one urban (Dodalab HDSS) and one rural (FilaBavi HDSS) setting in Vietnam.
- To investigate associations between the outcomes birth weight and growth and some possibly influencing, underlying and immediate factors in the two areas.
- To describe and compare breastfeeding practices during the first year of life in the two areas.

3. The research contexts

3.1. Demography, social and economic conditions in Vietnam

Vietnam is located in Southeast Asia with 90 million people living in an area of 331,000 square kilometers (Table 1). The country is divided into 63 provinces and large cities in eight geographic regions. Hanoi is the capital of Vietnam with more than 8 million inhabitants (2009). Each province is hierarchically divided into districts, communes and hamlets.

There are 54 ethnic groups in Vietnam. The largest group is Kinh which accounts for about 85% of the population and which resides mainly in the lowland plain areas. The highest population densities are found in the two river delta regions, the Red River in the north and the Mekong River in the south. More than 70% of the adult population are farmers who live in rural areas [79].

Table 1 contains some information about demographic, socio-economic and health indicators for Vietnam in 2009 [79].

Table 1- Demographic, socio-economic and health indicators for Vietnam in 2009

Indicators	
Area (km ²)	331,200
Population	85,789,573
Population density (inhabitants km ²)	259
GDP per capita (USD)	964
Adult literacy (%)	94
Crude death rate (deaths per year and thousand population)	6.8
Annual population growth rate (per year and thousand population)	10.5
Life expectancy at birth (years)	72.8
Infant mortality rate (deaths during first year per thousand live born children)	16
Under five mortality rate (deaths per thousand live born children)	25
Maternal mortality ratio (maternal deaths/100,000 live births)	75
Number of doctors per 10,000 inhabitants	6.6
Number of nurses per 10,000 inhabitants	8.8
Health budget in GDP (%)	3.63
Health budget per capita and year (USD)	35

Vietnam started liberalization of the socialistic political system with the Doi Moi in 1986. Doi Moi means "renewal" and describes the economic reforms aimed at creating what the government refers to as a socialist-oriented market economy. The Doi Moi policy accepted free market values which meant changes of Vietnam's economic structure and influenced domestic productivity and international trade positively [80].

Vietnam has shown impressive economic growth and social development over the last 20 years. The national percentage of poor households (USD 1.25 per person per day in purchasing power parities) decreased from 55% in 1989 to 10.6% in 2009. Seen from a global economic perspective, by passing GDP USD 1,000 per capita in 2009, Vietnam entered the ranks of middle income countries [79].

Vietnam has been successful in achieving a comparatively high level of social development and has 94 % adult literacy. Rural, agricultural activities are important. Half of the national income and nearly three quarters of the national employment are related to agriculture. Vietnam is the second largest rice exporter in the world [79]. Living conditions for the 26 million Vietnamese children have changed profoundly in the last 20 years [81]. Most children now attend primary and secondary school, have access to adequate health care and can expect to live longer than their parents [81].

Despite this overall socio-economic progress however, nearly 10 million people live below the poverty line and in undignified housing. Over 38% of the rural population lack access to clean water and over 50% lack adequate sanitation as reported in 2011 [82]. In contrast, 82% of the urban population has access to clean water and more than 76% has good sanitation since 2004 [83]. The plan of the Vietnamese government is that 100% of rural population will have access to at least 60 l/day clean water and use hygienic latrines by 2020. One hundred percent of the urban population will have access to clean water, 120-150 l/day [83].

3.2. Healthcare system in Vietnam

Before the Doi Moi reform in 1986, the health care system in Vietnam was totally run and financed by the Government. In 1989, the private health sector was introduced in Vietnam to reduce the overload of patients in the public healthcare facilities. Since then, Vietnam has had a mixed private and public healthcare system [84].

Public healthcare in Vietnam comprises four levels (Figure 2).

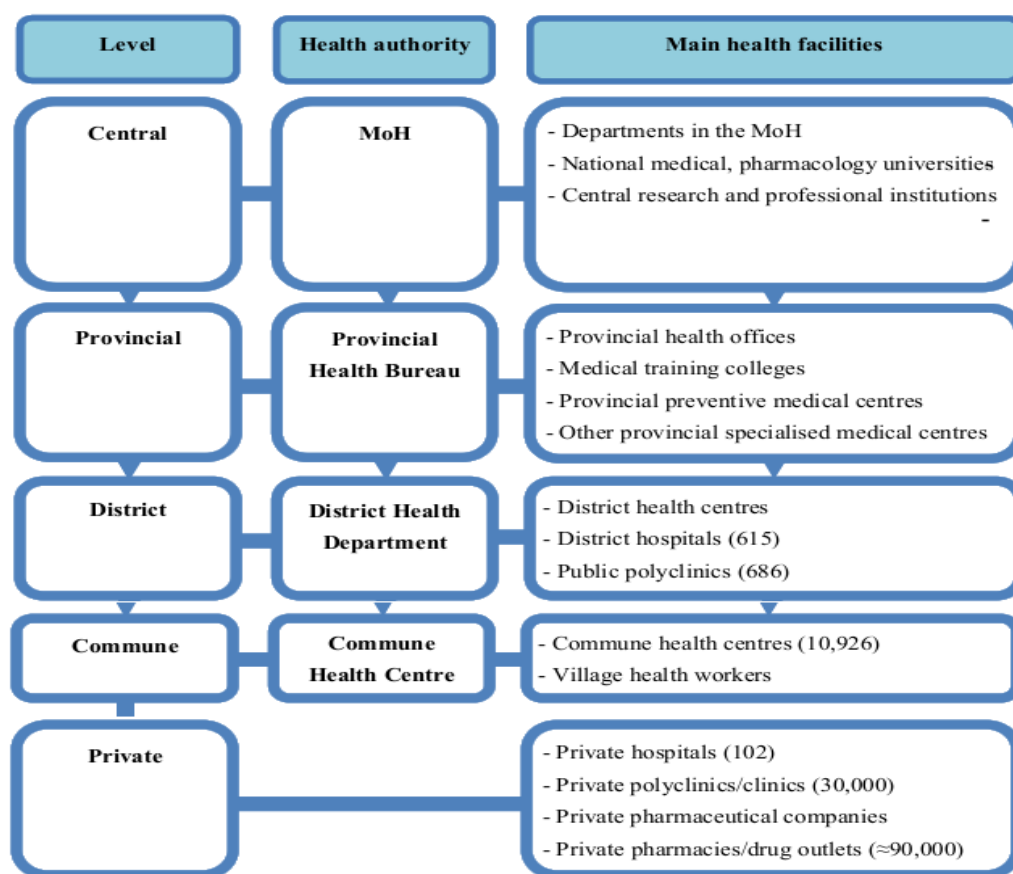
At the central level is the Ministry of Health (MoH), responsible for the provision of all preventive and a large part of the curative health services in the country.

At the provincial level there are the 63 Provincial Health Bureaus. Each province has at least one general hospital. In addition, each province may have one or more specialized hospitals (e.g. paediatric hospital, tuberculosis hospital, psychiatric hospital).

At the district level there are the District Health Centres, each of which serves the population of their respective district. Each district has a District General Hospital with 150 to 200 beds. Units for maternal and child healthcare and family planning are mostly

attached to these hospitals. District Health Centres are responsible for curative activities, preventive programs, surveillance and health statistics. District hospitals are supposed to serve as referral institutions for all polyclinics in the district. They also provide training facilities for health staff working in polyclinics and commune health centres in the district.

At the commune level, Community Health Centres (CHC) are responsible for providing primary health care, including preventive, ambulatory and inpatient services and for referring complicated cases to higher levels of care. Since 1995, commune health workers have received their salaries from government. They are expected to implement national health programs, such as maternal and child healthcare and family planning, acute respiratory infection program, expanded program of immunization, control of diarrhoeal diseases, malaria control, tuberculosis control as well as vitamin A and Iodine supplementation. They are also responsible for the management of all health services at the commune level [5].



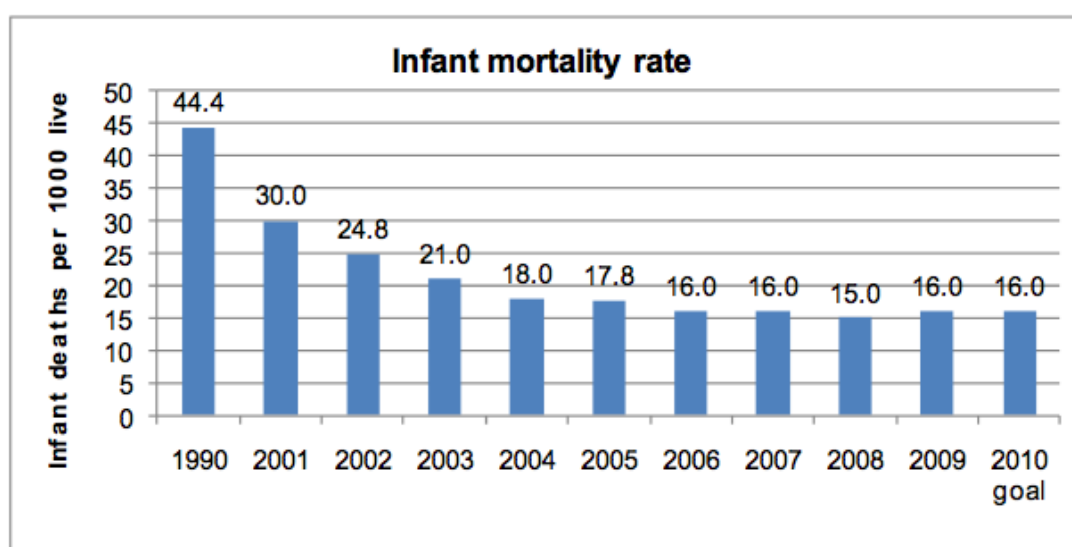
Source: Ministry of Health 2011

Figure 2. Healthcare system in Vietnam

The private health care sector has grown rapidly since the reforms in 1989. The total number of private facilities rose from 19,386 in 1998 to 35,000 in 2009 [85, 86].

3.3. Preventive health care, mortality and morbidity of children in Vietnam

According to the Health Insurance Act of 2008, the health insurance for all children under 6 years and poor people is the responsibility of the government [87]. Currently the national expanded immunization program in Vietnam includes 7 vaccines as protection against 10 infectious diseases. BCG vaccine, Hepatitis B, DPT (Diphtheria - Pertussis - Tetanus), Measles, Japanese encephalitis B, Cholera and Typhoid vaccines are given. To prevent neonatal tetanus and to give tetanus prophylaxis for mothers, immunization programs have been developed for pregnant women and women at childbearing age in high-risk areas. All vaccines in the expanded immunization program are free of charge [88]. High immunization coverage helped to eradicate polio in 2000 and maternal and neonatal tetanus in 2005 [81]. The IMR decreased from 44.4 per 1000 live born children in 1999 to 16 per 1000 in 2010. Figure 3 shows the trend of IMR from 1990 to 2010 in Vietnam according to the MoH [89]. The stipulated goal for 2010 was reached.



Source: Ministry of Health

Figure 3. Infant Mortality Rate, deaths during first year of life per 1,000 liveborns in Vietnam, 1990-2009

UNICEF has reported that the proportion of LBW children decreased from 9 % in 2000 [18] to 7% in 2007 throughout Vietnam [90]. However, the overall success conceals the fact that disparities are widening between the rich and the poor, between the Kinh majority and ethnic minorities and between urban and rural areas [81]. The infant and child mortality rates are much higher among ethnic minorities, the very poor, and those living in remote regions [91]. In 2006, the ethnic minorities in the Northwest region had IMR of 30 per 1,000 live born, more than three times that in the majority ethnic group, Vietnamese Kinh in the Southeast region (8 per 1,000 live births) [81]. Illnesses such as acute respiratory infection, diarrhea, dengue fever and malnutrition are common among children [91]. Poor nutrition and infection are claimed to be the main reasons why one out of three Vietnamese children is considered stunted [91]. The geographical variation of stunting is large. In 2010, the prevalence of stunting in children under five was much lower in the

South-eastern region (25.5%) than in the Central highland region (35.2%) [92]. The prevalence of underweight children decreased from 45% in 1990 to 26.6% in 2004. The rate of reduction of malnutrition has been higher in urban areas than in rural [93]. The percentage of LBW newborns in Vietnam was estimated to be higher in rural areas (5.9 %) than in urban areas (3.9%) in 2002 [94]. On the other hand, the prevalence of overweight children and obesity increased rapidly in children aged 4 to 5 years in urban Ho Chi Minh city from 2002 to 2005 particularly in well-off families [95].

In Vietnam a low national average proportion of exclusive breastfeeding of infants during the first six months is reported (19.2 per cent) to be compared with the WHO recommendation [91]. The average proportion of any breastfeeding of children during the first two years of life is 22.1% [92]. This may contribute to the high stunting level of children in Vietnam [91].

3.4. Legislation and cultural context in Vietnam

A two child population regulation was introduced in Vietnam at the end of the 1980s [96]. The Population Ordinance was revised in 2003 to say that each couple and individual have the right to decide on the time of delivery and number of children in their family [97]. However, a government decree for government staff and party members to enforce the two child policy was issued in 2006 [98]. Vietnamese people, especially in urban areas, currently prefer to have a small family with two children in line with the government's encouragement. The total fertility rate decreased from 6.36 children per women in 1960 to 2.03 in 2009 [79, 99].

Under the strong influence of Confucianism, sons are considered more valuable than daughters to parents in Vietnam. The first son will maintain the family line and be responsible for carrying out the cult and paying respect to ancestors. Almost all parents want only their sons, especially the first one, to inherit their house and other wealth [100, 101]. All parents therefore try to have at least one son. High sex ratios at birth (SRB), i.e. the number of boys divided by the number of girls born in a time period, have been reported in Vietnam. According to the MoH, SRB in Vietnam was 1.108 in 2008 [102].

After delivery, almost all Vietnamese mothers believe that the nutritional value of breast milk depend on the health of the mother and their use of traditional postnatal diet. For some time after delivery they therefore try to eat large quantities of food and drink much warm water. They also avoid sea food because their child is thought to have high risk of allergy if they do not. The most common food eaten to increase breast milk are pig nails with green papaya or red bean and potatoes [71].

A study in Vietnam showed that introduction of complementary food for infants increased from 16.4% at week 1 to 56.5% at week 16 and to nearly 100% at week 24. Home-cooked solid food was introduced by 4.8%, 40.9% and 74.3% at weeks 1, 16 and 24, respectively [103].

A study of the nutritional content of traditional Vietnamese complementary food given to children showed that it mainly consists of gruels made from rice flour, sometimes with the addition of green bean or soybean, oil seeds, vegetables, sugar, salt, and monosodium

glutamate. The nutrient value of the complementary food is often too low to appropriately meet the nutritional requirements of 6 to 12 month old children even together with breast milk [104]. Therefore, in Vietnam growth faltering often starts around the time of the introduction of complementary foods, when the child is 5–6 months old. In one study the prevalence of stunting was seen to increase from 20–30% by 12 months to 30–40% when children were 15–20 months old [105].

3.5. Urbanization and migration

Urbanization is rapid in many developing countries. In Vietnam the internal provincial migrant population increased from 1.3 million people in 1989 to 3.4 million people in 2009 [106]. Migration contributes substantially to the increased urban population size and rural-to-urban migration might contribute to increased socio-economic gaps between rural and urban areas. Inequalities are also created within the urban areas. Urban non-migrants have been seen to have more advantages regarding education, profession, living conditions or health care than in-migrants from rural areas [106] and migration had negative impacts on the education of children. Children among migrants attended primary school and secondary school less than children among non-migrants [106].

A city is generally defined as a political unit, i.e. a place organized and governed by an administrative body. The United Nations defines settlements of over 20,000 as urban, and those with more than 100,000 as cities [107]. Migration is defined as the long-term relocation of an individual, household or group to a new location outside the community of origin [107]. Urbanization is migration from rural to urban areas leading to increased concentration of people living in urban areas. Urbanization not only changes the distribution of population, but also the socioeconomic patterns, and diffuses urban lifestyles to rural areas [106].

In poor countries, urban areas for many appear to be more favorable settings for the resolution of social and environmental problems than rural areas. People, who live in urban areas, are thought to have better opportunities to get job and higher income than in rural areas. Urban areas are also supposed to present opportunities for social mobilization and women's empowerment. People living in urban areas have been seen to be the most optimistic about their future [108, 109]. Negative aspects of urban living like increased stress, crowding and pollution are however, also discussed.

4. Methods

4.1. Study setting

The studies that form the basis for this thesis were conducted in two HDSS, one urban, DodaLab and one rural, FilaBavi. Figure 4 shows the geographical locations of Vietnam, Hanoi and the two sites.

Dong Da is an urban district in central Hanoi with about 352,000 inhabitants. Three communes with 38,000 persons (12% of district's population) in 11,000 households, strategically selected from the 21 communes of the district to have different economic levels, were defined as the DodaLab HDSS in 2007 [110, 111]. In 2009, the reported yearly income per capita was equal to USD 1,300 [101]. Ba Vi is a rural district, incorporated into Hanoi in 2011, with 250,000 persons. A random sample of 12,000 households in 69 clusters with totally 51,000 persons, called FilaBavi HDSS has been followed there since 1999.

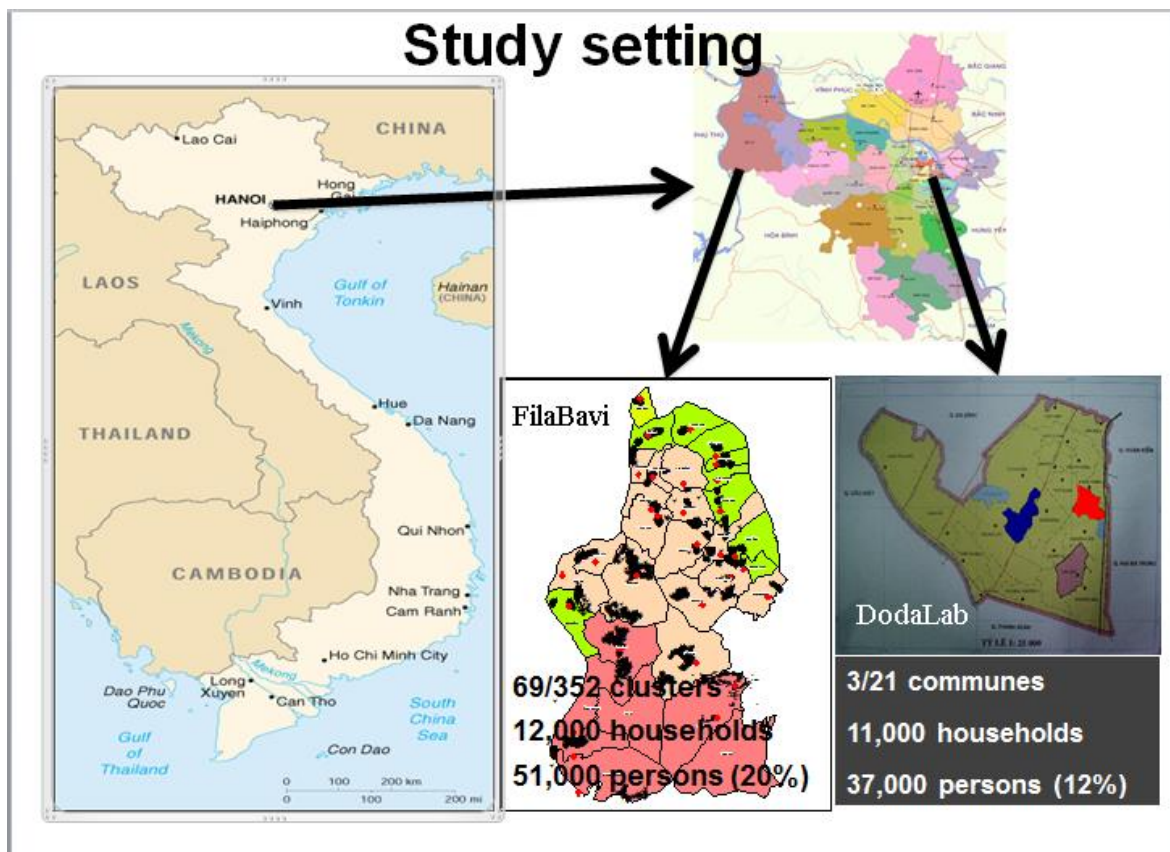


Figure 4. Geographical location of the study sites. For FilaBavi the 69 clusters are displayed as black spots. There are three area types: riverside in green, lowland in light pink and mountain in red. For DodaLab the three selected communes are Kim Lien in grey, Trung Phung in red and Quang Trung in blue.

Vietnamese Kinh is the ethnic majority in both sites with 99% in DodaLab and 95% in FilaBavi. The illiteracy percentage among adults is less than 0.5% in both sites. The proportion of adult people who graduated at least from high school is higher in DodaLab

(80%) than FilaBavi (35%). The main adult occupations are office work and business in DodaLab (65%) and farming in FilaBavi (70%) [101].

Household surveys were undertaken on both sites during 2007/2008, 2009 and 2012 to obtain baseline information about demographic conditions, education, occupation and economic conditions of the selected persons and households. The FilaBavi households were also surveyed in 1999, the baseline survey, 2001, 2003 and 2005. The protocol and questionnaires used in these surveys basically remained the same over time and in both places. Smaller changes were made, e.g. the list of household assets had to be extended.

At both sites, all households were routinely visited every three months to record vital events, birth, death and migration. Pregnancies were also routinely recorded and followed on the quarterly basis [110, 111]. Households and persons were included in the HDSS surveys, follow-up and the present studies after giving verbal consent. The non-response rate was 2.3% in DodaLab and 0.7% in FilaBavi.

Totally 106 field workers (46 in FilaBavi and 60 in DodaLab) were recruited. The field workers were employed part time in DodaLab and full-time in FilaBavi. With very few exceptions they were women. The field workers had the responsibility for collecting data through interviews with household representatives using structured questionnaires.

The information obtained in the interviews was forwarded to the field supervisors (8 in DodaLab and 6 in FilaBavi) who were healthcare staff or members of the communal women union. Both field workers and supervisors were rigorously trained on data collection procedures, interview skills and the contents of questionnaires. Manuals were developed and used for training courses and during the data collection. All questionnaires were carefully tested outside the sites before the start of field work. The field workers and supervisors reported to the researchers who were alternating PhD students serving on the two sites.

A multi-stage supervision procedure including the field workers, the supervisor and the researchers was established to control the quality of the data collected. The supervisors observed field workers during some interviews and feedback was provided to the field workers. Supervisors also had to check all information and order re-interviews when necessary. They also did routine re-interviews to maintain the quality standards over time.

Databases, one for DodaLab and one for FilaBavi were created in Access software. Normal routine checks were applied to detect abnormal data, duplications et cetera.

The information collected specifically for the studies of growth and breastfeeding was collected and subjected to quality control in the same way as the routine data.

4.2. Study design and subjects.

For the first specific aim of the thesis, following birth weight in FilaBavi over 12 years, the information about the 10,144 infants, born in the years 1999 to 2010, was taken from the routine data collected in the FilaBavi. Birth weight, sex of the child, twin state, parity and the date of last menstruation before pregnancy were reported by the mothers together with information about delivery. Maternal age and education as well as economic data were

taken from the major household surveys conducted in FilaBavi every second year from 1999 to 2009. Birth weight information was missing for 98 children.

For the later three aims, 1,466 children were intended to be followed from birth to 24 months of age. Information from an earlier pregnancy follow-up study of the mothers with interviews every three months [110] was also available. Information about antenatal and delivery care was taken from that study which was also the basis for the subsequently obtained information on breastfeeding. Totally 2,572 mothers were included in that study but only 1,466 were included in the two year follow-up of children. Table 2 shows some details of the different studies.

The mothers were interviewed after delivery about breastfeeding, supplemental food, vaccination, health care utilization and symptoms of illness every month from one month to 12 months. The 1,466 children, born from 1st March, 2009 to 30th June 2010, were measured monthly from one to 12 months of age and every three months during the second year of life with respect to weight and length.

Table 2. Overall design of thesis

Paper	Specific objective	Data collection
I	To study birth weight, delivery, sex ratio at birth and economic conditions during 12 years in a rural district in Northern Vietnam.	Data collected routinely for 10,144 children. Birth weight, delivery place and type, child sex and, infant death from quarterly follow-up in FilaBavi 1999-2010. Mother and household information from household surveys in 1999, 2001, 2003, 2005, 2007 and 2009.
II	To compare birth weight and growth in weight and length between one urban and one rural area in Hanoi, Vietnam.	Specific data collection for 1,466 children, born March 2009 - June 2010, subgroup of the children in paper 4 below. Weight and length measurements monthly for one year. During the second year children were measured every three months. The total number of measurements was 17,148. Mother and household information from household surveys in 2007 and 2009.
III	To investigate the associations between birth weight, growth and social and economic conditions for mother and household, sex, antenatal care, breastfeeding and illness of infants in the two sites.	Same 1,466 children and measurement as paper II. Information about pregnancy from antenatal care study. Information about breastfeeding from the study in paper IV.
IV	To investigate breastfeeding practices and related factors of infants in one urban and one rural area Hanoi, Vietnam.	Specific data collection from 2,572 mothers with children born March 2008 to June 2010. Breastfeeding, exclusive breastfeeding, vaccination, illness episodes et cetera recorded monthly for one year. Mother and household information from household surveys in 2007 and 2009. The number of interviews was 27,197.

4.3. Concepts, definitions and variables

4.3.1. Outcome variables

Birth weight: Mothers reported the information they received in hospitals or community health centres immediately after delivery.

Gestational age: The date of the last menstruation as reported by the mothers was used for the estimation of a proxy for gestational age at birth.

Child age: age is the number of days from the date of birth to the date of interview and measurement.

Attained weight and length: These are the absolute measurements for a child at any specific child age. Growth curves are the corresponding mean functions of child age estimated using fractional polynomial regression [112]. Cf. statistical analysis.

Child weight measurements: Standardized equipment for measuring the child recommended by Hanoi Medical University was used. A number of commune health centre staff members in DodaLab were trained specifically to measure children. In FilaBavi, a number of the permanent interviewers were trained to measure children. The principle for measurements was that the same field workers should assess a child at each visit using the same equipment. Two persons worked together measuring children, one doing the measuring and one filling the form. Weight was measured to the nearest 10 g with the child in light clothes using a Vietnamese mechanical infant scale.

Child length measurements: Length was measured to the nearest centimeter in horizontal position using a length board. Two persons worked together in order to have valid and reliable measurements.

Stunting, underweight, wasting and overweight are defined as length-for-age below mean minus 2 standard deviations (SD), weight-for-age below mean minus two SD and weight-for-length below mean minus 2 SD or above plus 2 SD according to WHO standards [36].

4.3.2. Underlying social and economic variables

Mother's education: Two key variables for social positioning of persons and households are education and occupation. The education of the mother was used as indicator of the social situation. Three levels were used: primary school or less, secondary school and higher than secondary school. The occupation for mothers did not provide much additional information when considering the urban rural dichotomizing at the same time. Urban women work in offices and business, whereas rural predominantly report farming as occupation.

Mother's age: Two strongly correlated variables were investigated, mother's age and parity. The age was used in the studies since it is the most informative. Due to the two-child policy parity mainly takes two value, one and two. Age therefore has a larger variation and is more informative.

Household economy: To describe household economy, we investigated different forms of wealth and assets indices and the reported household income. Traditionally, a list of assets, (bicycle, telephone, television et cetera) has been used to describe the economic status of households in the two sites. Two variables can be defined using the assets. One is the first component of a Principal Component Analysis (PCA) of variables indicating individual assets. Another is simply the sum of available assets. Both have been tested. They turn out to be almost identical and lead to the same conclusions when used as explanatory variables. In addition the households have reported annual monetary income. The variable has a strongly positively skewed distribution so a logarithmic transformation was used in the exploratory studies conducted. For the economic analysis in the thesis the variable used was the number of assets in the following list: bicycle, motorbike, car, telephone, radio, television, video player, sewing machine, computer, refrigerator and buffalo.

Antenatal care variables: Three indicators of describing ANC use were defined [110].

Three variables aimed at describing the use of ANC:

- Sufficient number of ANC visits during pregnancy (at least three, yes or no)
- ANC reported to contain counselling and advice (yes or no)
- First ANC visit during first trimester (yes or no)

Breastfeeding variables: At the monthly interviews, information about breastfeeding and additional food during the period since last interview was recorded carefully. Three variables were used to describe breastfeeding during infancy:

- Early initiation of breastfeeding defined as breastfeeding starting during the first hour after birth (yes or no).
- Exclusive breastfeeding: The infant receives breast milk, from the breast of the mother or a wet nurse or expressed, with the only additional oral intake of oral rehydration solutions or medication including vitamins or minerals. The age for the first statement of no exclusive breastfeeding was used to define duration.
- Any breastfeeding: The infant receives breast milk, from the breast of the mother or a wet nurse or expressed, with or without additional oral foods. This category includes the WHO definitions of exclusive breastfeeding as well as non-exclusive breastfeeding, that is predominant breastfeeding and complementary feeding according to the WHO definitions [113]. The age for the first statement of no breastfeeding was used to define duration.

Reported illness symptoms: The indicator Reported illness symptoms (fever, cough, diarrhea) for a child was defined as the number of interviews with any reported symptom divided by the number of interviews.

Smoking means that a woman reports herself as smoker or previous smoker.

Urban and rural: The type of area, urban and rural, can be seen as a basic factor. The classification is built on several factors, some rather widely accepted to define the two area types, other more problematic. The urban rural variable has been included in all regression models. In situations when the urban rural division can be suspected to modify associations between growth and other factors, it will define subgroups for stratified analysis.

Child sex: The variable denoting the child's sex also has a special position. With respect to birth weight, child sex can be seen as a basic factor since all experience points to boys being heavier than girls. Child's sex has therefore been included in all regression models. Like the urban rural division, when child sex can be suspected to modify associations it will also define subgroups for stratified analysis. In fact, most of the statistical analysis in the entire thesis in different ways takes four subgroups into account: urban boys, urban girls, rural boys and rural girls.

4.4. Statistical analysis

Standard simple and multiple, linear and logistic, regression models were used for the analysis of birth weight and associations with time and other factors.

The growth curves were smoothed using the Fractional Polynomials technique (FP) proposed by Royston [112]. Degree three was used for these estimations. For the analysis of association between attained weight and various factors, we used the relative residuals from the predicted curves. The relative residuals were defined as the deviations, positive or negative, of measurements from the FP predicted curve divided by the predicted value:

Relative residual = (value observed – value predicted)/ (value predicted).

Two approaches were used to study associations. One was assessment through repeated measurement analysis using linear mixed regression models applied to the relative residuals. This analysis was supplemented with analysis of the means of the relative residuals for individuals in collapsed datasets (one record per child). The variance of the relative residuals was reasonably constant over child age. The results were compared with those from repeated measurement analyses. The same conclusions were obtained with either method.

Results showing association were given as correlations, crude or partial (adjusted). The latter correspond to partial regression coefficients in multiple linear regression but are standardized to have values between minus one and plus one.

Survival analysis was used to study the duration of breastfeeding and exclusive breastfeeding, “surviving” meaning remaining breastfed. Log-rank tests, simple and stratified, as well as Cox regression were used to study associations between different factors and the duration of breastfeeding.

All statistical analysis used commands available in the software STATA version 11.

4.5. Ethical consideration

Approval of the project was obtained from the Scientific and Ethical Committee of Hanoi Medical University, Hanoi Health Bureau, Dongda district authorities and Bavi district authorities. The project proposal was also approved by the MoH and permission for the study was given. All mothers invited to participate were informed about the purpose of the studies and their right to decline participation or to withdraw unconditionally at any time. Verbal consent was sought and given by more than 99% of all invited mothers. All information about participating, mothers and children as well as their households was coded and could only be accessed by researcher and data managers. The information was used only for research purposes. The mothers and children could not be identified in analyses and presentations. Results have been duly disseminated to the involved local authorities. The mothers and their children received advice and help from obstetricians and paediatricians during the studies when needed.

5. Empirical results

The review of results is mainly organized according to the four papers of the thesis. However, papers two and three are closely related and will be presented in parallel. These papers both show the analysis of associations of child growth with immediate, underlying and basic factors.

5.1. Birth weight and delivery practice in a Vietnamese rural district, Ba Vi during 12 years of rapid economic development (Paper I)

Totally 10,114 children born alive 1999 – 2010 in FilaBavi, 5,389 boys and 4,725 girls, were included in the study. The number of mothers was 6,860, where 4,093 had one birth and 2,305 had two. The maximum number of births reported for one mother was five. The absolute number of births per year increased over the period. Comparing 2000 and 2009 the increase was about 30% for boys and 10% for girls.

Figure 5 shows the distribution of all available birth weights (absolute frequencies). The mean birth weight for all boys recorded 1999 - 2010 was 3,136 g (SD 451 g). For girls the mean was 3,057 g (SD 421 g). There were no strong tendencies for systematic change in birth weight over time for the main group of children, singleton children. The percentage of LBW was 5.3 with no systematic difference between boys and girls.

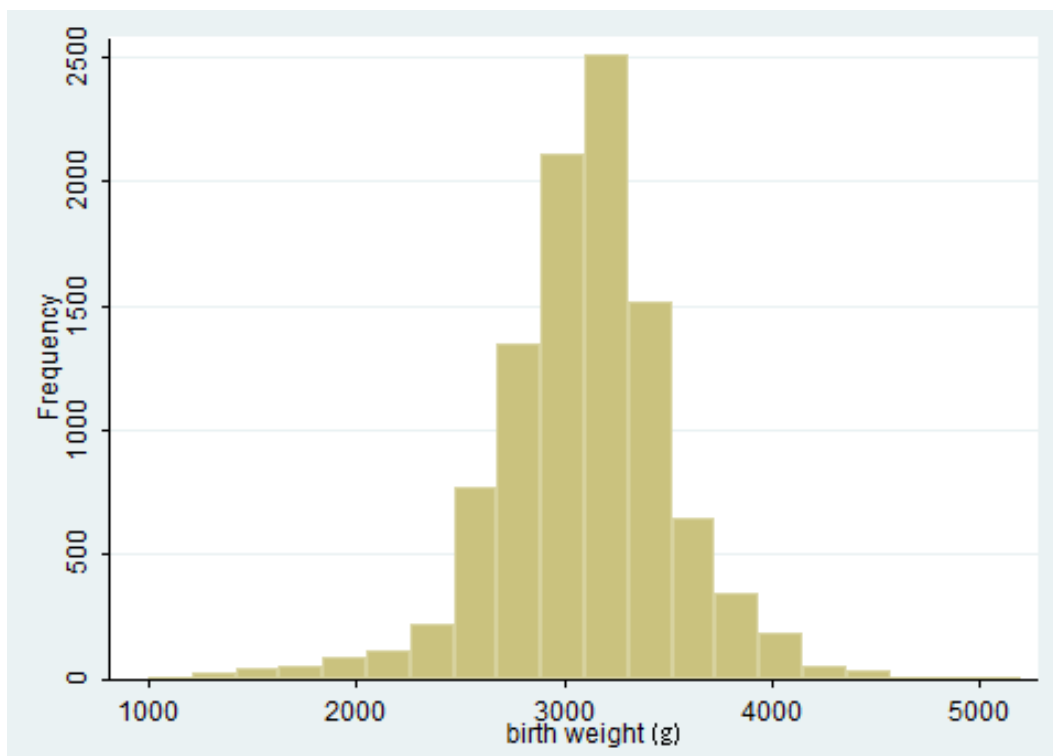


Figure 5. Birth weight distribution of 10,018 newborn in FilaBavi 1999-2009

The birth weight information was obtained from the mothers. Possible sources of errors were how the measured birth weight was reported to the mother and the recall by mothers. It could be suspected that the hospital or health centre staff tends to report a higher weight to please the mother. The percentage of LBW newborns was lower than expected. The precision of birth weight reporting was 100 g. Systematically and incorrectly rounding

upwards would create a bias of at least half that size. One could well suspect heaping of birth weights at 2500 g meaning that classification as LBW was deliberately avoided. With LBW defined as weight strictly less than 2,500 g the percentage was 5.3%. When we included the newborns with a birth weight of exactly 2,500 g we found 8.8%, which is a more realistic estimate and an indication of heaping. An unexplained peculiarity was that the frequencies for 3,000 and 3,200 g were more than 1,000 children each whereas the one for 3,100 g was just about 600.

Recall biases are likely to be small as it is considered important in Vietnamese tradition to remember the birth weight of a child.

The results of simple regressions at aggregated level of mean birth weight on birth year gives a minor average decrease of 3.4 g per year with a p-value equal to about 0.01. The stratified analysis by sex gives a yearly decrease for boys of 4.5 g and 2.5 g for girls. The former decrease is statistically significant, the latter not. Table 3 shows the detailed results.

Table 3. Results of the regression analysis of mean birth weight on birth year

Dependent variable: mean birth weight	Estimated regression, coefficient grams per year	Confidence interval for estimated regression coefficient	Probability of linear trend being random (p-value)
Boys	- 4.5	[-7.5; -1.5]	.030
Girls	- 2.5	[-5.0; -1.0]	.111

We also analyzed the data at the level of the individual child. The dependent variable was birth weight. Two independent variables, gestational age and child sex were systematically included in all models. For mothers, age and education level were used. The number of reported household assets was taken as an indicator of economic level. The time variable in the regressions was the year of birth. A variable indicating birth in hospital was also included in one model. The strategy for analysis of the birth weight variation was to use an overall linear model including all independent variables except the CS variable. In addition separate analyses by year were run for all variables, also excluding the CS variable. All CS took place in hospitals. To study possible associations between birth weight and CS therefore, a separate analysis including the CS variable and the other independent variables was run for the children where delivery took place in hospital. This analysis showed that children delivered using CS were on average 65 g heavier than those who were not.

Two variables, gestational age and child sex, were statistically significant in all analyses. The former showed the strongest correlation throughout ($r=0.30$) and child sex pointed to a boy girl difference somewhat less than 100 g. We also found that there were associations between birth weight and household economy as well as mother's age and education. Older mothers who had higher education living in households with good economic conditions delivered children with higher birth weight. Table 4 shows the basic regression results.

Table 4. Results of the regression analysis of birth weight

Independent variable	Estimated change (g) in dependent variable per unit change	Confidence interval for estimated change	Probability of observed change being random (p-value)
Sex girls-boys	-88.1	[-105; -70.7]	.000
Gestational age proxy	4.96	[4.55 5.38]	.000
Mother's educational level	40.4	[25.9; 54.9]	.008
Assets (items)	16.0	[10.7; 21.3]	.000
Mother's age (years)	9.97	[8.28; 11.7]	.001
Year of birth	-1.01	[-3.56; 1.54]	.439
Birth in hospital	-111	[-129; -94.1]	.000

No model for birth weight had an R^2 larger than 0.15 that is the variation in the independent variables explained 15% of the variation in the dependent variable.

The male to female sex ratio at birth (SRB) increased from 1.04 in 1999 to 1.19 in 2010. For some years it was larger than 1.21 which is the limit for being statistically significantly above 1.08 (at the 5% level), usually considered as an upper limit for a normal SRB [114].

The percentage of mothers giving birth in hospital roughly doubled over the studied time period. The increase was numerically not as fast for girls as for boys but the difference between the sexes was not statistically significant. Overall, delivery in hospital was more common for boys ($p < 0.001$). The use of CS during the studied period increased for both boys (2.0% in 1999 and 12.7% in 2010) and girls (2.7% in 1999 and 7.4% in 2010).

The median reported yearly income increased by 150% from 5,990,000 VND in 1999 to about 15,000,000 VND (adjusted for 118% inflation) in 2009. For the households in the lowest wealth-index quintile the increase was only 88%. In the highest quintile, income increased by 227%. Reported household health expenditures roughly doubled during the period and were not much different between the income quintiles.

5.2. Urban and rural birth weight (Paper II and paper III)

Figure 6 and 7 show the distributions of birth weight for DodaLab and FilaBavi. The suspicion of heaping at 2,500 grams mentioned in relation to Paper 1 remains for FilaBavi but is not as striking for DodaLab. Note that the graphs here are based on a smaller sample than the earlier from Filabavi resulting in increased irregularities.

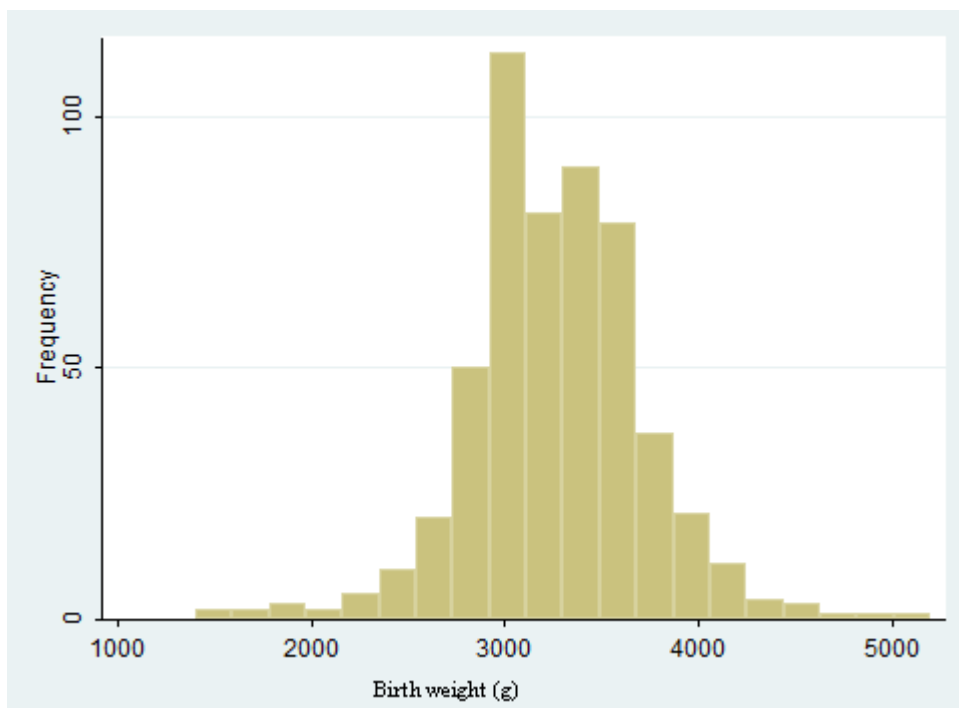


Figure 6. Birth weight distribution in DodaLab

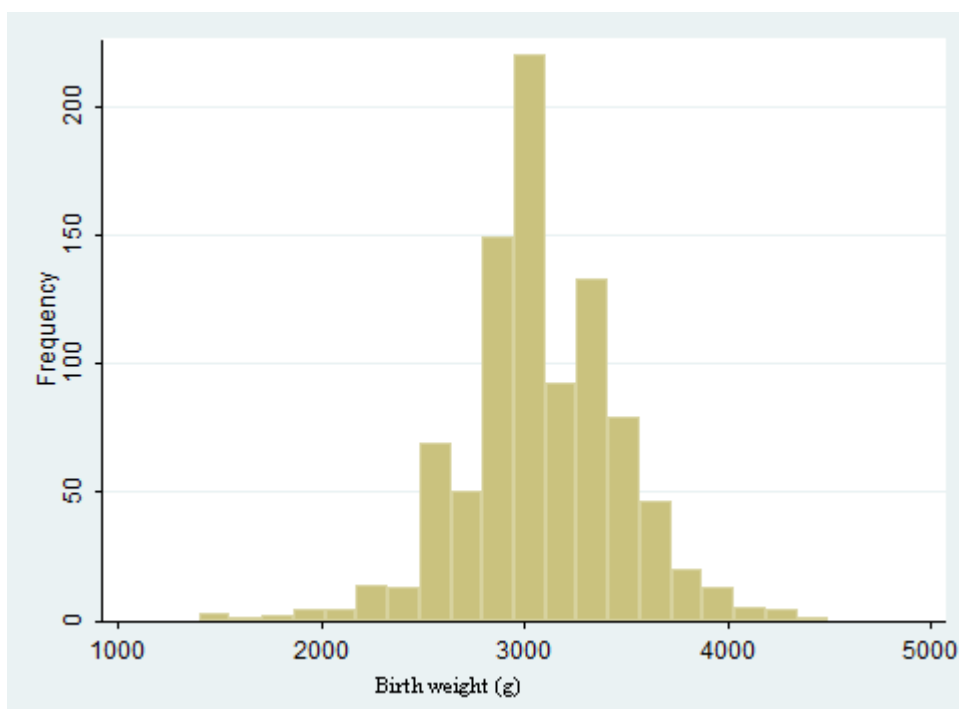


Figure 7. Birth weight distribution in FilaBavi

Considerable differences in mean birth weight were found between the urban and rural areas. Table 5 shows means, standard deviations and confidence intervals by area and child sex. The estimated birth weight difference between the areas for boys was 193 g (95% CI: 134; 252) and 146 g (95% CI: 79; 213) for girls.

Table 5. Birth weight and background variables*

	Urban boys	Urban girls	Rural boys	Rural girls
Birth weight, mean	3,298	3,203	3,105	3057
standard deviation and	450	435	390	408
95% confidence interval, g	[3,247;3,348]	[3,148;3,259]	[3,071;3,139]	[3,017; 3,097]
Low birth weight, %	2.3	4.2	4.1	4.9
Number of children in with reported birth weight	300	237	513	409
Days from reported last menstruation to birth, mean	272	271	271	272
Mother age, mean , years	28.7	28.3	25.4	25.3
Mother' highest education primary school, %	8.6	4.9	54.8	54.6
Mother education higher than secondary school, %	58.2	67.1	17.4	16.8
Number of household members, mean	4.6	4.4	5.2	5.7
Number of household assets, mean	9.4	9.1	4.7	4.8
Yearly reported household income, median VND	75 300 000	78 600 000	35 000 000	35 000 000

* Table 1 in Paper II with adjustment for errors in the confidence interval for urban boys and reported household income

Table 5 also gives an overview of the variables that were considered as independent variables in regression models i.e. area (urban vs. rural), child sex, gestational age, mother's age, mother's education (three levels), household income, number of household members and number of household assets. A key feature of this information is that rural mothers are younger and less educated than the urban. The reported number of assets and income are higher in urban households. The household size is somewhat larger in the rural area.

In a linear regression analysis of birth weight with three independent variables, area, child sex and gestational age (Model A of Table 6), all had statistically significant regression coefficients (all $p < 0.003$). The estimated urban rural difference was 179 grams and boys were 63 grams heavier than girls. The share of birth weight variation that was explained by the regression was 9.0%. In Model B the variables indicating mothers education and household assets were added. All basic variables remain statistically significant. The linear model was further extended with household income and mother's age (Model C). The

share of explained variance then increased marginally to 9.7%. The regression coefficient for child sex was about the same and remained statistically significant. No other regression coefficient had p-value smaller than 0.05, the closest appeared for the assets variable ($p=0.083$). The correlations between birth weight and mother's weight and height were separately investigated and found to be rather weak. Details of the regression analysis including the three models A, B and C are shown in Table 6.

Table 6. Regression analysis of birth weight

	Model A	p-value	Model B	p-value	Model C	p-value
	Regr. Coeff		Regr. coeff.		Regr. coeff	
Area (urban-rural)	179	0.000	158	0.000	20	0.877
Child sex (boys – girls)	63	0.003	61	0.004	60	0.006
Gestational age proxy	4.4	0.000	4.3	0.000	4.3	0.121
Mother age					2.1	0.366
Education			-24	0.133	-25	0.121
Assets incr. per item			10	0.022	8.5	0.083
Income (logarithm)					17	0.309
Household members					-5.2	0.301
Explanatory value R^2	0.0897		0.0942		0.0976	

We extended the analysis to also include investigation of possible relations between birth weight and antenatal care use by the mother during pregnancy. Also the number of ultrasound scans was investigated as an explanatory variable. No statistically significant associations between birth weight and ANC or ultrasound use variables were found.

Very few women reported themselves as smokers, four in the urban area and 17 in the rural. However, the differences in birth weight between the smokers and the non-smokers were large. Adding the smoking variable to the above mentioned basic model we obtained an estimate of the overall difference, adjusted for place, sex, household assets and mother education as 239 grams. Due to the small number, the corresponding confidence interval was very large [71; 407] grams. The p-value was 0.005 and the determination coefficient for the model increased with about 0.5%. This is rather small but expected considering there were few smokers.

5.3. Child growth and factors associated to child growth in urban and rural areas

To describe growth of a child we used graphs showing the means of weight or length as functions of age. The distribution of weight for a specific age sometimes exhibits certain positive skewness. The natural choice of mean can then be the geometric. The distribution of length measurements is normally symmetric. This thesis however, uses only arithmetic means since no definite skewness was observed. Different mathematical functions can be

fitted to summarize empirical observations as functions of age showing the mean state of children at different ages. The Fractional Polynomial approach generated comparatively simple functions with very good fit to the observations.

Beside the level of attained weight or length at different ages, there is also an interest in describing the rates of weight and length increase normally called “velocity of weight or length growth”. Velocity for any given age interval can be crudely estimated as the weight or length increment over the interval divided by the length of the interval. If a mathematical function is used to describe growth, the velocity becomes simply the first derivative of that function. For clinical practice, velocity is normally considered as averages over longer age periods, like three or six months.

The estimated weight and length growth curves differed statistically significantly between the sites for both sexes (Figure 8 and Figure 9). The mean attained weight was generally higher in the urban than in the rural area. The difference increased in absolute term with increasing age during the first year of life but decreased later. The differences in length were comparatively smaller.

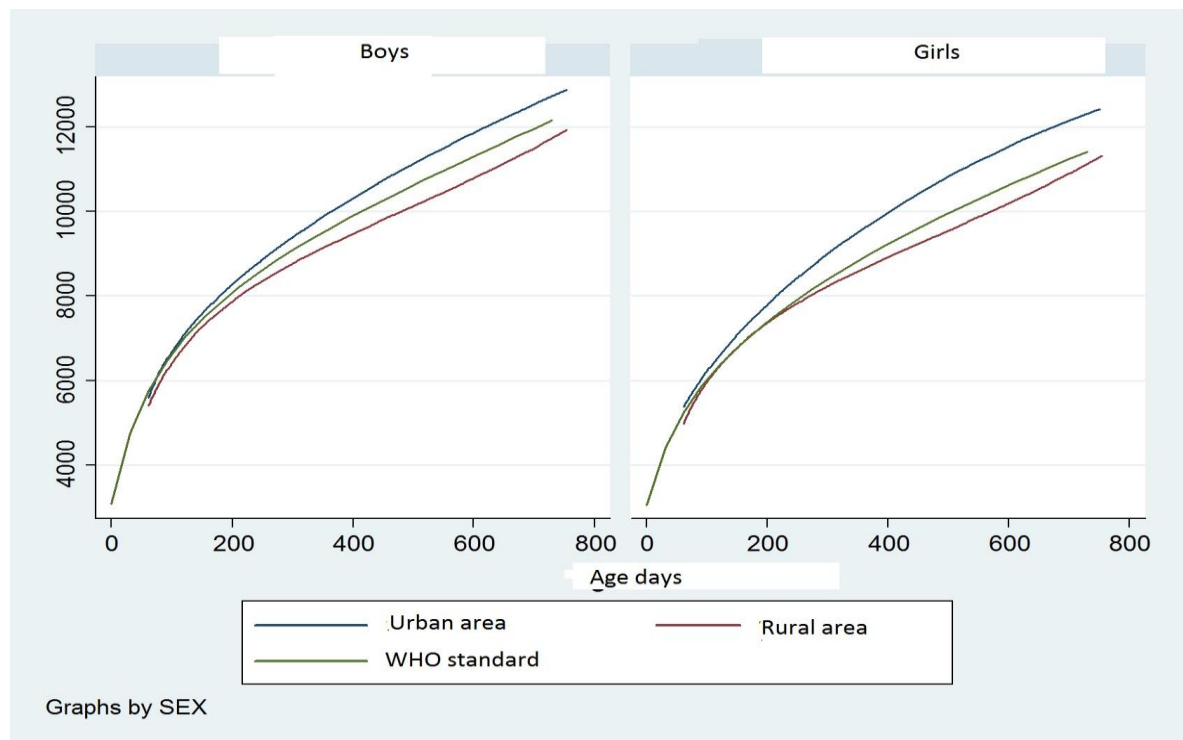


Figure 8. Estimated mean curves showing attained weight for age by sex together with WHO standard

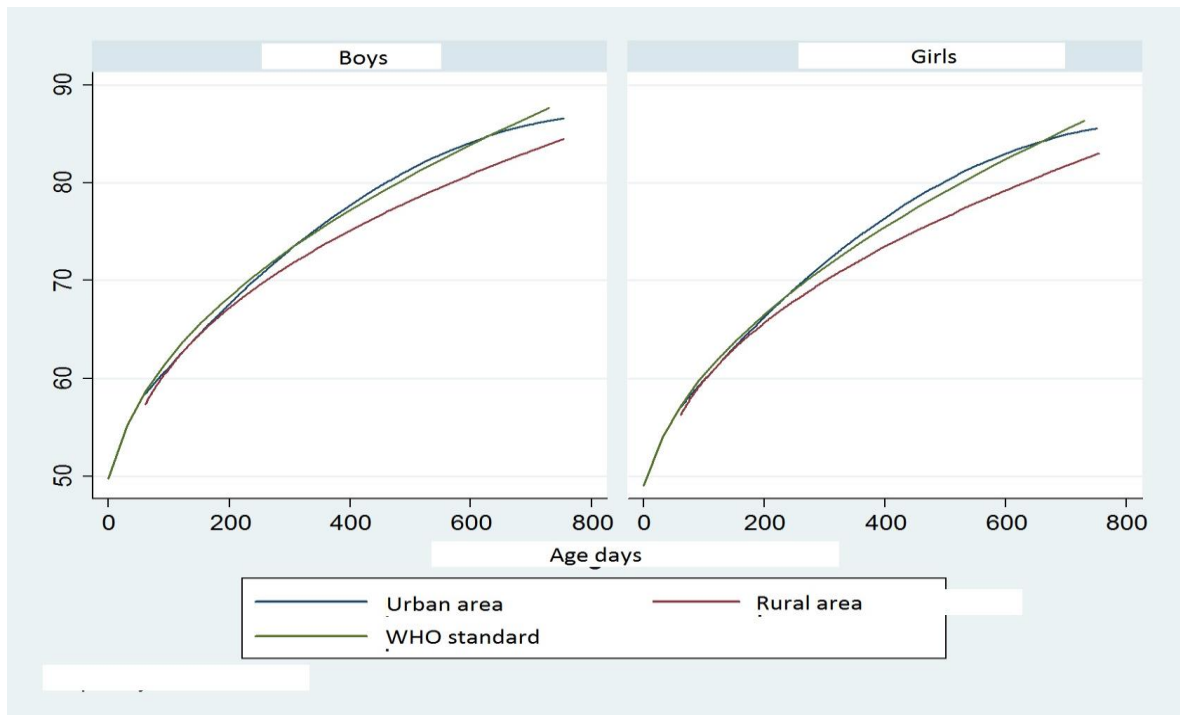


Figure 9. Estimated mean curves showing attained length for age by sex together with WHO standard

Lines showing the WHO growth standards published in 2006 [115] are included in the figures. The WHO curve for weight falls between the fitted curves for the urban and the rural area for both child sexes. The deviations from the WHO standard are statistically significant ($p < 0.01$). The WHO standard for length is statistically significantly higher than the curve observed for the rural area ($p < 0.01$). For the urban area no significant deviation can be stated.

In a linear regression with the mean of the relative residuals for a child as the dependent variable (Model A), all three independent variables, area, child sex and gestational age, had statistically significant regression coefficients (all $p < 0.003$) both for attained weight and length (Table 7). The share of the weight residual variation that was explained in the regression was 15.2% for weight and 8.6% for length. This linear model was extended with household assets and income as well as mother's education and age (Model C). The number of household members was also included. The share of explained variance increased marginally to 16.7% for weight and to 10.0% for length. The regression coefficient for child sex and gestational age were about the same and remained statistically significant. The variable indicating urban or rural area changed and became non-significant. The variables "mother's education" and "household assets" were both statistically significantly and positively associated with the weight residuals. For child length only the education variable was significantly associated. Generally thus, the growth was faster for boys and for children with longer gestational age. In addition the analyses showed associations with mother's education and household assets (for weight). The growth was better for children where the mother had a good education and had better household resources. The detailed regression results are shown in Table 7.

Table 7. Regression coefficients and p-values for Model A and C analysis of mean relative residuals for attained weight and length

	Model A				Model C			
	Weight		Length		Weight		Length	
	Coeff	p	Coeff	p	Coeff	p	Coeff	p
Area (urban-rural)	.057	.000	.010	.000	.044	.157	-.012	.292
Child sex (Boys – girls)	.061	.000	.021	.000	.060	.000	.020	.000
Gestational age proxy	.00041	.002	.00014	.003	.00041	.003	.00001	.011
Mother age					-.00006	.917	.0002	.238
Education					.010	.010	.0024	.125
Assets incr. per item					.0029	.010	.00072	.106
Income (logarithm					-.0010	.802	.0022	.191
Household members					.00002	.988	-.0007	.162
Explanatory value R ²	.1523		.0857		.1674		.0995	

Some estimates of growth velocity are shown in table 8.

Table 8 - Growth velocity for weight and lengths at selected ages

	Weight (g/day)				Length (cm/10days)			
	Urban		Rural		Urban		Rural	
Age	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
90 days	24.0	20.9	23.3	21.4	.84	.82	.79	.76
180 days	14.1	13.8	12.2	11.4	.60	.56	.59	.59
270 days	10.0	11.5	7.8	7.7	.51	.43	.53	.42
360 days	7.7	10.3	5.7	5.8	.47	.35	.53	.36
Average velocity	12.8	13.5	11.1	10.5	.58	.59	.59	.49
90-360 days with 95% CI	[12.2; 13.4]	[12.7; 14.3]	[10.7; 11.6]	[9.9; 11.1]	[.56; .60]	[.57; .61]	[.57; .61]	[.48; .50]

The average weight velocity differs between urban and rural areas for both boys and girls. The velocity differences between sexes are not statistically significant. For the averages of length velocity, three of the groups are at the same level but rural girls come out clearly lower.

5.4 Factors explaining growth variation

Three underlying factors of possible importance for growth are the mother's use of antenatal care (ANC) during pregnancy, the use of breastfeeding, particularly exclusively and child morbidity. These were studied separately. The growth data for the first year was used. The second year of follow-up had a substantial drop-out rate and the risk of bias did not appear to be compensated by the increase in precision.

Some statistically significant correlations between the use of ANC and growth were found. The strongest positive correlations between weight and length residuals were those with the number of ANC visits and a positive answer to the question if the mother was given advice and counselling, which was reported by 44% of all women (Table 9)

Table 9. Correlations and partial correlations between weight and length residuals and ANC, breastfeeding and reported illness. The partial correlations are adjusted for area, sex, mother's education and household assets.

	Attained weight	Attained weight adjusted	Attained length	Attained length adjusted
Number of ANC visits	.1979	.0379	.1790	.0762
Advice during ANC	.1859	-.0063	.0923	-.0392
Early initiation of breast- feeding	.0687	.0790	.0546	.0359
Duration of exclusive breastfeeding	.1211	.0404	-.0051	-.0200
Reported illness symptoms	-.3076	-.1769	-.1770	-.0808

The ANC variables could together explain about 4% of the growth variation. Adding the ANC variables to the basic regression model A in Table 7 above, increased the determination coefficient less than one percent unit. The partial ANC correlation coefficients, adjusted for area, sex, education and assets, differ markedly from the overall. The correlation between length and number of ANC visits remains positive and statistically significant. A further breakdown for strata defined by site and child sex is given for weight residuals in Table 10. The correlations with number of ANC visits are highest for the rural area but in general quite weak.

Table 10. Partial correlations between weight residuals and ANC, breastfeeding and reported illness, adjusted for mother's education, by area and sex.

	Urban boys	Urban girls	Rural boys	Rural girls
Number of ANC visits	.0340	.0003	.0942	.0378
Early initiation of breastfeeding	.0224	.0575	.0914	.1653
Reported illness symptoms	-.0803	-.0674	-.2165	-.1788

Early initiation of breastfeeding and duration of exclusive breastfeeding were positively correlated to attained weight whereas the duration of breastfeeding showed a significant association only for early initiation. The correlation between weight growth and early initiation remained statistically significant also after adjustment. The stratified results in Table 10 show stronger correlations between weight growth and early initiation of breastfeeding for the rural children.

The reported symptom of illness variable was found to be associated to attained weight and length. Both the crude and the adjusted correlation coefficients were statistically significant at 5% or lower level (Table 9). The crude correlation coefficient between growth and reported symptom of illness was as low as - 0.31. In the strata defined by site and child sex (Table 10) the rural correlations remained statistically significant. The associations between growth and illness were all negative, meaning that an increasing number of reported symptoms of illness are numerically seen to reduce growth. Symptoms of illness were much more commonly reported in the rural area where the risk (probability of reported illness at an interview) was over 0.40 compared with about 0.20 in the urban. The reported symptom of illness variable was also negatively correlated to growth velocity, but less strongly.

Information about postnatal healthcare visits for the mother and the child was requested in the interviews. Rather low frequencies of such visits were recorded in both areas and were lowest in the rural. We could not establish any relations between the use of postnatal healthcare and growth. Questions about vaccination during the first year of life were asked. However, we consider the information obtained as uncertain.

5.5. Stunting

Table 11 shows percentages of measurements indicating stunting by basic factors in four half-year age groups. The increases over time for children in the rural area, children with low maternal education and in households with limited resources are particularly marked. Overall, stunting measurements were most frequent in boys and children having mothers with a low education and where there was a low level of household assets. Slight overweight was seen in children (3.8%) where the mothers had high education in the urban area.

Table 11. Percentages of length measurements indicating stunting according to WHO definition and standard

	First half year	Second half year	Third half year	Fourth half year	Overall, two years
Boys	12.0	12.7	14.2	21.4	14.1
Girls	8.2	8.9	11.4	19.8	10.7
Urban area	11.3	8.8	2.6	6.8	8.8
Rural area	9.9	12.2	18.4	26.4	14.6
Low education	9.2	13.2	19.6	28.5	15.2
Middle education	11.5	11.4	12.4	20.1	13.0
High education	10.3	7.9	6.7	9.5	8.8
Low assets	10.5	13.4	18.4	26.0	14.5
Middle assets	11.0	10.8	13.8	22.0	14.9
High assets	8.0	8.6	6.5	11.4	9.4
Total	10.3	11.0	13.0	20.7	12.4

5.6. Breastfeeding of infants in rural and urban areas

Early initiation of breastfeeding, during the first hour, was significantly more common in urban (40% boys and 49% girls) than in rural newborns (35% boys and 40 % girls). After CS, initiation of breastfeeding should be expected to be delayed. The differences between sites as well as between the sexes were statistically significant ($p < 0.01$). The statistically significant results of a logistic regression analysis for the dichotomous variable early initiation (yes/no) are shown in table 12.

Table 12. Logistic regression of early initiation of breastfeeding

Independent variable	Odds ratio	95% confidence interval	p-value
Site (urban=1, rural=2)	.19	[.05 ; .68]	.011
Child sex (boy=1, girl=2)	1,22	[1.01;1.47]	.034
Birth weight	1.0006	[1.0003;1.0008]	.000
CS (yes=1, no=2)	.12	[.09; .16]	.000

Mother's age, mother's education, mother's occupation, number of antenatal visits, household income, household assets and household members did not show statistically significant associations with early initiation.

Exclusive breastfeeding in the first months was significantly more common in the rural area than in the urban (Figure 10). At all ages girls were more frequently exclusively breastfed in both sites but the differences were not statistically significant.

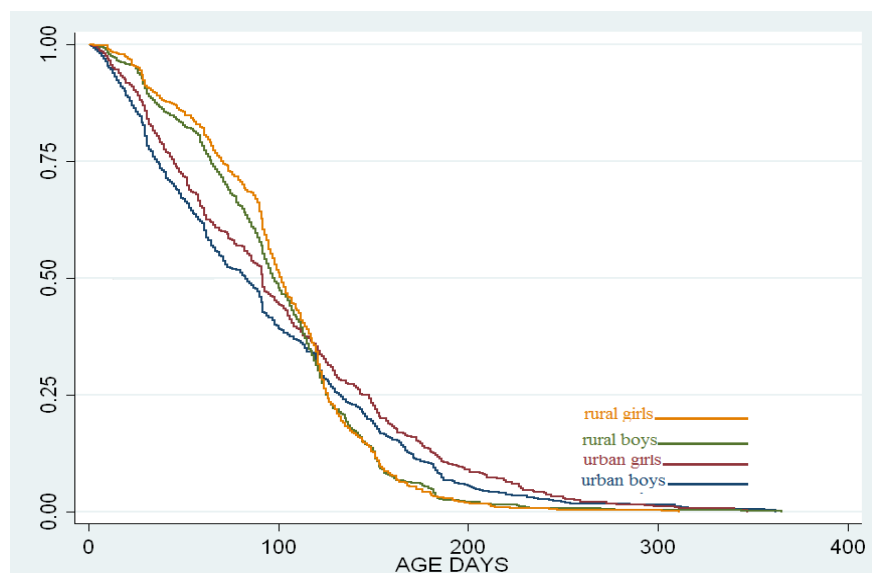


Figure 10. Estimated proportions of exclusive breastfeeding as a function of age for urban and rural infants with some exclusive breastfeeding

Most infants, in both areas, were breastfed at least partially for the first 6-9 month. Later, breastfeeding declined, most rapidly in the urban area (Figure 11).

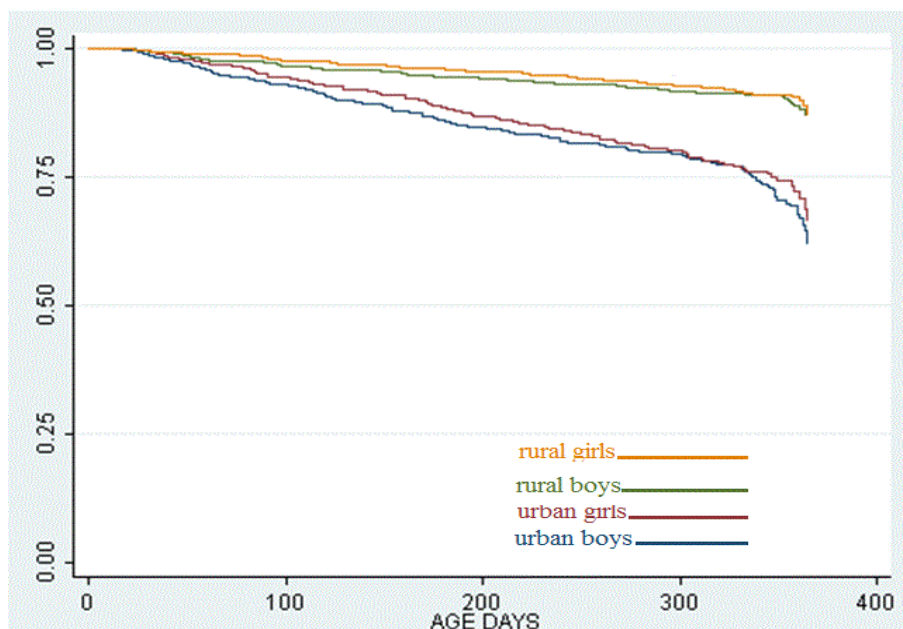


Figure 11. Estimated proportions of any breastfeeding as a function of age for urban and rural infants for children with some breastfeeding

The survival curves for any breastfeeding differ significantly between the urban and the rural areas ($p<0.001$) but not between sexes ($p=0.44$).

The median duration of exclusive breastfeeding for the three groups of education were in the urban area 108 days for mothers with primary school or less, 88 days for secondary school and 82 days for higher education. These differences were however, not statistically significant. The corresponding results for the rural area were 98, 98 and 108 days, respectively. Here the difference was statistically significant.

The median exclusive breastfeeding duration for those attending less than three antenatal care visits was 105 days, whereas the duration for those attending three visits or more was significantly shorter, 92 days ($p<0.05$). For children delivered via CS the median duration was 78 days. The difference was statistically significant different from the 98 days for normal deliveries for both sites.

Cox regression analyses for exclusive breastfeeding were performed separately in four strata of the total data material; urban boys, urban girls, rural boys and rural girls. The independent variables were birth weight, mother age, mother's education, mother's occupation, number of antenatal care visits, CS, household assets, household reported income (logarithm) and number of household members. Table 13 summarizes the statistically significant findings.

Table 13. Statistically significant findings from Cox regressions for exclusive breastfeeding in four strata

Stratum	Independent variable	Hazard ratio	95% confidence interval	p-value
Urban boys	Mother age	0.98	[.95; .998]	.034
	Mother educ.	1.23	[1.01; 1.51]	.043
	CS	1.29	[1.07; 1.56]	.006
	Income	1.27	[1.03; 1.56]	.024
Urban girls	Income	1.10	[1.00; 1.54]	.035
Rural boys	Income	1.12	[1.00; 1.26]	.043

High household income turned out to be significantly associated with a hazard ratio above one in three out of the four strata. For urban boys, the mother's age and education were significantly associated with the risk of ending exclusive breastfeeding earlier. Older mothers showed a lower risk whereas better educated women exhibited increased risk compared with the overall risk.

6. Discussion

This thesis aims to summarize and discuss the results of studies in birth weight and growth of infants in urban and rural areas in Northern Vietnam as well as to identify and discuss statistically associated, possibly influencing factors. We found that birth weight was higher and that the growth was faster in urban infants than in rural and that boys had higher birth weight and faster growth than girls. At the level of underlying factors we identified the mother's education and household economy as being related to birth weight and growth. ANC utilization, early initiated breastfeeding and child symptoms of illness were also associated. Generally, the most important factors appear to be education and economy, not least since all other identified factors are in turn related to these.

6.1. Birth weight and delivery practice in FilaBavi from 1999 to 2010

This study gives a picture of birth weight trends in FilaBavi during twelve years as well as the incidence of LBW, the choice of delivery place, presence of medical attendance at delivery and type of delivery, particularly the use of CS. We found associations between birth weight and delivery characteristics on the one hand and economic condition of households as well as maternal education on the other.

The main finding regarding birth weight in FilaBavi from 1999 to 2010 is that the mean birth weight has been stable over the years despite rather drastic economic and technological development. Previous studies in Vietnam, and other countries, have found increases in mean birth weight and reductions in the incidence of LBW over time periods with improved economy [14-17]. Possible explanations for the observed increases in mean birth weight have been proposed. Improvement of socioeconomic conditions can lead to better nutrition of mothers. Increased economic resources can facilitate access to ANC for pregnant women [14-17].

The present FilaBavi results show no systematic changes over time in the gestational age proxy indicator used. The stable mean birth weight cannot be explained by increased prematurity. The yearly distributions of birth weight are in fact strikingly similar with respect both to central tendency and variation. There is no trend over time in the birth weight standard deviations which might be the case if the economic gaps increase.

The present study shows that the median reported yearly income dramatically increased during the period from 1999 to 2009 but also that there are large discrepancies between different economically defined segments of the population and that the gaps have been widening. The relative increase, adjusted for inflation, was smaller in the poorest group than in the richest. The reported household health expenditure roughly doubled during the period, similarly in different income quintiles, meaning that poor households spent a much higher share of their total income on health than the higher income groups. Also the educational level of mothers has increased over the time period.

The number of private health facilities increased from 19,386 in 1998 to 35,000 in 2009 in Vietnam [85, 86]. In Bavi more than half of all household' healthcare expenditure was spent in private healthcare [116]. The increased number of private healthcare providers has been regarded as increasing the population's access to healthcare but the quality of private

healthcare facilities is considered to be lower than in the public health facilities [117]. This could negative influence the overall quality of ANC and birth weight in Vietnam.

The utilization of health insurance in Vietnam is rather low. A study in FilaBavi showed that 52% of households pay the full cost of each visit to the Commune Health Station or District Health Centre and for the medicine prescribed by doctors despite the fact that they could benefit from having some kind of health insurance [116]. Many pregnant women have to pay themselves for antenatal care, even if they are covered by health insurance, particularly if they go to a private clinic or directly to a provincial or national hospital, without referral from primary healthcare. There is a need for detailed studies of how the increased economic resources are actually used for different purposes. The present data however, were collected routinely and do not allow detailed studies e.g. of the extent to which money was used for good maternal nutrition during pregnancy.

The percentages of women who delivered in hospitals and women who delivered using CS, increased during the time period observed. Another study in Vietnam found that the use of ultrasound has become increasingly common in Vietnam [118]. The percentages of women, who delivered with trained attendance increased over the twelve years. Increased technology does not appear to promote increased birth weight related to pregnancy and delivery.

It cannot be judged from the available information if health expenditure is rational. For pregnant women it may to an unknown extent be payment for unnecessary health technology, like ultrasound investigations, instead of for improvement of nutrition and other forms for truly beneficial ANC. Also other improvements that would have been expected have not occurred. For example the prevalence of anaemia in pregnant women in Vietnam have not changed significantly between 2001 (32.2%) [119] and 2008 (31.4 %) [120]. A study in Vietnam about nutritional status of middle-aged Vietnamese women in Ho Chi Minh City showed that the total protein intake remained lower in rural women compared with other groups [121].

From more detailed studies in 2008-2009 we know that the proportion of deliveries in hospitals in FilaBavi is higher among women with higher education [101]. Most likely all women want to have the best possible delivery care and believe that the quality of delivery care is better in hospitals than in commune health centres. There is no formal barrier for women to go directly to any hospital to give birth, if a woman can pay for delivery care herself. According to the Health Strategy and Policy Institute, about 90-95% of all patients in the Central Obstetric Hospital in Hanoi, including mothers with low economic conditions, went directly to this hospital without transferring from local hospitals. Delivery in a specialized hospital should be motivated by medical indications like high risk deliveries. Still the proportion of normal delivery (delivery without any medical intervention) there is high (33%) [122]. The main reason for this behavior can be that there is a high confidence in professional staff, medical equipment, and infrastructure in central and specialized hospitals [122] or turned the other way around, such confidence is not there for lower level health care.

The use of CS increased from a level lower than that which should be expected as clinically justified, over the 12 years in FilaBavi along with the improved economic conditions and mother's education. At the individual level, CS use has been seen to increase with increased education level, among women living in lowland areas or in richer households [101]. The use of CS has increased in many low, middle and high income countries. The highest percentages of CS in Asia have been found in China (46.2%) followed by Vietnam (35.6% in 2007) [123].

One reason for the use of CS without medical indication can be that families want to choose a “good” time and day for delivery according to Vietnamese tradition, that the operation is believed to be safe and generally a wish that the child will have a good future.

The use of CS has advantages and disadvantages. In some situations it can be a lifesaving action. E.g. a large study of CS use in situations of obstructive labor showed that CS could prevent asphyxia for newborns and that it is believed to be a safe and painless technique for both mother and child [123]. However, the same study also shows that CS increased the risk of breathing problems in newborn, maternal mortality and led to a higher cost for the health system [123]. The use of CS without medical indication is therefore debated in Vietnam and other countries. For the data in FilaBavi from 1999 to 2010 we unfortunately do not have information about the distribution of medical vs. non-medical indications. The increase of CS in FilaBavi during the study period starts from a very low level to what is considered normal. The increase together with other results points to the need for surveillance of CS use.

The SRB was not a primary aim of the study in FilaBavi 1999-2010 but it can not be left without comment. We found that the male to female SRB increased in Filabavi to 1.19 in 2010 i.e. quite far from the normal (1.04-1.08) [114]. In Vietnam as a whole, SRB increased from 1.05 in 2001 to 1.12 in 2006 [124], similar to result from other studies in Vietnam [102] and other Asian countries, particularly India and China. Some research has estimated that around 80 million females in China and India are “missing” [125].

A strict population regulation was introduced in Vietnam at the end of the 1980s saying that families should have no more than two children [124]. In Vietnam, parents may in different ways try to have at least one son since sons are considered more important than daughters [100]. It is forbidden by Vietnamese law to make ultrasound and inform the mother about the sex of the foetus, but it is nevertheless not very difficult for women to know early on. Women can also decide freely about early abortion. One can suspect that the beliefs and traditions also influence the choices of delivery place and method. It has been observed that mothers with no previous sons more frequently deliver in hospitals than others [101].

6.2. Differences in birth weight between rural and urban areas

In the 2007-2009 studies comparing DodaLab and FilaBavi we found that the mean birth weight was higher in the urban area than in the rural area. This conclusion holds for both sexes. The birth weight of boys was higher than for girls as expected in both the investigated sites [14, 126]. The area variable in itself, urban vs. rural, was found to be less

important when other variables with large differences between the areas, like mother's education and household assets, were taken into account. Previous studies have concluded that birth weight is associated with social and economic conditions, maternal nutrition and weight gain during pregnancy and antenatal care [14-17]. Maternal education, also radically different between the present two study contexts, has also been reported positively correlated to birth weight [127].

We did not find any significant statistical associations between the ANC variables, e.g. number of visits, and birth weight. This finding is different from some other studies where larger numbers of prenatal visits and early first antenatal visit during pregnancy were associated with higher birth weights [128, 129]. There can be several reasons why these findings are not confirmed in the present studies. ANC can mean different things, have varying quality and therefore vary in relevance for birth weight. Comparison of research results can also be confounded by differences in study design, not least differences in sample size.

We are led to the question about what services are actually provided within ANC? Is the health expenditure spent on ANC by pregnant women rational? A study of pregnant women's use of ANC during pregnancy in the same settings showed several indications of poor antenatal care quality [101]. Many antenatal visits did not contain advice and information about the nutrition of mothers during pregnancy and basic clinical tests were not made.

No statistical association between the number of ultrasound scans used by a mother during pregnancy and the birth weight was found in our study. Undoubtedly though, the use of ultrasound scans is high, both in the rural and the urban area. The present data do not make it possible to state how much resources that are spent on health technology rather than on nutrition and more appropriate antenatal healthcare.

Several previous studies have indicated that smoking is an important negative factor for birth weight [28, 29]. Very few women in the present study reported themselves as smokers, but the difference in birth weight between the children of those who did and the children of non-smokers was still large and statistically significant. As smoking has an effect on fetal growth, it is important that pregnant women do not smoke. If they do, they must not do so during pregnancy. From a public health point of view monitoring the trends of smoking among young women and creating smoking cessation programs are urgent preventive strategies.

6.3. Differences in child growth in rural and urban areas

The main conclusion from the present study is that urban children grow faster than rural. This is in accordance with results from previous studies in other countries [130-132]. Differences in the growth of infants between urban and rural areas were previously described in Peru in 1980. Length and weight of rural infants were lower at birth and did not later catch up with the urban [132]. Later studies in China showed that urban infants were taller than rural from one to 12 months [130, 131]. Compared with the results of a study in urban Hanoi more than 15 years ago, the attained weight and length of children

at ages from birth to one year of age in the present study are higher in both sites [133]. This indicates that growth of children is likely to have improved in both urban and rural areas. There is, however, a large gap between the two Hanoi contexts in the present study, suggesting significant differences in child healthcare and nutrition.

Poor nutrition has been seen as the most important risk for poor growth [134]. The nutritional status of children under five years of age has been proposed as a sensitive indicator of parental and household economic conditions. The education of parents has been demonstrated as one of the main factors behind this [135]. Differences in economic conditions and education could therefore be the main underlying and basic reasons for the observed differences.

According to WHO and UNICEF, the prevalence of stunting among children under five in Asia was 27 % in 2011 [36]. One third of all children under five were stunted or underweight or both for age in Vietnam [136]. In the present study, the percentage of measurements indicating stunting at the age of two years exceeds 20% and increases as age increases, especially in the rural area and for mothers with low education and low household assets. The Vietnamese Government has declared stunting as a public health problem [53].

A plan to reduce the prevalence of stunting to 23% by 2020 and being underweight to 12.5% by the same year in children under five was launched in 2012 [137]. A contributing factor for the high stunting measurement proportion in boys may be that boys are less breastfed than girls [75]. This can be another expression of the more intensive care for the higher valued boys given the belief that breastfeeding is inferior to the use of formula milk. In a sense this is also an irrational “technology” preference.

The results for stunting were presented as proportions of measurements indicating stunting. In a cross-sectional study they could be said to be the prevalence of stunting in the surveyed group at the particular time. However, stunting is supposed to be a chronic state. This causes problems for the definition of a child being stunted or not when a particular child shows stunting at some of the repeated measurement occasions but not at others. This can happen if the child grows close to the cut-off points for stunting. For the present study we simply consider the measurements at specific ages as results from repeated cross-sectional studies in which case it is appropriate to talk about prevalence.

Some estimations of being overweight were made in this study. In contrast to being underweight, overweight, is more common in children of mothers with many household assets. Being overweight is expected to become a public health problem in Vietnam in the future. One study in Ho Chi Minh City 2005 showed that the prevalence of overweight and obesity in preschool children increased from 21.4% in 2002 to 36.8% [95]. A study in 2011 in a northern city of Vietnam showed that 6.7% of secondary school children were overweight and obesity was seen in 2% [138].

The partial correlations between growth and ANC use, adjusting for education level of the mother and the household resources, are small and not statistically significant. The simple explanation can be that the ANC variables are themselves associated with education and

economy. In regression models with all background variables, underlying and immediate, the education and assets variables turn out to be much more important than the ANC indicators.

A fairly strong negative association between growth of children and reported illness symptoms was found, particularly in the rural area. The most common causes of illness are diarrhea and acute respiratory infection. Diarrhoea has been seen to drastically reduce the velocity of increases in weight and length in a Brazilian study [52]. Diarrhoea during the first six months increased the risk of low BMI and weight for length after 6 months in Vietnam [53]. Beside diarrhoea, acute respiratory infection has been seen to be significantly associated with incremental weight loss of infants in Indonesia [54]. In the present study, symptoms of illness were more commonly reported in the rural area than in the urban. At the same time the negative correlations with growth were stronger in the rural area. Illness could thus be important to explain the slow growth of rural infants.

Early initiation of breastfeeding, within one hour, can be a positive factor for growth and has been claimed to protect newborn from acquiring infections [139]. This can partly explain why there is a difference in growth as early initiation of breastfeeding is more common in urban areas [75]. Exclusively breastfed infants have been seen to grow faster during the first 6 months of life compared with groups of weaned and partially breastfed children in other studies [49, 140]. It is also known that exclusive breastfeeding can decrease the number of diarrhea and acute respiratory infection episodes [141]. The duration of exclusive breastfeeding though, does not relate significantly to growth in the present study. A reason may be that the duration of exclusive breastfeeding is actually rather short in both areas, less than two months for most children. The Vietnamese Government has noted that the short duration of breastfeeding is a serious problem in Vietnam and has extended opportunities for mothers to stay home from work. From May 2013, Vietnamese mothers have six months of maternity leave [142].

Rather small fractions, less than 20% of the variation in weight and length growth, can be explained by the variation of education of the mother, household wealth, ANC use, early initiation of breast feeding and illness symptoms in regression models. In addition, all variables explanatory for growth variation are associated to social and economic conditions. The decisions taken by mothers about use of ANC, breastfeeding, nutrition, child healthcare utilization are dependent on the educational level of mothers and household resources. Likewise the risks for illness are associated with education and economy. Most of the explained variation in growth in the present study is therefore directly or indirectly due to variation in education and economy.

Different standards for child growth have been published by various institutions and international organisations. Most recently, WHO launched growth standards in 2006. These were constructed to show child growth under ideal conditions [143]. A recent study in Vietnam that assessed the growth of children using the new WHO child growth standards as reference, showed that deficient growth of infants is common in Vietnam [53]. The present results for urban boys and girls reached levels similar to the WHO child growth standards whereas the growth levels of rural infants were lower.

In the analyses for this thesis, birth weight and growth data have not been linked since they have been obtained by different methods. It is interesting though to note that the WHO growth standards give the birth weight means for boys and girls as 3,346 g and 3,232 g respectively i.e. almost 200 grams more than the results for both areas combined in the present study.

6.4. Differences in breastfeeding of infants in rural and urban areas

Breastfeeding can be expected to influence infant growth, both directly, being the basis for good nutrition, and indirectly by preventing disease and is thus an important factor to discuss in its own right. Two aspects of breastfeeding are often considered to be important, early start of breastfeeding and the duration of exclusive breastfeeding. In the present study, early initiation of breastfeeding during the first hour, was statistically significantly more common for urban than for rural newborns. Similar findings have been reported from Tanzania where the percentages of early initiation were estimated to be 82% in an urban area and 52% in a rural. Only 10% of the urban mothers discarded colostrum compared with 43% of the rural mothers [144].

Comparisons between breastfeeding patterns in rural and urban areas in Vietnam have not previously been published. In addition, little is known regarding the knowledge and attitudes to colostrum. A study of Vietnamese women living in Australia suggested that the proportion of early initiation of breastfeeding was low due to negative views on colostrum. Only 25.7% thought that colostrum was healthier for babies than formula. Formula milk was given already in the hospital to 40% of the children [68]. The education of mothers in urban areas of Vietnam is likely to be better than in rural areas, suggesting that there is a difference in knowledge about colostrum and the value of early breastfeeding. However, evidence based breastfeeding positive knowledge has to fight the commercial information that might emphasize other views.

Vietnam began to implement the policy of ‘Baby-Friendly Hospitals’, which is strongly supportive of breastfeeding, in 1995 [145]. In the present research, the proportion of urban mothers who delivered their child in hospitals was higher than in the rural area [101]. This can have contributed to good information and a higher level of early breastfeeding in urban areas. On the other hand, the more frequent use of CS in the urban area could hamper early initiation of breastfeeding.

Exclusive breastfeeding during the first three months was more common in the rural area than in the urban. This is in line with results from China where early exclusive breastfeeding was more common in a rural area (61%) than in an urban (38%) [77]. The opposite was however, reported from Tanzania [144]. The use of CS has been seen to increase the risk for not breastfeeding in Vietnam and China [69, 70]. The babies are often taken away from the mother. Mothers might also be worried about side effects of medicines like antibiotics given prophylactically passing to their babies through breast milk [70]. In the present study the median duration of breastfeeding of children delivered using CS was significantly shorter than for other groups in both settings. The percentage of women having CS was substantially higher in the urban (38.9%) than in the rural one (12.2%) [101]. The use of CS could be one important factor behind the differences found

in exclusive breastfeeding. To support breastfeeding, every health facility should develop routines to let babies stay together with mothers and also prevent overuse of antibiotic prophylaxis at CS.

The economic situation of a mother and her household can influence breastfeeding practices in different ways. Marketing of formula milk has been shown to affect the breastfeeding behaviours of mothers [71, 73]. Mothers are given the impression that formula milk is as good as or better than breast milk [71]. Marketing is likely to be more aggressive in urban areas where the economic conditions are better than in rural areas. In rural areas the reasoning can be turned the other way. The lack of economic resources may actually prevent women from buying formula milk [73]. The different economic conditions between the two sites might partly explain differences in breastfeeding practices.

Another economic aspect to consider is the fact that urban women, particularly with high education, are more often employed than the rural women, including highly educated women. This can be a reason to stop breastfeeding earlier since the officially granted maternity leave, at the time of the study, was fairly short.

Another factor of importance behind the differences may be education. An earlier study in a rural area of Vietnam showed that non-exclusive breastfeeding women had less education than exclusively breastfeeding women [73]. In the present study, the median duration of breastfeeding for the group with the highest level of education in the urban area and for boys was the shortest. In the rural area, the longest median duration of exclusive breastfeeding was in the group with the highest education level. The distributions of the mothers educational level were radically different between the urban and rural areas. The issue of education and information is complex. To understand the details it is necessary to study what education really means and what type of information it is that actually reaches mothers.

Mothers with three antenatal care visits or more breastfed for a shorter duration than other mothers. A possible interpretation of the rather weak correlations between breastfeeding and ANC is that many antenatal visits did not necessarily give mothers adequate information about breastfeeding. The present study did not collect detailed information about the actual breastfeeding recommendations given at the ANC visits. Lack of adequate information and misunderstanding of mothers about breastfeeding has however, been found to be a barrier for breastfeeding in Vietnamese women in England [146].

The results of this thesis show that exclusive breastfeeding decreased rapidly with increasing child age and was uncommon at six months of age in both sites. Similar results have been seen in China and in other studies in Vietnam. The percentages of infants less than 6 months of age, who were exclusively breastfed, was 19.6 % in a study from 2010 in Vietnam [120]. In China, exclusive breastfeeding at six months of age dropped to 0.2% in an urban area and to 7.2% in a rural area [77]. It seems that the most important reason was that the mothers had to return to work [73, 74, 147]. Vietnamese mothers now have a legal right to six months maternity leave [76]. This is strictly seen sufficient in relation to the WHO recommendation of six months exclusive breastfeeding. The recent change gives an opportunity to study possible effects on the breastfeeding practices in Vietnam.

Most infants, in both areas, were breastfed at least partially for the first 6-9 months. Towards the end of the first year, any breastfeeding declined, most rapidly in the urban area. As previously mentioned, boys are considered more important than girls in Vietnam [100], but the present study found that boys were given less breastfeeding than girls in both sites and at all ages. This supports the hypothesis that formula is believed to be better than breastfeeding.

6.5. Method discussion

Many low and middle income countries as Vietnam lack functioning health information systems. Routine information might be collected but is often of low quality. There are many advantages of performing research in an HDSS from a methodological perspective. The context is well described and rich baseline information can be made available. Sampling frames can easily be constructed both for random samples and strategic samples. Triangulation from different sources, quantitative population studies, qualitative studies, information from health care institutions and other data sources are facilitated. The most important advantage of a HDSS is the possibility to conduct longitudinal studies to follow health trends and healthcare systems in their demographic, socioeconomic and cultural contexts. This advantage is clearly illustrated by the 12 year FilaBavi follow up of birth weight. The longitudinal study following 1,466 pregnant women and their children during the period from pregnancy to two years of age, is the first of its kind that has been conducted in Vietnam.

6.6. Validity issues

6.6.1. Children lost to follow up

As in all longitudinal studies, a major problem is missing measurements. The original plan was that all children should be interviewed and measured monthly from birth to one year of age. During data collection, we found that it was more difficult to do this research in the urban area than in the rural and particularly in one of the urban communes. The percentages of scheduled measurements actually done were 65% for DodaLab and 77% for FilaBavi. The frequency of missed measurements increased with the age of the child. The percentages of children followed to at least 12 months were 80% in DodaLab and 90% in FilaBavi. After 20 months the corresponding percentages were 65% and 80%.

There are several reasons for missing measurements. One was that after delivery, mothers and children, especially in the urban area, moved to the house of the mother's parents to stay there for some time. Another reason was that after 4 months, urban mothers had to go back to work, so their children could not stay at home during weekdays. Field workers had to come to the household during weekends or return several times to do the measurement. Another reason for early missing data i.e. late first interview, in the urban area was that registration of newborn children can be done rather late after birth.

The drop outs cannot be expected to be random but systematic and possibly bias creating. To investigate that, we compared the growth curves fitted using all available observations with other curves using only the data from children with complete sets. The former curves came out systematically lower than the latter but the differences were small, 30 to 50

grams after two years of age, largest in DodaLab. A second approach was to correlate the child relative residual means for the first half-year to the number of visits. Very weak positive correlations were found. Both approaches thus indicate that the risk of dropping out is higher for children with slower growth. The estimated correlations between birth weight and number of measurements however, did not support that conclusion.

6.6.2. Validity of DodaLab and FilaBavi routine data

The validity of data collected in the household surveys and the quarterly follow-up was monitored by the system for data check that is routinely applied. Specific studies have been undertaken e.g. for the validity of information about deaths [148]. It was found that the death reporting through FilaBavi gave larger numbers than the official administrative reporting in Ba Vi district. Also the reporting of births appeared to be more complete in the FilaBavi interviews. Other validation exercises have been undertaken as comparisons of differences between repeated household surveys taking reported vital events in-between into account. No serious problems have been noted and necessary corrections have been undertaken.

6.6.3. Information from mothers

The specific information for the study of pregnancies and the subsequent follow-up of newborn has been given by the mothers. Questionnaires were constructed and tested using standard procedures. Just as with the routine data collection there is no direct way of checking answers other than the partial re-interviewing that took place. Some pieces of information reported by the mother are crucial to the present thesis. First, the mothers reported the date of their last menstruation. This is needed to know the gestational age at birth which in turn is crucial for the study of birth weight and growth. The date of birth is known and the difference from the reported date of last menstruation can be calculated. Many of the reported gestational ages however, turned out to be unrealistic and the conclusion is that the dates for last menstruation can have serious errors. Vietnamese women in general do not remember this date well. At the group level, it seems that the mean gestational age is underestimated. As we need some information about gestational age we still use the dates as uncertain proxies. The bias appears to be that gestational age is systematically underestimated.

The information about birth weight for the child was also obtained through interview with the mothers. We could not use birth weight information from hospital or commune health centres birth certificates. These are kept by the commune administrations in different offices and it would not have been possible for the field workers to examine all birth certificates.

When a child is born it is weighed and the birth weight is communicated orally to the mother. There are several threats to the validity of weight reported in the interview: (i) The weighing procedure is inadequate. The procedure might create bias and excess random variation due to poor standardization and poor calibration of the scales. An important factor in this is that measurements are made by different persons possibly working differently. This source of error is shared with many studies and difficult to eliminate in

any context. (ii) The health staff report incorrectly to the mother. There can be some reasons why the weight reported to the mother is incorrect such as a tendency to “increase” for low weight babies and “decrease” for high weight babies, i.e. a wish to avoid extremes and thereby “please” the mother. This could lead to underestimation of the proportions of low birth weight children and to a biased estimate of the standard deviation (underestimated). This appears to happen in the present data, although hardly to an extent that distorts the main conclusions. (iii) The mother reports incorrectly in the interview. It has been claimed though, that mothers are likely to remember the birth weight of her child quite well for a longer time. This is part of the Vietnamese tradition. All these possible sources of error can hardly be studied specifically one by one.

Theoretically one can think of comparing the estimated birth weights obtained from clinical records and those obtained from the interviews with mothers. To use e.g. all the more than 10,000 interviews done in FilaBavi 1999-2010 and records is unrealistic, so any comparison has to be made at an aggregated level using a sample of clinical records. We collected information about birth weight from 30 randomly selected children for each year in a small study of records in the Bavi district hospital. The means of these birth weights for each year were compared to the means obtained in FilaBavi. There were no trends over the 12 years in the birth weight means estimated using the data collected at Bavi district hospital. The overall means were 3,110 g for boys and 3,047 g for girls. The corresponding estimates using mother reports were 3,110 and 3,057 g i.e. differences are 0 and 10 g. We also collected birth weight data for 40 children in each of two CHC for two years, 2005 and 2009. There was no significant difference between the years. Generally, the CHC means are higher than the reports from the mothers. The explanation can be that the group of children delivered at the CHC is selected to be those where pregnancy and delivery is uncomplicated. However, the conclusions are based on small numbers of observations. Nevertheless we dare say that the mothers reported birth weights are not likely to deviate grossly from those registered in the hospital.

We have also compared information of birth weight between the different kinds of interviews, quarterly interviews in FilaBavi 1999-2010 and the quarterly interviews in FilaBavi and Dodalab 2008-2010. The results are that the estimated means of birth weight match very well for both sexes.

The conclusions concerning birth weight are basically about comparisons over time, between socio-economic characteristics etc. The crucial issue is then if there could be systematic differences between e.g. different years and economic groups. We find it hard to think that mothers giving birth during specific years should intentionally exaggerate or underestimate birth weight. It appears more plausible that mothers in different socio-economic conditions should report differently but we fail to find any support for this.

The information about exclusive breastfeeding for the child was also obtained through interviews with mothers. Even if the interviewers were carefully trained to ask for data e.g. on additional foods from the whole period since birth or last interview, recall bias cannot be excluded. Moreover, it could not be excluded that hospital staff may have given an early formula meal without the knowledge of the mother, particularly to babies born with CS.

The present study shares these methodological problems with most other published breast feeding studies.

6.6.4. Measuring weight and length of infants

The principle for measurement was that the same field worker should assess a child at each visit using the same equipment. Weight was measured to the nearest 10 g with the child in light clothes using a portable mechanical infant scale. Length was measured to the nearest centimetre in horizontal position using a length board. Two persons worked together in order to have valid and reliable measurements and recordings [111, 149].

Children were supposed to be weighed in “light clothing”. An adjustment of 50 g was made for this. Special cases with more clothes were noted and appropriate adjustments were made. A number of commune health centre staff members in DodaLab were trained specifically to measure children. In FilaBavi, a number of the permanent interviewers were trained for the same purpose.

Ten per cent of all measurements were observed by field supervisors. Three per cent randomly selected forms were checked in re-interviews by field supervisors. Discrepancies were discussed with the surveyor to identify problems. All questionnaires were checked by the field supervisors. All forms were re-checked by data clerks before data entering.

6.6.5. Estimation of breastfeeding duration

Using the first time for reporting that a child is no longer exclusively breastfed to estimate the duration means that the duration is overestimated. We might say this is an optimistic approach. An alternative would be to use the last time for reporting breastfeeding which would create a negative bias, a pessimistic view. We have chosen to present the former but also investigated the other. The conclusions about urban rural differences and associations remain the same although the Kaplan-Meier curves are shifted to the left.

6.6.6. Internal and external validity, generalization

Internal validity is the matter of how good a study is conducted and how “true” the result are. To obtain a strong internal validity of the study, procedures and questionnaires were designed, tested and adapted to local language and context. Field workers were trained very carefully. Several supervision steps were applied to control the quality of data collection.

External validity addresses the ability to generalize results of the study to other contexts and other situations. The research was conducted on two sites within the capital of Vietnam. These areas are generally considered to have rather good socio-economic conditions compared with the rest of the country. Even so, the birth weights and growth of infants are higher in the urban area than in the rural area. This suggests that differences are also likely to occur in other, comparatively poorer, settings in Vietnam.

The results from the two specific HDSS cannot be generalized in a statistical sense. It is impossible to claim that the studied sites formally represent more than themselves. Public health research though, has a clear imperative that knowledge shall have a wider applicability for improvement of health in a broader context. Various forms of theoretical,

analytical and analogical generalization methods can help [101]. Ideally systems of several HDSS should be built that together would create a broad representativeness. There is a parallel to clinical trials. Individual experiments can produce interesting findings but only repeated trials can create a solid basis for action.

7. Conclusion

This thesis shows that there are large and significant differences in child birth weight, child growth and infant breastfeeding between urban and rural areas. All predictors of child birth weight and growth discussed are directly and indirectly associated to social and economic conditions.

To improve and maintain good conditions for child growth it is important to strengthen the education of mothers and improve the socio-economic conditions particularly in the rural areas. Globalization and urbanization means obvious risks for increasing gaps within and between the rural and urban areas. Large discrepancies in a society will lead to serious public health problems in all segments of the population.

8. Recommendations

The Vietnamese MoH should enhance the quality of the Integrated Management of Childhood Illness program aimed at helping lay community health workers assess and treat sick children. Improvements of health staff skills as well as the health system itself are obviously needed at least in the rural area.

The development of ANC practices, contents and quality, must be monitored. Programs for education of mothers concerning specific nutritional issues like the use of colostrum, importance of breastfeeding et cetera should be introduced into ANC routines.

The newly established regulation about a minimum of six months maternity leave will hopefully be an important measure to prolong the duration of breastfeeding. Different approaches to promote limitations of advertisement and marketing of formula milk should be explored and imposed.

9. Future research

A natural extension of the present studies would be to follow the children beyond two years of age to see how the observed differences develop with increasing age. Do the rural children catch up or do the gaps widen? After two years of age is also where tendencies to overweight as well as stunting are likely to develop more clearly and become possible to study. One ambition for further research is to continue follow-up to at least 5 years.

The present study describes the current situation and finds some associated factors to birth weight and growth of infants. To obtain a deeper insight of the mechanisms behind the observed statistical associations, qualitative research should be conducted to create better understanding of the knowledge, attitudes and practices of mothers, family members and healthcare staff.

The research was carried out in one rural area and one urban area of Vietnam and is not in a statistical sense necessarily representative for Vietnam. The possibilities of using methods for theoretical, analogical and other forms for generalization should be explored. However, even if some theoretical generalization can be demonstrated to be meaningful, the best way to get information for large areas, provincial and national, would be similar studies in other, strategically selected areas of Vietnam. To monitor the development over time it would be necessary to start new cohorts of newborns for follow-up with regular time intervals.

ACKNOWLEDGEMENTS

This thesis would not have been completed without the contribution of institutions, colleagues, friends, family members and many people who supported the creation and completion of this work. Actually, I feel that it is very difficult for me to state in words.

First of all, I would especially like to thank my supervisors and co- authors

Professor Henry Ascher, my main supervisor, for excellence guidance and encouragement in research and training. I have deeply admired your brilliant advice and suggestions whenever I have gotten stuck in research progress.

Professor Bo Eriksson, my co-supervisor for bringing me into research and providing me with the great opportunity to study in Nordic School of Public Health. You are the best teacher in my life, Bo. What I have learned from you is much more than what I am writing in this thesis. I could not have asked for anything better, and simply say: I am very happy to have been your student.

Professor Max Petzold, my co-supervisor, for great contributions in the process of writing my papers and my thesis. I am very grateful for your continuously valuable contribution and support to my studies.

Professor Nguyen Thi Kim Chuc, my co-supervisor and the coordinator of HSRP in Vietnam, for bringing me into HSRP and providing me opportunity to study in Sweden. Without your generous support, guidance and practical arrangement, my study would not have been possible.

Professor Nguyen Thanh Liem, my co supervisor and former director of my hospital, for very strong support and encouraging me to study in Sweden. Without your generous support, I could not have had the chance to study in Sweden.

Professor Göran Bondjers, former Dean of The Nordic School of Public Health and co-author, for recruiting me to become PhD student of NHV and support during the whole research process and in writing my papers and my thesis. Your continuous encouragement has made me more confident.

I would like to express my special thanks to those who accepted and given me opportunity to reach to this training state

Professor Vinod K. Diwan, head of IHCAR and coordinator of HSRP, for recruiting me and giving me the opportunity to be a PhD student in a very excellent environment, for your brilliant knowledge in science and warm support to my study.

Professor Lars Åke Persson, department of Children and Women's and Children's Health of Uppsala University, for giving me brilliant and valuable advice to my thesis.

Professor Le Thanh Hai, director of National Hospital of Pediatrics for valuable support and for encouraging me to continue my training in Sweden

Professor Tran Dinh Long, former head of Nephrology Department of National Hospital of Pediatrics for allowing me to continue my training program.

I greatly thank to my teachers, colleagues and friend in Sweden, who kindly supported me during my research and training

All professors and teachers at Nordic School of Public Health for your teaching and your contributions for my research competence development in one way or the other.

All the administrative staffs at Nordic School of Public Health and IHCAR for your valuable help in administration and practical arrangements.

All PhD students, master student at NHV, Karolinska Institutet, Umeå University and Gothenburg University: Dr Tran Khanh Toan, Dr. Nguyen Quang Huy, Dr. Nguyen Quynh Hoa, Dr. Pham Thai Son, Dr. Nguyen Ngoc Quang, Nguyen Cam Tu, Nguyen Minh Thoa, Umesh Raj Aryal, Abhinav Vaidya, Suraj Shakya, Susann Regber, Hanna Gyllensten, Hrafnhildur Gunnarsdottir, Ylva Bjereld, Johanna Andersson, Richard Steve and Do Minh Loan for valuable and useful discussions, comments related to research work, sharing your time with me in Sweden and helping me in many other aspects.

Special thanks to Susanne Tidblom-Kjellberger, Viveca Larsson, Anne Svanholm and your families for making a close friendship and a wonderful familial atmosphere in Sweden. With your help, I always feel that I am at home.

I also would like to thank to my colleagues and friends in Vietnam for the valuable support and contributions for my study:

Colleagues in the Nephrology and Dialysis Department of National Hospital of Pediatrics for their help, encouragement and especially their willingness to do my work when am away for training.

Colleagues and friends in FilaBavi, DodaLab and Health System Research Project offices: Nguyen Binh Minh, Nguyen Thi Hai, Nguyen Thi Phong Lan, Truong Hoang Long, Tran Kim Thanh, Nguyen Thi Thu Hong, Vu Duy Trang, Dinh Thi Thuy An, Dang Thi Tuyen, Tran Thanh Do, Ho Dang Phuc, Nguyen Ngoc Linh, Nghiem Nguyen Minh Trang and many others that I cannot mention their names.

In particular, I would like to say special thanks to Sida/SAREC, Health System Research project and the Nordic School of Public Health for financially supporting and giving me opportunity to study in Sweden. Thanks colleagues in Ba Vi district hospitals, Ba Vi District Health Centre, Phu Cuong CHC and Van Thang CHC, Dong Da District Health Centre, Kim Lien CHC, Quang Trung CHC and Trung Phung CHC and all households, fieldworkers in DodaLab and FilaBavi HDSS and others who participated in the project. Their contributions are invaluable and unforgettable.

Most of all, this thesis is dedicated to my family: to my beloved husband, my son and my daughter for all the love, constant devotion and encouragement that has given me energy to go forward. To my parents, my sister, my parent in law, my sisters in law, my nieces and nephews, for great support and patient care of my children from time that I started this thesis.

Thanks all of those I did not mention by name here. Thank you all for your love.

Gothenburg, 2014 Nguyen Thu Huong

REFERENCES

1. Barker DJP: **Fetal origins of coronary heart disease.** *BMJ* 1995, **311**:171-174.
2. Barker DJP: **Fetal programming of coronary heart disease.** *Trends Endocrinol Metab* 2002, **13**(9):364 - 368.
3. J G Eriksson, T Forsén, J Tuomilehto, C Osmond, Barker DJP: **Early growth and coronary heart disease in later life: longitudinal study.** *BMJ* 2001, **322**:949-953.
4. Danaei G, Finucane MM, Lu Y, Singh GM, Cowan MJ, Paciorek CJ, Lin JK, Farzadfar F, Khang YH, Stevens GA *et al*: **National, regional, and global trends in fasting plasma glucose and diabetes prevalence since 1980: systematic analysis of health examination surveys and epidemiological studies with 370 country-years and 2·7 million participants.** *The Lancet* 2011, **378**(9785):31-40.
5. Son PT, Quang NN, Viet NL, Khai PG, Wall S, Weinehall L, Bonita R, Byass P: **Prevalence, awareness, treatment and control of hypertension in Vietnam: results from a national survey.** *Journal of Human Hypertension* 2012, **26**(4): 268-280.
6. Seward JF, Serdula MK: **Infant feeding and infant growth.** *Pediatrics* 1984, **74**(4):728-762.
7. Robert E Black, Lindsay H Allen, Zulfiqar A Bhutta, Laura E Caulfield, Mercedes de Onis, Majid Ezzati, Colin Mathers, Rivera J: **Maternal and child undernutrition: global and regional exposures and health consequences.** *The Lancet* 2008 **371**(9608):243 - 260.
8. Lakshman R, Zhang J, Zhang J, Koch FS, Marcus C, Ludvigsson J, Ong KK, Sobko T: **Higher maternal education is associated with favourable growth of young children in different countries.** *J Epidemiol Community Health* 2013, **67**(7):595-602.
9. Alom J, Quddus MA, Islam MA: **Nutritional status of under-five children in Bangladesh: a multilevel analysis.** *J Biosoc Sci* 2012, **44**(5):525-535.
10. Teresa Janevic, Oliver Petrovic, Ivana Bjelic, Amber Kubera: **Risk factors for childhood malnutrition in Roma settlements in Serbia.** *BMC Public Health* 2010, **10**:509
11. Amy Webb Girard, Oluwafunke Olude: **Nutrition Education and Counselling Provided during Pregnancy: Effects on Maternal, Neonatal and Child Health Outcomes.** *Pediatric and Perinatal Epidemiology*. Available from: <http://onlinelibrarywileycom/doi/101111/j1365-3016201201278x/full> 2012.
12. Aras RY, Shenoy AJ, Chavan YB, Pai NP: **Effectiveness of antenatal care on weight of infants attending underfive clinic.** *Indian J Public Health* 1996, **40**(4):101-105.

13. WHO: **The Ottawa Charter for Health Promotion. First International Conference on Health Promotion, Ottawa, 21 November 1986.** Available from: <http://www.who.int/healthpromotion/conferences/previous/ottawa/en/> 1986.
14. Hop LT: **Secular trend in size at birth of Vietnamese newborns during the last 2 decades (1980- 2000).** *Asia Pacific J Clin Nutr* 2003, **12**(3):266-270.
15. Chowdhury S, Ammari F, Burden AC, Gregory R: **Secular trend in birth weight in native White and immigrant South Asian populations in Leicester, UK: possible implications for incidence of type 2 diabetes in the future.** *Practical Diabetes Int* 2000, **17**(4):104-108.
16. Ulijaszek S: **Secular trend in birthweight among the Purari delta population, Papua New Guinea.** *Ann Hum Biol* 2001, **28**(3):246-255.
17. Satpathy R, Das DB, Bhuyan BK, Pant KC, Santhanam S: **Secular trend in birthweight in an industrial hospital in India.** *Ann Trop Paediatr* 1990, **10**(1):21-25.
18. UNICEF/WHO: **Low birth weight. Country, regional and global estimate.** In.: New York: United Nations Children's Fund and World Health Organization, 2004
19. Stacy Beck, Daniel Wojdyla, Lale Say, Ana Pilar Betran, Mario Meriáldi, Jennifer Harris Requejo, Craig Rubens, Ramkumar Menon, Paul FA Van Look: **The worldwide incidence of preterm birth: a systematic review of maternal mortality and morbidity.** *Bulletin of the World Health Organization* 2010, **88**: 31-38.
20. Goldenberg RL, Culhane JF, Iams JD, Romero R: **Epidemiology and causes of preterm birth.** *The Lancet* 2008, **371**(9606):75-84.
21. de Onis M, Blössner M, Villar J: **Levels and patterns of intrauterine growth retardation in developing countries.** *Eur J Clin Nutr* 1998, **52**(1):5-15.
22. David Peleg, Colleen M. Kennedy, Stephen K. Hunter: **Intrauterine Growth Restriction: Identification and Management.** *Am Fam Physician* 1998, **58**(2):453-460.
23. Magnus P, Berg K, Bjerkedal T, Nance WE: **Parental determinants of birth weight.** *Clin Genet* 1984, **26**(5):397-405.
24. L B Johnston, A J L Clark, M O Savage: **Genetic factors contributing to birth weight.** *Arch Dis Child Fetal Neonatal* 2002, **86**(1):2-3.
25. Magnus P: **Causes of variation in birth weight: a study of offspring of twins.** *Clin Genet* 1984, **25**(1):15-24.
26. Zhang RL, Chen LP, Chen QY, Xiu XY, Chen JF, Wang XM: **Study on the influence of maternal physiology, mentality and prenatal health care on children born with low birth weight.** *Zhonghua Liu Xing Bing Xue Za Zhi* 2008, **29**(6):569-572.

27. Griffiths LJ, Dezateux C, Cole TJ: **Differential parental weight and height contributions to offspring birthweight and weight gain in infancy.** *Int J Epidemiol* 2007, **36**(1):104-107.
28. Oliver G Brooke, H Ross Anderson, J Martin Bland, Janet L Peacock, Stewart CM: **Effects on birth weight of smoking, alcohol, caffeine, socioeconomic factors, and psychosocial stress.** *BMJ* 1989, **298**(6676):795–801.
29. Magee BD, Hattis D, Kivel NM: **Role of smoking in low birth weight.** *J Reprod Med* 2004, **49**(1):23-27.
30. UNICEF: **ChildInfo. Monitoring the Situation of Children and Women. Statistics By Area / Child Nutrition. A World Fit for Children Goal.** Available from: [http://www.childinfo.org/low_birthweight.html] 2013.
31. McCormick MC: **The contribution of low birth weight to infant mortality and childhood morbidity.** *N Engl J Med* 1985, **312**(2):82-90.
32. Mahrshahi S, Battistutta D, Magarey A, Daniels LA: **Determinants of rapid weight gain during infancy: baseline results from the NOURISH randomised controlled trial.** *BMC Pediatr* 2011, **11**:99.
33. Rosenbloom AL: **Physiology of Growth.** *Anestlé* 2007, **65**:97-108.
34. C. R. M. Silveira, M. G. Beghetto, P. R. A. Carvalho, E. D. Mello: **Comparison of NCHS, CDC and WHO growth charts in the nutritional assessment of hospitalized children up to five years old.** *Nutr Hosp* 2011, **26**(3):465-471.
35. WHO: **Child growth standards - The WHO child growth standards.** Available from: http://www.who.int/childgrowth/standards/chts_wfa_boys_z/en/index.html. 2012.
36. Mercedes de Onis, David Brown, Monica Blössner, Borghi E: **Level and Trends in Child Malnutrition. UNICEF- WHO- The World Bank Joint Child Malnutrition Estimates.** Available from WHO web site: http://www.who.int/about/licensing/copyright_form/en/index.html 2012.
37. Shea Oscar Rutstein, Rojas G: **Guide to DHS statistics. Demographic and Health Surveys Methodology.** *This document is part of the Demographic and Health Survey's DHS Toolkit of methodology for the MEASURE DHS Phase III project, implemented from 2008-2013* 2006.
38. USAID: **Measure Demographic and Health Survey.** Available from: <http://www.measuredhs.com/> 2013.
39. Chloe Angood, Marko Kerac, Marie Mc Grath, Jeramy Shoham: **Management of Acute Malnutrition in Infants (MAMI) Project.** Available from: [www.ennonline.net/research]. 2010.
40. WHO: **Stunting among children aged five or younger: inequality by child's sex.** http://www.who.int/gho/health_equity/outcomes/stunting_children/en/. 2013.

41. Mendelson S: **Child malnutrition in India: Why does it persist?** Available from: www.cini.org.uk/childmalnutrition.pdf. 2005.
42. Onis Md, Wijnhoven TMA, Onyango AW: **Worldwide practices in child growth monitoring.** *J Pediatr* 2004, **144**(4):461-465.
43. Kurup PJ, Khandekar R: **Low birth weight as a determinant of protein energy malnutrition in "0-5 years" Omani children of South Batinah region, Oman.** *Saudi Med J* 2004, **25**(8):1091-1096.
44. Brooks AM, Byrd RS, Weitzman M, Auinger P, McBride JT: **Impact of low birth weight on early childhood asthma in the United States.** *Arch Pediatr Adolesc Med* 2001, **155**(3):401-406.
45. Banci M, Saccucci P, Dofcaci A, Sansoni I, Magrini A, Bottini E, Gloria-Bottini F: **Birth weight and coronary artery disease. The effect of gender and diabetes.** *Int J Biol Sci* 2009, **5**(3):244-248.
46. Mohammadzadeh A, Farhat A, Amiri R, Esmaeeli H: **Effect of Birth Weight and Socioeconomic Status on Children's Growth in Mashhad, Iran.** *Int J Pediatr* 2010, **2010**:1-5.
47. Hien NT, Ushijima H: **Nutrition status of low birthweight ethn minority infants in Backan province, Vietnam.** *Pediatr Int* 2007, **49**(2):266-272.
48. N H Ng'andu, Watts TE: **Child growth and duration of breast feeding in urban Zambia.** *J Epidemiol Community Health* 1990, **44**(4):281-285.
49. Hop LT, Gross R, Giay T, Sastroamidjojo S, Schultink W, Lang NT: **Premature Complementary Feeding Is Associated with Poorer Growth of Vietnamese Children** *J Nutr* 2000, **130**(11):2683-2690.
50. Owen CG, Martin RM, Whincup PH, Smith GD, Cook DG: **Effect of infant feeding on the risk of obesity across the life course: a quantitative review of published evidence.** *Pediatrics* 2005, **115**(5):1367-1377.
51. Patwari AK: **Diarrhoea and malnutrition interaction.** *Indian J Pediatr* 1999, **66**(1):124-134.
52. Bittencourt SA, Leal Mdo C, Rivera J: **Diarrhea and growth among children under 18 months of age in Rio de Janeiro.** *Bull Pan Am Health Organ* 1993, **27**(2):135-144.
53. Vaktskjold A, Trí ĐV, Phi DT, Sandanger T: **Infant growth disparity in the Khanh Hoa provine in Vietnam: A follow- up study.** *BMC Pediatrics* 2010, **10**:62.
54. Kolsteren PW, Kusin JA, Kardjati S: **Morbidity and growth performance of infants in Madura, Indonesia.** *Ann Trop Paediatr* 1997, **17**(3):201-208.
55. WHO: **Exclusive breastfeeding. Nutrition topics.** Available from: http://www.who.int/nutrition/topics/exclusive_breastfeeding/en/ 2013.

56. Gartner L, Morton J, Lawrence R, Naylor A, O'Hare D, Schanler Rea: **Breastfeeding and the Use of Human Milk, section on breastfeeding.** *Pediatrics* 2005, **115** (2):496-506.
57. Chen A, Rogan WJ: **Breastfeeding and the risk of postneonatal death in the United States.** *Pediatrics* 2004, **113**(5):435-439.
58. Wilson AC FJ, Greene SA, et al: **Relation of infant diet to childhood health: seven year follow up of cohort children in Dundee infant feeding study.** *BMJ* 1998, **316**(7124):21–25.
59. Lamberti LM, Fischer Walker CL, Noiman A, Victora C, Black RE: **Breastfeeding and the risk for diarrhea morbidity and mortality.** *BMC Public Health* 2011, **11**(3):15.
60. Mary S Fewtrell, Jane B Morgan, Christopher Duggan, Geir Gunnlaugsson, Patricia L Hibberd, Alan Lucas, Kleinman RE: **Optimal duration of exclusive breastfeeding: what is the evidence to support current recommendations.** *Am J Clin Nutr* 2007, **85**(2):635-638.
61. Bernardo L. Horta, Rajiv Bahal, Martines JC, Cesar G. Victora: **Evidence on the long- term effects of breastfeeding. Systematic reviews and meta analyses** WHO; 2007.
62. Michael S. Kramer , Lidia Matush, Irina Vanilovich, Robert W. Platt, Natalia Bogdanovich, Zinaida Sevkovskaya, Irina Dzikovich, Gyorgy Shishko, Jean-Paul Collet, Richard M. Martin *et al*: **A Randomized Breast-feeding Promotion Intervention Did Not Reduce Child Obesity in Belarus.** *The American Institute of Nutrition* 2009, **139**(2):4175-4215.
63. Marie-Jo A Brion, Debbie A Lawlor, Alicia Matijasevich, Bernardo Horta, Luciana Anselmi, Cora L Araújo, Ana Maria B Menezes, Cesar G Victora, George Davey Smith: **What are the causal effects of breastfeeding on IQ, obesity and blood pressure? Evidence from comparing high-income with middle-income cohorts.** *Int J Epidemiol* 2011, **40**(3):670–680.
64. Kramer MS, Aboud F, Mironova E, Vanilovich I, Platt RW, Matush L, Igumnov S, Fombonne E, Bogdanovich N, Ducruet T *et al*: **Breastfeeding and child cognitive development: new evidence from a large randomized trial.** *Arch Gen Psychiatry* 2008, **65**(5):578-584.
65. Wiener R, Wiener M: **Breastfeeding prevalence and distribution in the USA and Appalachia by rural and urban setting.** *Rural and Remote Health* 2011, **11**(2):1713.
66. Senarath U, Dibley MJ, Agho KE: **Factors associated with nonexclusive breastfeeding in 5 east and southeast Asian countries: a multilevel analysis.** *J Hum Lact* 2010, **26**(3):248-257.
67. Ahmed S, Parveen SD, Islam A: **Infant feeding practices in rural Bangladesh: policy implications.** *J Trop Pediatr* 1999, **45**(1):37-41.

68. Helen L McLachlan, Della A Forster: **Initiatial breastfeeding attitudes and practices of women born in Turkey, Vietnam and Australia after giving birth in Australia** *Int Breastfeeding J* 2006, **1**:7.
69. Duong DV, Binns CW, Lee AH: **Breast-feeding initiation and exclusive breast-feeding in rural Vietnam.** *Public Health Nutr* 2004, **7**:795-799.
70. Qiu L, Zhao Y, Binns CW, Lee AH, Xie X: **Initiation of breastfeeding and prevalence of exclusive breastfeeding at hospital discharge in urban, suburban and rural areas of Zejiang China.** *Int Breastfeeding J* 2009, **4**:1.
71. Lundberg PC, Thu TTN: **Breast-feeding attitudes and practices among Vietnamese Mothers in Ho Chi Minh City.** *Midwifery* 2012, **28**(2):252-257.
72. Samir Arora, Cheryl McJunkin, Julie Wehrer, Kuhn P: **Major Factors Influencing Breastfeeding Rates: Mother's Perception of Father's Attitude and Milk Supply.** *Pediatrics* 2000, **106** (5):67
73. Duong DV, Lee AH, Binns CW: **Determinants of breast-feeding within the first 6 months post-partum in rural Vietnam.** *J Paediatr Child Health* 2005, **41**:338–343.
74. Deaden K, Quan NL, Do M, Marsh D, Pachón H, Schroede D, Lang T: **Work outside the home is the primary barrier to exclusive breastfeeding in rural Vietnam: insights from mothers who exclusive breastfeed and worked.** *Food Nutr Bull* 2002, **23**(4):101-108.
75. Huong NT, Bo Eriksson, Toan TK, Max Petzold, Bondjers G, Chuc NTK, Liem NT, Ascher H: **Breastfeeding practices in one urban and one rural area of Hanoi Vietnam.** *BMC Public Health* 2012, **12**:964.
76. National-Assembly-of-Socialist-Republic-of-Vietnam: **Social insurance law.** In: 71/2006/QH11. [http://www.congdoanbdvn.org.vn/writing/document_para.aspx]; 2006.
77. Liqian Q, Yun Z, Colin W, Andy H, Xing X: **A cohort study of infant feeding practices in city, suburban and rural areas in Zhejiang province, PR China.** *Int Breastfeeding J* 2008, **3**:4.
78. Upul Senarath, Michael. J.Dibley, Kingsley.E.Agho: **Factors associated with non exclusive breastfeeding in 5 East and Southeast Asia countries: A multilevel analysis** *J Hum Lact* 2010, **26**(3):248-257.
79. Vietnam General Statistics Office: **Vietnam national census of population and housing in 2009: main results.** In. Hanoi: Statistical Publishing House; 2010.
80. Tho TV: **Chapter 2 in The Vietnamese Economy: Awakening the dorming dragon. Economic development in Vietnam during the second half of the 20th century: How to avoid the danger of lagging behind.** Available from: http://www.f.waseda.jp/tvttran/en/recentpapers/E03_Longterm_development_of_Vietnam.pdf 2003

81. UNICEF-Vietnam: **The children in Vietnam**. Available from:
[<http://www.unicef.org/vietnam/children.html>]. 2012.
82. Kien-Giang-Union-of-Friendship-Organizations, Kien-Giang-Women's- Union:
Housing, Water and Sanitation Improvement Credit Project/Kien Giang.
http://www.ewb.org.au/resources/download/2405P2012-02-22_20:52:19. *Habitat for Humanity Vietnam Website* 2011.
83. Camellia Staykova, Kingdom B: **Water Supply and Sanitation Strategy. Building on a solid foundation**. Available from:
<http://water.worldbank.org/publications/water-supply-and-sanitation-strategy-building-solid-foundation>. 2006.
84. World Bank: **Vietnam growing healthy: A review of Vietnam's health sector**. In: *Government Fiscal Year*. Hanoi, Vietnam: Worl Bank; 2001: 217.
85. Nguyen Quoc Trieu et all: **MOH, Joint anual health review**. *Vietnam Misntriy of Health Hanoi* 2009:13-17.
86. Ministry-of-Health: **The Vietnam Health Report 2006**. Available from:
<http://jahr.org.vn/downloads/Nghien%20cuu/Khac/Vietnam%20National%20Health%20Report%202006.pdf>.2006.
87. National-Assembly: **Law of Health Insurance 25/2008/QH12**. Available from:
http://www.chinhphu.vn/portal/page/portal/chinhphu/hethongvanban?class_id=1&page=1&mode=detail&document_id=81142. 2008.
88. **National Expended Immunization Program** <http://www.nihe.org.vn/items-vn/chuong-trinh-tiem-chung-mo-rong-quoc-gia.vhtm?page=2>. In.: National Institute of Hygiene and Epidemiology; 2012.
89. Vietnam-Ministry-of-Health: **Join Annual Health Review 2011**.
http://jahr.org.vn/index.php?option=com_content&view=article&id=117&Itemid=57&lang=en. In 2010.
90. UNICEF: **State of the world's children**.
[<http://www.unicef.org/sowc09/report/report.php>]. In.; 2009.
91. UNICEF-Vietnam: **Child Survival**.
[<http://www.unicef.org/vietnam/immunization.html>]. 2012.
92. National-Institute-of-Nutrition-and-UNICEF: **A review of the nutrition situation in Vietnam 2009-2010**. *Medical Publishing House* 2011.
93. Khan NC, Tuyen le D, Ngoc TX, Duong PH, Khoi HH: **Reduction in childhood malnutrition in Vietnam from 1990 to 2004**. *Asia Pac J Clin Nutr* 2007, 16(2):274-278.
94. WHO: **Department of Making Pregnancy Safer. Vietnam Country profile**. 2007 [http://www.who.int/making_pregnancy_safer/countries/vtn.pdf].

95. Dieu HT, Dibley MJ, Sibbritt DW, Hanh TT: **Trends in overweight and obesity in pre-school children in urban areas of Ho Chi Minh City, Vietnam, from 2002 to 2005.** *Public Health Nutr* 2009, **12**(5):702-709.
96. Vietnam Council of Ministers: **Decree on some regulations on population and family planing.** In. Hanoi: Council of Ministers Office; 1988.
97. **Population Ordinance** In: *Number 06/2003/PL-UBTVQH11.* National Assembly Standing Commity; 2003.
98. **Providing for sanctioning of administrative violations and child population.** In: *114/2006/NĐ-CP.* Vietnam goverment; 2006.
99. Tiep BTM: **Impacts of changes on age structure of population in economic development in Vietnam.** *Population and Development* 2011, **11**(128).
100. Belanger D: **Son preference in a rural village in North Vietnam.** *Stud Fam Plann* 2002, **33**(4):321-334.
101. Toan TK: **Antenatal and delivery care utilization in urban and rural contexts in Vietnam - A study in two health and demographic surveillance sites.** *PhD thesis.* Gothenburg; 2012.
102. UNFPA: **Sex ratio at birth imbalances in Vietnam: Evidence from the 2009 census.** Available from: http://www.unfpa.org/webdav/site/vietnam/shared/UNFPA_SRB_Booklet_2010_Eng.pdf. 2010.
103. Dat V Duong, Colin W Binns, Andy H Lee: **Introduction of complementary food to infants within the first six months postpartum in rural Vietnam.** *Acta Paediatrica* 2005, **94**(12):1714-1720.
104. Van Hoan N, Van Phu P, Salvignole B, Bergera J, Trèchea S: **Effect of the consumption of high energy dense and fortified gruels on energy and nutrient intakes of 6-10-month-old Vietnamese infants.** *Appetite* 2009, **53**(2):233-240.
105. Pham VP, Nguyen VH, Salvignol B, Treche S, Wieringa FT, Dijkhuizen MA, Nguyen CK, Pham DT, Schwartz H, Berger J: **A Six-Month Intervention with Two Different Types of Micronutrient-Fortified Complementary Foods Had Distinct Short- and Long-Term Effects on Linear and Ponderal Growth of Vietnamese Infants.** *J Nut* 2012, **142**(9):1735-1740.
106. Vietnam-General-statistics-office: **Vietnam population and housing census 2009. Migration and urbanization in Vietnam: pattern, trends and differentials.** Available from: http://vietnam.unfpa.org/webdav/site/vietnam/shared/Census%20publications/7_Monograph-Migration-Urbanization.pdf. *Ministry of planing and investment* 2009.
107. University-of-Michigan: **Urbanization and Global Change.** Available from: http://www.globalchange.umich.edu/globalchange2/current/lectures/urban_gc/. 2002.

108. Pichler F, Shucksmith M, Cameron S, Merridew T: **First Europeance Quality of Life Survey: Urban - Rural differences**. Available from: <http://www.eurofound.europa.eu/pubdocs/2006/63/en/1/ef0663en.pdf>. *European Foundation for the Improvement of Living and Working Condition* 2006.
109. UNFPA: **Linking population, powerty and development. Urbanization: A Majority in Cities**. Available from: <http://www.unfpa.org/pds/urbanization.htm>. 2007.
110. Tran TK, Nguyen CTK, Nguyen HD, Eriksson B, Bondjers G, Gottvall K, Ascher H, Petzold M: **Urban - rural disparities in antenatal care utilization: a study of two cohorts of pregnant women in Vietnam**. *BMC Health Serv Res* 2011, **11**(1):120.
111. Huong NT, Eriksson B, Liem NT, Chuc NTK, Petzold M, Bondjers G, Ascher H: **Physical growth during the first year of life. A longitudinal study in rural and urban areas of Hanoi, Vietnam**. *BMC Pediatr* 2012, **12**:26
112. Roystone P, Altman D: **Regression using fractional polynomials of continuous covariates: parsimonious parametric modeling**. *Journal of the Royal Statistical Society* 1994, **43**(3):429-467.
113. WHO: **Indicators for assessing infant and young child feeding practices : conclusions of a consensus meeting held 6–8 November 2007 in Washington D.C., USA**. Available from: <http://www.who.int/nutrition/publications/infantfeeding/9789241596664/en/> 2008.
114. UNFPA: **Sex Ratio At Birth In South East Asia With A Focus On Viet Nam. An annotated bibliography designed to guide futher policy research**. Avaiaible from: http://vietnamunfpaorg/webdav/site/vietnam/shared/UNFPABibliography_Engpdf 2010.
115. WHO: **Child Growth Standards: length/height-for age, weight-for length,weight for height and body mass index - for - age: method and development**.Available from: http://www.who.int/childgrowth/standards/technical_report/en/. 2006
116. Curt Lofgren, Nguyen X Thanh, Nguyen TK Chuc, Anders Emmelin, Lars Lindholm: **People's willingness to pay for health insurance in rural Vietnam**. *Cost Eff Resour Alloc* 2008, **6**:16.
117. Tuan T, Dung VT, Neu I, Dibley MJ: **Comparative quality of private and public health services in rural Vietnam**. *Health Policy Plan* 2005, **20**(5):319-327.
118. Tine Gammeltoft, Nguyễn HTT: **The commodification of obstetric ultrasound scanning in Hanoi, Vietnam**. *Reprod Health Matters* 2007, **15**(29)(29):163 - 171.

119. World-Statistics: **Prevalence of anemia among pregnant women % - Health Nutrition and Population Statistics.** *Encyclopedia of the Nations* 2011. Available from: [<http://www.nationsencyclopedia.com/WorldStats/HNP-prevalence-anemia-pregnant-women.html>].
120. UNICEF: **UNICEF and Nutritional Institute of Nutrition. A review of the nutrition situation in Vietnam 2009-2010.** *Medical Publishing House* www.unicef.org/vietnam/resources_16434.html. 2011.
121. Tran Thi Minh Hanh, Tatsushi Komatsu, Nguyen Thi Kim Hung, Nguyen Van Chuyen, Yukio Yoshimura, Pham Gia Tien, Yamamoto S: **Nutritional Status of Middle-Aged Vietnamese in Ho Chi Minh City.** *J Am Coll Nutr* 2001, **20**(6):616-622.
122. Cuong LQ, Oanh TTM, Khuong Anh Tuan, Duong Huy Luong: **Hospital overload in Hanoi and Ho Chi Minh City – An assessment and recommendations.** *Health Strategy and Policy Institute* 2009. Available at: <http://www.hspi.org.vn/vcl/en/home/InfoDetail.jsp?area=1&cat=100&ID=1043>.
123. Lumbiganon P, Laopaiboon M, Gulmezoglu AM, Souza JP, Taneepanichskul S, Ruyan P, Attygalle DE, Shrestha N, Mori R, Nguyen DH *et al*: **Method of delivery and pregnancy outcomes in Asia: the WHO global survey on maternal and perinatal health 2007-08.** *Lancet* 2010, **375**(9713):490-499.
124. Guilmoto CZ, Hoang X, Van TN: **Recent increase in Sex Ratio at Birth in Vietnam.** *PloS ONE* 2009, **4**(2):4624.
125. Hesketh T, Xing ZW: **Abnormal sex ratios in human populations: causes and consequences.** *Proc Natl Acad Sci U S A* 2006, **103**(36):13271-13275.
126. Vaktskjold A, Trí ĐV, Odland JØ, Sandanger T: **Parity and Birth Weight in the Khanh Hoa province, Vietnam.** *The Open Women's Health J* 2010, **4**:1-4.
127. Shoham Y I, Barell V: **Maternal Education as a Modifier of the Association between Low Birthweight and Infant Mortality.** *Int J Epidemiol* 1988, **17**(2):370-377.
128. Florey CD, Taylor DJ: **The relation between antenatal care and birth weight.** *Rev Epidemiol Sante Publique* 1994, **42**(3):191-197.
129. Peter J. Donaldson, Jonh O. G. Billy: **The Impact of Prenatal Care on Birth Weight. Evidence from an Intenational Data Set.** *Medical Care* 1984, **22**:177-188.
130. He M, Mei J, Jiang Z, Chen Q, Ma J, Dai J, Li M, Su Y, Lui SS, Yeung DL *et al*: **Growth of infants during the first 18 months of life in urban and rural areas of southern China.** *J Paediatr Child Health* 2001, **37**(5):456-464.
131. Li H, Zong X, Zhang J, Zhu Z: **Physical growth of children in urban, suburban and rural mainland China: a study of 20 years change.** *Biomed Environ Sci* 2011, **24**(1):1-11.

132. Graham GG, MacLean WC, Jr., Kallman CH, Rabold J, Mellits ED: **Urban-rural differences in the growth of Peruvian children.** *Am J Clin Nutr* 1980, **33**(2):338-344.
133. Hop LT, Gross R, Giay T, Schultink W, Thuan BT, Sastroamidjojo S: **Longitudinal observation of growth of Vietnamese children in Hanoi, Vietnam from birth to 10 years of age.** *Eur J Clin Nutr* 1997, **51**(3):164-171.
134. Nguyen ND, Allen JR, Peat JK, Schofield WN, Nossar V, Eisenbruch M, Gaskin KJ: **Growth and feeding practices of Vietnamese infants in Australia.** *Eur J Clin Nutr* 2004, **58**(2):356-362.
135. Rayhan I, Khan SH: **Factors Causing Malnutrition among under Five Children in Bangladesh.** *Pakistan Journal of Nutrition* 2006, **5**(6):558-562.
136. WHO: **Core health indicators for Viet Nam.** *WHO Statistical Information System* 2006. http://apps.who.int/whosis/database/core/core_select.cfm.
137. **Government of the Socialist Republic of Vietnam, 226/QĐ-TTg - 2012. To approve the national strategy on nutrition period 2011 - 2020 and Vision 2030.** Available at: <http://www.chinhphu.vn/portal/page/portal/chinhphu/noidungchienluocphattrienkinhtexahoi>. 2012
138. Huong Thi Le, Nga Thi Thu Vu, Doan Thi Thu Huyen, NV T: **Overweight, obesity and associated factors among secondary school students in a northern city of Vietnam in 2011.** *Health Policy Plan* 2013, **5**(1):24-29.
139. WHO: **Infant and young child feeding.** Available at: <http://www.who.int/mediacentre/factsheets/fs342/en/index.html> July 2010.
140. Kramer MS, Guo T, Platt RW, Shapiro S, Collet JP, Chalmers B, Hodnett E, Sevkovskaya Z, Dzikovich I, Vanilovich I: **Breastfeeding and infant growth: biology or bias?** *Pediatrics* 2002, **110**(2 Pt 1):343-347.
141. López-Alarcón M, Villalpando S, Fajardo A: **Breast-Feeding Lowers the Frequency and Duration of Acute Respiratory Infection and Diarrhea in Infants under Six Months of Age.** *J Nutr* 1997, **127**(3):436 - 443.
142. **Labor law.** In: 10/2012/QH13. National Assembly of Socialist Republic of Vietnam; 18th June, 2012.
143. WHO: **Child Growth Standards based on length/height, weight and age.** *Acta Paediatr Suppl* 2006, **450**:76-85.
144. Shirimaa R, Greinera T, Kylberga E, Gebre-Medhina M: **Exclusive breast-feeding is rarely practised in rural and urban Morogoro, Tanzania.** *Public Health Nutrition* 1999, **4**(2):147-154.
145. Liubai L, Doan T, Nguyen T, Hiroshi U: **Prevalance of breastfeeding and its correlates in Ho Chi Minh city.** *Pediatr Int* 2002, **44**(1):47-54.

146. Sutton J, He M, Despard C, Evans A: **Barriers to breastfeeding in a Vietnamese community: a qualitative exploration.** *Can J Diet Pract Res* 2007, **68**(4):195-200.
147. Lundberg PC, Trieu TN: **Vietnamese women's cultural beliefs and practices related to the postpartum period.** *Midwifery* 2011, **27**(5):731-736.
148. Huy TQ, Long NH, Hoa DP, Byass P, Ericksson B: **Validity and completeness of death reporting and registration in a rural district of Vietnam.** *Scand J Public Health Suppl* 2003, **62**:12-18.
149. Yen NT: **Longitudinal observation of growth and development of Vietnamese children from birth to five year-olds.** *PhD's thesis.* Hanoi Medical University; 2004.