Childhood overweight and obesity in preschool children – an emerging problem in urban and rural Vietnam

A study of epidemiology and associated factors

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Gothenburg 2017

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ISBN 978-91-629-0098-4 (PRINT)
ISBN 978-91-629-0097-7 (PDF)

Gothenburg, Sweden 2017
Printed by Ineko AB

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ABSTRACT

Background: Childhood overweight and obesity is considered a global epidemic. From being a health problem mainly in high-income countries, it is now an emerging problem in low- and middle-income parts of the world as well. Contextual knowledge of obesity development dynamics is important as a basis for prevention and intervention strategies.

Aims: To study overweight and obesity in preschool children focusing on prevalence, incidence and associated factors including parents' conceptions, in one urban and one rural setting of Hanoi, Vietnam.

Methods: All studies were conducted identically in two Health and Demographic Surveillance Sites, one urban and one rural. Cross-sectional studies were used to study the prevalence of overweight, obesity and associated factors as well as feeding practices involving a total of 2,677 children three to six years of age. Follow-up studies of the same children were used to describe incidences and prevalence changes over three years. Parents were interviewed and anthropometric data of children and parents were collected. The children were classified as overweight or obese following the definitions of the International Obesity Task Force. Focus group discussions about mothers' conceptions of childhood overweight were conducted and analysed with a phenomenographic approach.

Results: In 2013, the estimated prevalence of overweight in the urban and rural area was 13.3% and 4.8% respectively. For obesity, the prevalence was 9.2% and 3.5% respectively. Three years later, the prevalence of overweight increased to 25.6% in the urban and to 7.7% in the rural children. The prevalence of obesity decreased to 7.1% in the urban and to 1.9% in the rural

rural area, frequent consumption of fried food, irregular snacks, and increased sedentary time were identified as additional risk factors. The main protective factors were physical activity, having meals at home in the urban area and longer sleep duration at night in the rural area. At the family level, higher socioeconomic status was associated with a higher prevalence of overweight in the urban children. Frequently watching TV food advertisement and availability of snacks at home were risks for the rural children. The qualitative study showed that mothers were concerned about health problems in overweight children. They used their own experiences, growth charts and information from health care providers as well as the mass media to recognise overweight. The mothers considered unhealthy lifestyle, heritability and economic development as factors contributing to overweight development and based their management of overweight on these as much as possible. This was sometimes challenged by grandparents who commonly regard chubbiness as healthy.

Conclusion: The prevalence of overweight among preschool children is considerable in Vietnam and increases with age, particularly in the urban area. Obesity prevention and interventions should start early, already at preschool age and include education programmes with focus on healthy lifestyle for children as well as the entire extended families, not least grandparents. The prevention and interventions should preferably be tailored differently for urban and rural areas. Restrictions on non-healthy food advertisements are recommended.

Keywords: overweight, obesity, preschool children, follow-up study, IOTF, Vietnam.

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SAMMANFATTNING PÅ SVENSKA

Bakgrund: Övervikt och fetma bland barn utgör idag en global epidemi. Från att ha varit ett hälsoproblem främst i höginkomstländer, är det nu ett växande problem också i låg- och medelinkomstländer. Kunskap om hur fetma uppstår och utvecklas är viktigt som underlag för förebyggande strategier och interventioner.

Mål: Att studera övervikt och fetma hos förskolebarn i städer och på landsbygd i Hanoi, Vietnam, med fokus på prevalens, incidens och associerade faktorer, och föräldrarnas uppfattningar.

Metoder: Samtliga studier genomfördes på samma sätt vid två epidemiologiska fältstationer, en i den urbana delen av Hanoi och en i den rurala. Tvärsnittsstudier med sammanlagt 2,677 barn, tre till sex år gamla, gjordes för att studera förekomsten av övervikt, fetma och associerade faktorer och ätvanor. Uppföljande studier av samma barn gjordes för att beskriva förändringar i incidens och prevalens över tre år. Föräldrar intervjuades och antropometriska uppgifter om barn och föräldrar insamlades. Övervikt och fetma klassificerades utifrån definitionerna av International Obesity Task Force. Fokusgruppsdiskussioner med mödrar om övervikt bland barn genomfördes och analyserades med en fenomenografisk ansats.

Resultat: Den uppmätta prevalensen av övervikt i den urbana studien och i den rurala var 13,3% bland urbana barn och 4,8% bland barn i rural miljö år 2013. För fetma var prevalensen 9,2% respektive 3,5%. Tre år senare hade prevalensen av övervikt ökat till 25,6% bland urbana barn och 7,7% bland rurala. Prevalensen av fetma minskade till 7,1% respektive 1,9%. De viktigaste riskfaktorerna på barnets individuella nivå både i stad och på landsbygd var stor matkonsumtion och frekvent konsumtion av fet mat. Bland rurala barn utgjorde frekvent konsumtion av stekt mat, täta mellanmål och ökat stillasittande ytterligare riskfaktorer. De viktigaste skyddsfaktorerna utgjordes av fysisk aktivitet, måltider i hemmet för urbana barn och längre nattsömn för rurala. På familjenivå var högre socioekonomisk status kopplat till ökad förekomst av övervikt bland barn i staden. Att ofta titta på TV-reklam för mat liksom tillgänglighet till extramål hemma var risker bland barn på landet. Den kvalitativa studien visade att mödrar var oroliga hälsoproblem hos överviktiga barn. De använde sina egna erfarenheter, tillväxtkurvor och information från vårdgivare samt massmedia för att identifiera övervikt hos sina barn. Mödrarna ansåg att ohälsosam livsstil, ärftlighet och ekonomisk utveckling var faktorer som bidrar till överviktsutveckling och utifrån detta försöker de förebygga och behandla övervikt hos sina barn. Mödrarnas uppfattning ifrågasattes ibland av far- och morföräldrar som ofta betraktar knubbighet hos barn som ett tecken på hälsa.

Slutsats: Förekomsten av övervikt bland förskolebarn är hög i Vietnam och ökar med åldern, särskilt i urban miljö. Förebyggande insatser och behandling av fetma bör starta tidigt, redan i förskoleåldern, och innefatta utbildningsprogram med fokus på en hälsosam livsstil för barn samt riktas mot alla generationer i en familj, inte minst mor- och farföräldrar. Förebyggande åtgärder och interventioner bör anpassas på olika sätt för stad och landsbygd. Restriktioner mot reklam för ohälsosam kost bör införas.

LIST OF PAPERS

This thesis is based on the following studies, referred to in the text by their Roman numerals.

I. Do ML, Tran KT, Eriksson B, Petzold M, Nguyen TKC, Ascher H. Preschool overweight and obesity in urban and rural Vietnam: differences in prevalence and associated factors. Global Health Action 2015; 8: 28615.

II. Do ML, Larsson V, Tran KT, Nguyen TH, Eriksson B, Ascher H. Vietnamese mother's conceptions of childhood overweight: findings from a qualitative study. Global Health Action 2016; 9: 30215.

III. Do ML, Eriksson B, Tran KT, Petzold M, Ascher H. Feeding of preschool children in Vietnam: a study of parents' practices and associated factors. BMC Nutrition 2015; 1: 16.

IV. Do ML, Tran KT, Eriksson B, Petzold M, Ascher H. Prevalence and incidence of overweight and obesity among Vietnamese preschool children: A longitudinal cohort study. BMC Pediatrics. Submitted.

CONTENT

ABBREVIATIONS

BMI	Body mass index
CFQ	Child Feeding Questionnaire
FGDs	Focus group discussions
HDSS	Health and Demographic Surveillance Sites
IOTF	International Obesity Task Force
OR	Odds Ratio
OWB	Overweight including obesity
PA	Physical activity
SES	Socioeconomic status
SD	Standard deviation
WHO	World Health Organization

DEFINITIONS IN SHORT

BMI	Body mass index (BMI) is calculated as weight (in kg) divided by squared height (in m).
Overweight	In the thesis, children were classified as overweight according to the definitions of the IOTF proposed by Cole 2000.
Obesity	In the thesis, children were classified as obese according to the definitions of the IOTF proposed by Cole 2000.
Preschool children	In the thesis, preschool children are defined as children three to six years old.

1 INTRODUCTION

Obesity was first mentioned in the medical literature in the eighteenth century. The first scientific monograph was published in 1727 (1), the treatment was described in 1760 (1) and the first classification of obesity as a disease was made in 1780 (1). Negative influences of obesity on human health, such as fatigue, gout and difficulty in breathing, were first noted during the eighteenth century (2) and obesity was considered as a cause of several diseases in the middle of the nineteenth century (3).

For a long time, obesity was regarded as a condition related to high socioeconomic status. United States and some parts of Europe were the first regions in which obesity became recognized as a public health problem (4). However, in the past three decades it has increasingly appeared in developing countries as well. The global epidemic of obesity was formally recognized by World Health Organization (WHO) in 1997 (3).

1.1 Childhood overweight and obesity - A global public health concern

WHO defines overweight and obesity as an abnormal or excessive fat accumulation that presents a risk to health (5). The terms “overweight” and “obesity” indicate two different levels of excess body fat. Obesity may be considered as a heavier degree of adiposity or excess weight and reflects more serious health risks than overweight.

The prevalence of overweight and obesity in children has increased over the past decades in many countries, and statistics tend to be alarming (6). In some American and European countries, such as Brazil, Canada, United States, Finland, France, Germany and Sweden, the prevalence of overweight and obesity in school-age children doubled or trebled between the 1970s and the 1990s (7). The prevalence of overweight and obesity in developed countries is estimated to have increased from 7.9% in 1990 to 11.7% in 2010 and is expected to reach 14.1% in 2020 (8). A similar increase, but at a lower level, was found in a group of developing countries to be 3.7% and 6.1% in 1990 and in 2010 respectively, and is anticipated to hit 8.6% in 2020 (8). WHO estimates that more than 42 million children under the age of five years worldwide were overweight in 2013 and that the overwhelming majority of these, about 31 million, live in developing countries (9). Recent results show

that the rate of increase of obesity in low- and middle-income countries today is larger than in high-income countries (10).

The global epidemic of overweight and obesity in children together with its negative consequences constitutes a major public health concern. Being overweight and obese during childhood can accelerate and increase associated adult health risks (11). Obesity adversely affects almost all body systems and several health conditions need to be given special attention:

Cardiovascular diseases: In a population-based sample of 5-17 year olds in America, 70% of the overweight children had at least one and 39% had at least two risk factors, such as high cholesterol levels, high blood pressure or abnormal glucose tolerance (12). A 57-year follow-up study of a British cohort reported that overweight in childhood resulted in a doubled risk of death from ischemic heart disease in adulthood (13).

Metabolic disorders: Impaired glucose tolerance, insulin resistance, metabolic syndrome and type 2 diabetes, are related to obesity. Results of a surveillance programme of UK children found that 83% of those diagnosed with type 2 diabetes were obese and 95% were overweight (14). A study by Weiss et al. indicated that a BMI increase of 0.5 standard deviations (SD) resulted in a 50 percent increase in the risk for developing a metabolic syndrome among overweight children and adolescents (15).

Pulmonary disorders: A recent meta-analysis concluded that overweight and obese children have a 35-50% increased risk of asthma compared to normal weight children (16). A recent review reported that the prevalence of obstructive sleep apnoea among obese children and adolescents could be as high as 60% (17).

Psychological problems: Obese children are at greater risk of having psychological problems than non-obese children and the risks increase with age. Girls are more likely to have psychological problems than boys (18). One study in the United States reported low self-esteem for 34% of obese girls compared with 8% of non-obese (19).

Other health problems: Hepatic, renal, musculoskeletal, and neurological complications have been recognized more frequently than normal in obese children. Fatty liver disease is seen in 50% of obese children (20).

Adult obesity: Obesity in childhood and adolescence increase the risk for adult obesity. A follow-up study found that 76-78% of overweight children aged 9-11 years became obese in adulthood (21). A literature review indicated that 26-41% of obese preschool children were still obese as adults (22).

The economic impact of overweight and obesity is huge. Wang and Dietz used The National Hospital Discharge Survey to analyse obesity-associated hospital annual costs for discharges where obesity was listed as principal or secondary diagnosis in American children 6-17 years old. The result showed that the hospital's costs trebled; from $35 million during 1979-1981 to $127 million during 1997-1999 (23). The mean hospital charges and the length of stay in hospital have been found to be higher for paediatric discharges with obesity as a secondary diagnosis compared to non-obese children (24).

The costs of overweight and obesity in adults include both direct costs and indirect costs, reduction in productivity due to absenteeism from work and premature death. Evaluating annual medical expenditures among adults (18-65 years), Sturm found that health care costs and medication costs were 36% and 77% higher for obese persons compared with those for non-obese in the United States (25). Finkelstein et al. estimated in 1998 that for the American adult population as a whole, 3.7 percent and 5.3 percent of medical expenditures were attributable to overweight and obesity respectively (26). The economic costs due to obesity in several developed countries were in the range 2-7% of the total health care cost (3).

1.2 Conceptual framework for childhood overweight and obesity development

Obesity is a consequence of an energy imbalance over a considerable period of time (3). When this balance is positive, the body will store the redundant energy as fat which especially in combination with a genetic propensity can result in weight gain. Many factors affect the energy balance, directly or indirectly. Some important factors can be conceptualized at individual child level, family level and community level as suggested by Davison and Birch (27) (Figure 1).

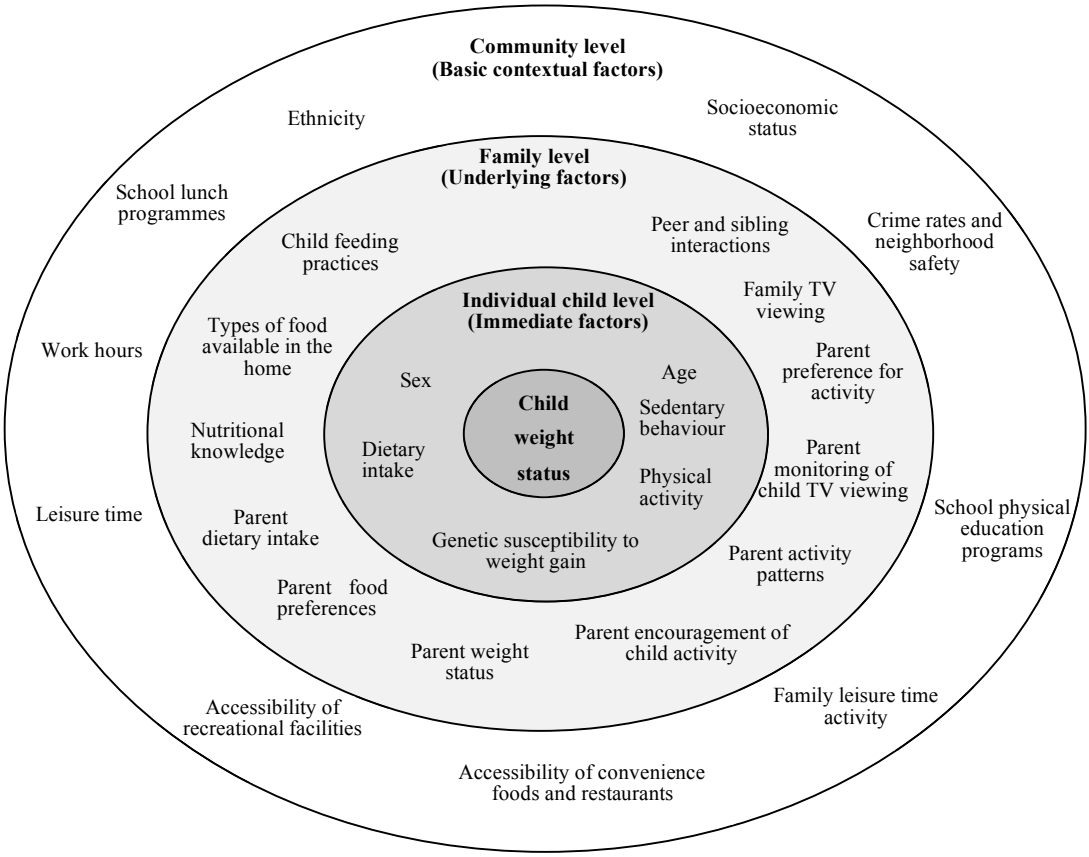

Figure 1. Conceptual framework for childhood overweight and obesity adapted from Davison and Birch (27).

Factors possibly associated with overweight and obesity at the individual child level include age, sex, genetic susceptibility to weight gain and child's behaviours (eating habits, physical activity and sedentary lifestyle). These can be called immediate factors as they are often considered to directly influence weight status. Several studies have, for example, shown associations between high consumption of sweet beverages and obesity (28-30). There is also evidence that a large amount of food with high energy density can contribute to increased energy intake leading to weight gain (31). A longitudinal study by Dubois et al. indicated that regularly overeating preschool children were 6 times more likely to be overweight than children who were never overeaters (32). Reduction of physical activity (PA) and increased sedentary behaviour can contribute to energy imbalances. Recent studies have found that the prevalence of obesity in children is related to the

amount of time watching television (33-35). The more a child watches TV, the higher the risk of overweight and obesity. The listed immediate factors do not act independently of each other. For example, PA decreases with age (36-38), and boys are considerably more active than girls (37, 39). Gender differences in food preferences and consumption have been demonstrated in some studies. Girls were found to consume more fruit and vegetables than boys, while boys were likely to prefer and to consume more high fat food and food with high sugar content (40, 41).

Factors at family level (underlying factors) include parenting style and family characteristics, such as feeding practices, nutritional knowledge and parents' dietary intake and activity patterns. These can influence the development of their child's behaviours. For example, children are mainly exposed to the food that parents provide them. Children learn what and how much to eat by observing and imitating the eating behaviour of parents and other adult people in the family. A study by Young et al. indicated that parent modelling and fruit and vegetable availability at home were significant predictors of fruit and vegetable consumption in middle school students (42). The influence of parents on child's eating behaviour and resulting weight status have been confirmed in several studies (43-45).

Parents also influence the PA habits of their children. Children who received greater parental support for activity and had parents who rated PA as highly enjoyable were significantly more likely than others to engage in daily PA (46). Children with physically active parents are also more active compared to children of inactive parents (47).

There is an increased risk of overweight and obesity in children with obese parents (35, 48). Wardle et al. found in a twin study of children aged 8-11 years that genetic differences between persons contributed to 77% of the variation in BMI (49). Genes may be associated with basal metabolism, dietary thermogenesis, appetite, satiety, endocrine function and fat storage (50, 51). Individuals carrying a genetic susceptibility for obesity could have an increased risk of developing obesity when exposed to an adverse environment.

At the community level, basic contextual factors, like socioeconomic conditions, culture, demography as well as governmental policies and regulations can affect child weight status through their influence on parenting practices, child eating and activity behaviour. Urbanization together with globalization means that people are increasingly exposed to media and other advertisement pressure. Such collective factors play important roles

influencing taste and food preferences (52). Economic and technological development at the national level unintentionally encourages sedentary behaviours in daily life. Computers, videos, mobile phones, motorbikes, cars and other modern equipment that may be useful can also make people less physically active. Trang et al. in a longitudinal study of sedentary behaviour in urban adolescents in Ho Chi Minh City showed that over a 5 year period, from 2004 to 2009, "screen time" increased by 28% (53). The availability and accessibility as well as the cost of recreational facilities, restaurants, supermarkets and food are much influenced by governmental policies. Awareness of healthy food, lifestyle and healthy weight in society can be increased, or neglected, in health and educational policies.

In summary, factors and interactions between factors at the individual child, family and community levels need to be taken into consideration in understanding the development of overweight and obesity and in the design of prevention and management programmes.

1.3 Vietnam's transitional period and children's nutritional status

Vietnam is to a large extent an agricultural country. Rice farming has been one of the main bases for the economy. The population in 2014 was 90.5 million with 33.1% living in urban and 66.9% in rural areas. The total fertility rate was estimated to be 2.09 children per woman and the sex ratio at birth was 112.2 male births per 100 female births. The life expectancy at birth in 2014 was 70.6 years for men and 75.6 years for women (54).

1.3.1 Development of economy

From 1945 to 1975 Vietnam experienced wars which resulted in a backward and impoverished economic situation. Between 1975 and 1985, Vietnam had an underdeveloped agricultural economy with 80 percent of the population and 70 percent of the labour force depending on agriculture (55). The years directly after the reunion of North and South Vietnam in 1975 saw overspending of the state budget increase significantly from 25% to 45% of all revenue. The country suffered from outbreaks of famine. Not only food supply but also other necessary aspects of daily life such as health and health care, education, consumer goods etc. were in poor condition or not available. Shortages of essential goods occurred frequently.

The renovation policy, *Doi Moi*, initiated by the Vietnamese Government in 1986 started a transition from a socialist economy to a market driven one.

The aims were to decrease or abolish state-subsidized mechanisms, to develop private organizations and economic sectors, as well as to stimulate the integration of Vietnam into the world and specifically into the South-East Asian regional economies (55). Since the reform, Vietnam has moved from one of the poorest countries in the world, with per capita income per year below $100, to a lower middle income country with per capita income of over $2,000 by the end of 2014 (56). Between 2001 and 2010 the average economic growth per year was 7.3% (57).

Economic development has led to poverty reduction as well as health and educational improvements. The percentage of people living in extreme poverty dropped from over 50% in the 1990s to 3% in 2012 (56). Families can afford to invest in education by sending their children to school. The adult literacy rate increased from 88% in 1989 to 94% in 2009 (58). Only 4.4% of children aged 5 and over never attended school in 2014 (54). Infant mortality has dropped from 42 per thousand live births in 1985 to 18 per thousand in 2014 (59).

The economic improvement has, however, also brought negative effects. Gaps in economic and social conditions between population groups have widened (60). The inequities in health and access to health care between high- and low-income groups have increased. Thoa et al. found that higher income groups utilize a higher level of public health services than others (61). The growing economy can increase the risk for the development of unhealthy lifestyles such as poor eating habits and increased sedentary behaviour. A study of adolescents in urban Ho Chi Minh City found that the time spent for moderate to vigorous PA decreased by 38% per annum during a 5 year follow-up (62). Estimates of PA in Vietnam indicate that around 70 percent of adults aged 25 to 64 years old meet the WHO recommendations of PA necessary to remain healthy (63).

1.3.2 Changed eating habits

Traditionally, the meal structure in Vietnam starts with breakfast, usually between 6 and 7.30 a.m. In rural areas, many farmers have a heavy breakfast at 4 or 5 a.m. before going to the fields. Breakfast could be sticky rice called “xôi”, rice gruel called “cháo” or bread with sausage, salad, onion, spices and pork fat. One of the favourite dishes for breakfast is instant noodle called “phở” with pork, chicken or beef. In some rural areas, breakfast food is quite simple, like a little cold rice (left over from the day before) or some boiled sweet potatoes or corns. In the past, people usually prepared breakfast at

home. Nowadays, mainly in urban areas, they often buy breakfast or eat on the way to work. Busy people or teenagers can even skip breakfast.

Lunch and dinner are the main daily meals, typically comprising of three or four dishes: vegetable soup (canh), a dish of vegetables, a dish of fish, eggs, or meat (mainly pork, beef, chicken) and rice. These dishes as well as the ways they are cooked may change according to taste, for example vegetables can be boiled or fried. Lunch is often eaten around 11.30-12.30. Traditionally people go home to eat with their family, but this is now changing. Some people who are busy or do not like cooking remain in their office to have their meal at the canteen or eat in a nearby street cafe. Some prepare lunch at home or buy from a street vendor. Dinner is the time when all the members of the family reunite and eat together at around 6.30-7.30 p.m. In Vietnamese families, women are mainly responsible for cooking at home.

Not only is urbanization changing traditional Vietnamese eating habits, but globalization is having an impact too. Eating out was not common until recently. Traditionally, going out for eating takes place on special occasions like birthdays or wedding anniversaries. As modern life results in less time and interest for cooking, eating out has gradually become more frequent and even a daily habit. Many new restaurants with imported menus have opened. Kentucky Fried Chicken (KFC) is an example. It was first launched in Vietnam in 1997. Up to now there are 140 restaurants in 19 provinces in Vietnam (64). McDonald's is another example, the first restaurant was opened in 2014 and now, two years later, nine restaurants are operating (65).

Food consumption and dietary composition have changed over time to lower amounts of starchy staples and higher amounts of proteins and lipids. The general nutritional surveys in 1985 and 2010 (66) indicated that the mean consumption of total food intake per capita per day excluding sauces and beverages increased from 789g to 877g. Daily consumption of rice decreased from 458g in 1985 to 373g in 2010 and of vegetables from 214g in 1985 to 190g in 2010. In contrast, meat and poultry intake increased nearly eight-fold from 11g in 1985 to 84g in 2010. Trends of increase were also found for fish, eggs and milk consumption. Over 25 years, oil and fat consumption per capita per day increased five-fold from 1.6g in 1985 to 8g in 2010.

1.3.3 Children's nutritional status

In parallel with economic improvement, childhood malnourishment has significantly decreased over the past 10 years. By 2010, the prevalence of underweight (weight-for-age less than -2 z-scores) and stunting (height-for-

age less than -2 z-scores) in children under 5 years of age, decreased by about 42% and 32% respectively, compared to the level in 2000 (Figure 2) (66). However, the traditional malnourishment problems are still significant in Vietnam. The government has set the target that by 2020, the prevalence of underweight among children under 5 years old will be reduced to 12.5% (67).

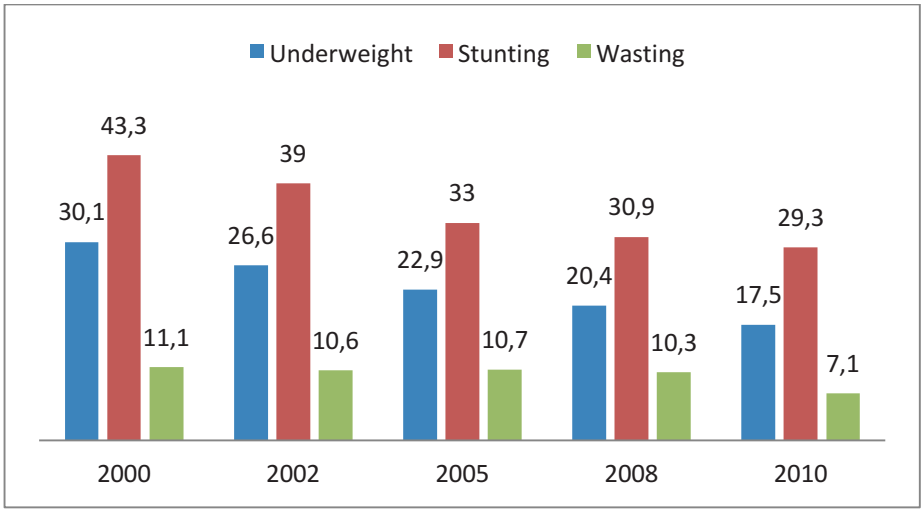

Figure 2. Prevalence (%) of undernutrition in children under 5 years of age (66). Underweight=weight-for-age <-2 z-scores; Stunting= height-for-age <-2 z-scores; Wasting=weight-for-height <-2 z-scores (68).

Childhood overweight and obesity was not reported in Vietnam until 1995. In recent years, they have tended to rise quickly, especially in urban areas (Figure 3). The prevalence of overweight in children under 5 years of age increased from 1.4% in 1998, to 5.6% in 2010 in a nationally representative sample (69). Among junior high school students, the estimates of overweight prevalence were 15.7% with 6.8% for obesity (70) and among senior high school students 9.4% and 2.3% respectively (71).

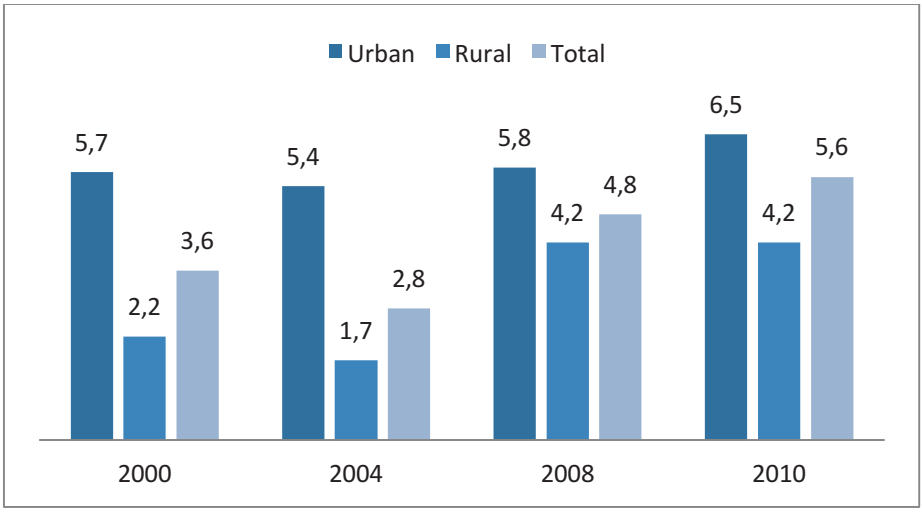

Figure 3. Prevalence (%) of overweight in children under 5 years of age (66).

1.4 The rationale for the present research

Childhood overweight and obesity is an emerging problem in Vietnam (66, 72). Therefore, knowledge of changes of the magnitude and the distribution of the problem is needed as this can form the basis for the development of public health programmes and interventions.

Until now there has been a paucity of follow-up studies of Vietnamese children in general and in particular in preschool children with respect to overweight and obesity during the transitional period and the influence of rapid socioeconomic changes. Follow-up studies provide an opportunity for the study of individual changes over time.

Engagement of parents in obesity prevention efforts is less likely to occur without an understanding of their perceptions, knowledge and attitudes regarding the problem of obesity, all which remain largely unexplored.

Very few studies in Vietnam have addressed the disparities between urban and rural areas in prevalence and factors possibly associated with childhood overweight and obesity.

2 AIM

2.1 General aim

The general aim of the research presented in this thesis was to study changes in the epidemiology of overweight and obesity in preschool children focusing on the prevalence, incidence, associated factors and parents' conceptions of overweight in one urban and one rural setting of Hanoi, Vietnam.

2.2 Specific aims

The specific aims of the studies were:

Study I: To estimate the prevalence of overweight and obesity among preschool children in an urban and a rural area of Hanoi, Vietnam and to study associations with factors at individual child and family levels.

Study II: To explore mothers' conceptions of childhood overweight.

Study III: To describe the use of parental feeding practices and to study associations between these practices and children's diet, children's BMI, parents' perceptions of children's weight as well as socioeconomic factors.

Study IV: To describe the changes in prevalence of overweight and obesity within a cohort of preschool children followed for three years, and to estimate and compare the incidences in urban and rural children of Hanoi, Vietnam.

3 METHODS

3.1 Study settings

All studies were conducted in two Health and Demographic Surveillance Sites (HDSS), DodaLab in urban and FilaBavi in rural Hanoi, Vietnam. The establishment of a HDSS aims to provide appropriate demographic, economic and other information at community level for health planning and policy making as well as to serve as a research setting for various studies. Household surveys are repeated every 2 years, and routine vital events information, such as births, deaths, migrations etc., is collected quarterly.

DodaLab is located in Dong Da, an old central district in Hanoi city. Dong Da district covers an area of 9.96 km², with approximately 352,000 inhabitants in 2007, almost all belonging to the Kinh ethnic group (73). DodaLab was formed in 2007 by three communes strategically selected from the 21 communes in Dong Da district. The communes were selected to represent slightly different social and economic conditions. At the time of establishment, the DodaLab cohort had about 11,000 households and 38,000 people (73). The yearly income per capita was USD 780. In 2013, the reported figure was about USD 1,750. The socioeconomic characteristics here are typical for large urban cities of Vietnam.

FilaBavi is situated in Ba Vi district about 60 km west of central Hanoi. The population of the district is about 250,000 inhabitants, mainly belonging to the Kinh ethnic group (91%). The district consists of 32 communes (74) in an area of 428 km² with different geographical characteristics: lowland, highland and mountain. FilaBavi was established in 1999 using 69 randomly selected clusters (villages or hamlet) from the total 352 clusters in Ba Vi district. At that time, FilaBavi had approximately 11,000 households with 51,000 inhabitants. The average incomes per capita per year according to the surveys in 2007 and 2013 were about USD 340 and USD 1,000 respectively.

Data collection in the two HDSS involved 60 field workers in DodaLab working part time and 46 in FilaBavi working full time. They are mainly women, trained in the skills necessary for collecting information by interviews using structured questionnaires.

Eight of the field workers in DodaLab and twelve in FilaBavi were specifically trained to understand the contents of the special questionnaires used in this research, and to work with small children, with special focus on

how to obtain anthropometric information, i.e. measuring weight and height. Working in pairs, they were responsible for collecting data in the areas where they live. Supervisors in each of the two areas and the researcher were responsible for supervising the work of the interviewers and for the data quality control. They checked randomly about 3% of the anthropometric measurements and records. In the case of large discrepancies, the household was revisited by a third person and the information could be adjusted.

3.2 Research design and data collection

Both quantitative and qualitative methods were used in the studies. The purpose of combining the two methods was to complement each other to best fulfil the research aims. Results of quantitative studies may identify research areas that require application of qualitative methods to provide an in-depth understanding of the phenomenon or when the use of quantitative methods is insufficient to answer questions that relate to human behaviour such as feelings, values, and beliefs. In addition, qualitative methods could be used to explore a phenomenon and identify factors that need investigation using quantitative studies.

3.2.1 Quantitative studies

Quantitative research is used to obtain numerical information, e.g. about how common a phenomenon is, to describe and to analyse. The results can sometimes be generalized from a sample to some population of interest. The following quantitative methods were used in the present studies:

A cross-sectional study, the baseline study in 2013, was applied to estimate overweight and obesity prevalence and to study associated factors (Study I). The cross-sectional method was also used to examine parental feeding practices and their association with children's diet and BMI (Study III).

A prospective study was used to follow the cohort consisting of the children in the baseline study for three years to 2016 (Study IV). The total cohort comprises of two sub-cohorts, one urban and one rural, each with four age sub-cohorts, defined by the age of children in 2013 (3, 4, 5 or 6 years).

Structured questionnaires were used for the baseline and the follow-up studies to obtain information about the child's lifestyle and eating habits as well as other characteristics of the family, partly following the conceptual framework. The questions were formulated based on the author's pre-understanding of childhood overweight and obesity in Vietnam and in the

world and after taking questionnaires used in other studies in this field into consideration.

The Child Feeding Questionnaire (CFQ) developed by Birch et al. (75) is a tool to collect information about or related to the feeding of the children (Study III). The CFQ consists of 7 subscales assessing parental attitudes, beliefs and practices related to child feeding. Four of them were used to obtain the following information: (i) perceived responsibility (3 items); (ii) restriction (6 items); (iii) pressure to eat (4 items); and (iv) monitoring (3 items). All items were measured using a 5-point Likert scale ranging from "disagree" to "agree" or "never" to "always". To evaluate parental perception of child weight, the question "How would you describe your child's weight at present" from the CFQ was used. The possible answers were "Markedly underweight", "Underweight", "Normal", "Overweight" and "Obesity".

The field workers, working in pairs made the anthropometric measurements of the parents and their children at home. They also interviewed the mothers and the fathers separately. Digital Tanita scale for weight and mobile measurement for length/height were used. Measurements were made to the nearest 0.1kg and 0.1cm respectively.

The consistent ambition was that all field work should be done exactly in the same way in the urban and rural areas throughout the entire timeframe. The same field workers were involved in the baseline and follow-up studies. The interviews and measurements were conducted in 2013 (baseline study) and repeated in 2014 and 2016 (follow-up study).

3.2.2 Qualitative study

A phenomenographic approach was used to explore parents' conception of childhood overweight and obesity in Study II. This method is often used to describe qualitatively the different ways a group of people makes sense of, experiences and understands phenomena in the world around them (76). Focus group discussions (FGDs) were used as the method to collect information from the participants.

Thirty-three mothers with 4-6-year-old children participated in four FGDs, two in the urban area and two in the rural. Each group consisted of 7 to 10 mothers with different backgrounds, such as age, education, weight and family economy. The FGDs lasted about 60-90 minutes and were conducted at health centres. They were led by two researchers: a moderator and an assistant. The discussions were audio taped and transcribed verbatim in Vietnamese before analysis.

3.3 Participating children and parents

All children born from 1 January 2007 to 31 December 2009, living in some strategically selected communes in DodaLab and FilaBavi were recruited for the baseline cross-sectional study in 2013. Overall, 2,842 children were selected, 1,482 in the urban site and 1,360 in the rural site. Of these, 2,677 children, 1,364 urban and 1,313 rural children, had parents who gave consent to participate in the study.

The so formed cohort of children was followed for 3 years. At the time when the study ended, complete weight and height information had been obtained from 2,602 children, 1,311 urban and 1,291 rural. Seventy-five children (2.8%), 53 (4.0%) from the urban site and 22 (1.7%) from the rural site, dropped out of the study as their families moved to other places and could not be reached. Of these, 7 children (9.3%) were overweight and 5 (6.7%) were obese.

Among the 2,677 mothers of children participating in the survey in 2013, 33 were strategically selected with respect to the mothers' age, education and work, the mothers' and children's weight status in both the urban and the rural areas, to participate in FGDs.

The parents of the same 2,677 children as in the baseline study were invited to provide information about the feeding of their children. Of these, 1,346 urban mothers and 1,303 urban fathers were interviewed separately. In the rural area, the number of mothers and fathers interviewed were 1,292 and 1,248 respectively.

The numbers of persons in the different studies by site is shown in Figure 4.

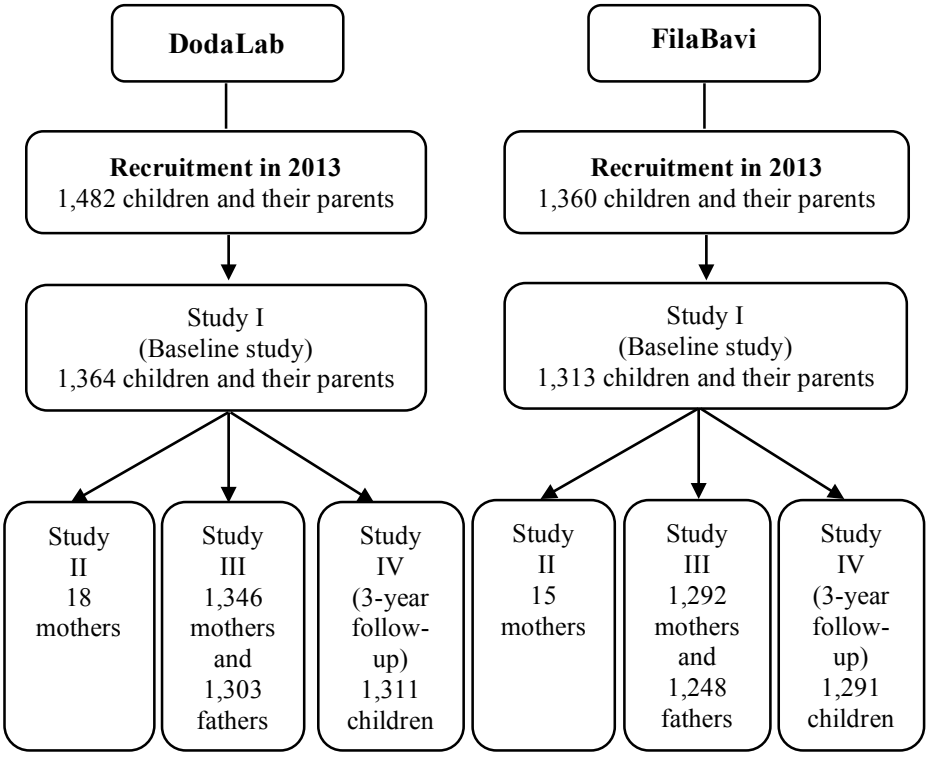

Figure 4. Design of the research.

3.4 BMI as an indicator of overweight and obesity

The classification of children as overweight or obese should ideally be based on direct measures of body fat. Several methods can be used to measure body composition such as dual-energy X-ray absorptiometry (77-80), underwater weighing (densitometry), measurement of skinfold thickness (78), isotope dilution ($H_2{}^{18}O$) (81), and bioelectrical impedance analysis (82). However, these methods are all expensive and difficult to use both in clinical applications and population studies. Body mass index (BMI) has therefore become the most commonly used indicator of body fat.

The use of BMI, calculated as weight (in kg) divided by squared height (in m), as a measure of overweight and obesity for children is a fairly recent development (83, 84). There is a quite strong consensus that BMI can be used both in population studies as well as in clinical practice (3, 85-90). However,

the use of BMI has some limitations. For example, it cannot distinguish between body fatness, muscle mass, and skeletal mass. The results of studies evaluating the validity of using BMI to identify children with excessive adiposity indicate high specificity (range between studies 95-100%), but low sensitivity (33-75.9%) (78, 91). That may indicate that BMI-based classification is likely to underestimate overweight and obesity prevalence compared to methods directly measuring body fat.

For adults, BMI above 25 is considered as overweight. The cut-off point for obesity is 30. For children, age and sex specific BMI cut-off points are used (3, 90). Two different classification systems are commonly utilized: the WHO reference and the International Obesity Task Force (IOTF) cut-off values.

The WHO has generated two references of BMI: the WHO Child Growth Standard 2006 for children under five years of age (68) and the WHO reference 2007 for children 5 to 19 years (92). The first was based on growth data collected from 6 countries: Brazil, Ghana, India, Oman, Norway and the United States. The children in these studies were raised under optimal conditions, for example they had to have been exclusively breastfed for more than 4 months, fed with complementary food by 6 months, had continuation of breastfeeding until at least 12 months, lived in a non-smoking environment etc. (93). The WHO reference therefore shows how children could grow under ideal conditions. The WHO reference 2007 is a re-analysis of the 1977 National Centre for Health Statistics (NCHS)/WHO growth reference from 5 to 19 years, supplemented with data from the WHO Child Growth Standards to facilitate a smooth transition (94). According to these references, for children under 5 years, BMI-for-age above +2 but below or equal to +3 z-scores was classified as being overweight. Obesity was defined as z-score above +3 (68). However, for children 5 to 19 years old, overweight was classified as BMI-for-age above +1 but below or equal to +2 z-score. Obesity was defined as z-score above +2 (92).

The IOTF cut-off BMI values were published in 2000. Overweight and obesity in childhood from 2 to 18 years of age were defined to match the adult cut-off of BMI equal to 25 and 30 at age 18 years (85). The reference was the result of an international survey of six large nationally representative samples including Brazil, Great Britain, Hong Kong, the Netherlands, Singapore and the United States (85). The data was collected between 1963 and 1993. Although the IOTF reference has been widely used, one disadvantage is that they are not expressible as BMI centiles or z-scores. Therefore, new cut-offs were published in 2012 to address these limitations

(95). They show slight differences from the originals with prevalence rates differing by less than 0.2% on average (95).

BMI-based classifications are used for different purposes and the choice of reference depends on the objectives. For international comparisons, the same reference should be applied. For national population surveillance and screening purposes, a national reference could be useful. However, it must be kept in mind that BMI is a screening tool, not a diagnostic tool. Children with BMI over the cut-off points do not necessarily have clinical complications or health risks related to overweight or obesity. In clinical settings, additional measures are required to confirm that high BMI value reflects excess body fat (96). Despite these limitations, BMI-based classifications have many advantages in practice: easy procedure and use, acceptable validity and low cost.

3.5 Variables

3.5.1 Outcome variables

Overweight and obesity: The children were classified as overweight or obese according to the definitions of the IOTF (85). Hence, the outcome variables were binary (0/1) with 1 indicating overweight and/or obesity. For overweight or obesity in adults, cut-off point of 25 and 30 kg/m^2 respectively were used.

3.5.2 Explanatory variables

The explanatory variables investigated in the studies fall into two groups in line with the conceptual framework for childhood overweight, one with variables defined for the individual child level and one with variables defined for the family (Figure 1). Variables at individual child level consist of sex, age and behaviour expected to be related to overweight and obesity, mainly eating habits and physical activity habits. The family characteristics considered are the socioeconomic variables, feeding practices, TV viewing and food availability in the home.

Variables at individual child level

1. Age sub-cohort*:* Age sub-cohorts 3, 4, 5 or 6 years were defined by the age of the child at the time of the baseline survey in 2013.

2. Amount of food: The portion size of food that a child eats in each main meal was estimated by the parents and classified by them as “less than”, “the same” and “more than” compared to other children of the same age.

3. Fatty food consumption: Frequencies of fatty food intake, i.e. fatty meat and butter, were estimated by the parents and categorized by them into 6 levels: (1) never or less than once a week, (2) 1-3 times/week, (3) 4-6 times/week, (4) 1 time/day, (5) 2 times/day and (6) 3 times or more/day.

4. Fried food consumption: Frequencies of fried food intake, i.e. vegetable, meat, fish and eggs that were fried, were estimated by the parents and categorized by them into 6 levels: (1) never or less than once a week, (2) 1-3 times/week, (3) 4-6 times/week, (4) 1 time/day, (5) 2 times/day and (6) 3 times or more/day.

5. Irregular snacks: Portions of food normally smaller than a regular meal that children eat at any time. Three categories were used: “never or rarely”, “sometimes” and “often”.

6. Eating speed: The speed was estimated by the parents and classified by them as “fast”, “normal” or “slow” compared to other children of the same age.

7. Number of meals per day: The total number of meals that the child regularly eats per day, snacks excluded.

8. Family meals: The total number of meals that the child eats at home per day.

9. Outdoor physical activity: The activity was estimated by the parents as the daily time, in hours, for walking, running, jumping, playing in the yard or street around the house or at a playground.

10. Indoor physical activity: The activity was estimated by the parents as the daily time, in hours, for the following activities: playing indoors with peers or toys, going up and down stairs or doing house work.

11. Sedentary time: The daily time, in hours, estimated by the parents used for watching television and playing computer games.

12. Night-time sleep: the number of hours, estimated by parents, of sleep that the child normally has during the night.

Variables at family level

13. Family economy: The number of assets available in the households was used as an indicator of family economy. In the analysis the variable was bracketed into terciles (97).

14. Mother's education: The level of education was categorized into three categories: secondary school or less, high school and higher than high school.

15. Household size: The number of people living in the household.

16. Watching food advertisement: The possible answers were "no", "sometimes" or "often" to the questions if parents watched TV food advertisements. In the analysis, "sometimes" and "often" were combined to a category "yes".

17. Snack availability at home: The possible answers were "no", "yes, sometimes" or "yes, often".

3.6 Ethical considerations

The HDSS in FilaBavi and DodaLab have been ethically approved by the Ministry of Health of Vietnam as well as by the Scientific and Ethical Committee of Hanoi Medical University. Permissions have also been granted by Dong Da and Ba Vi district authorities. In addition, the Scientific and Ethical Committee of Hanoi Medical University has specifically approved this research of overweight and obesity.

All participants were provided information about the purpose of the study and had the possibility to decline participation or to withdraw at any time. They were able to get advice on childhood obesity from medical doctors in the National Hospital of Paediatrics. Verbal consent from all mothers and fathers participating in the study was obtained. The collected information was only accessed by members of the research group, and was used only for research purposes. All information about participants was coded and anonymized before analysis and presentation.

3.7 Analysis

3.7.1 Quantitative analysis

Conventional statistical methods were used to summarize and describe data in tables and graphs. For comparisons of two groups, Student's t-test or

Wilcoxon rank sum test were used as appropriate. The correlations between variables were studied mainly using Spearman rank correlation coefficients. Statements of statistical significance were based on confidence intervals or p-values. Throughout, all analysis was conducted separately in parallel, for the two areas, the urban and the rural.

Analysis of associations between incidence and prevalence of overweight and obesity and changes in weight status and individual child and family variables (Study I and Study IV)

Simple logistic regressions were used to study the statistical associations of the binary dependent, outcome, variables *overweight* and *obesity* with risk factors and background variables. Crude odds ratios were estimated for each independent variable. Also, the changes in weight status from 'normal' to 'overweight' or 'obesity' were used as binary dependent variables.

Multiple logistic regression models were used to further explore the associations and to identify and adjust for confounding. All studied variables at the individual child and family levels were included in these models. The goodness of fit of all logistic regression models and their predictive value was studied using the McFadden Pseudo R^2 and Tjur's Coefficient of discrimination (CD) (98).

Analysis of feeding practices using CFQ (Study III)

The key dependent variables were the mean scores over the subscales for restriction, pressure to eat and monitoring. Simple Pearson correlation coefficients were used to describe associations. Correlations between obviously skewed variables were checked using Spearman rank correlations. We used a stratification approach to compare the questionnaire responses between mothers and fathers taking education differences into account.

The software used for the statistical description and analysis was Stata version 12-14.

3.7.2 Qualitative analysis

The analysis was based on seven steps as described by Dahlgren and Fallsberg (99): (1) Reading all transcripts; (2) selecting meaningful statements; (3) identifying similarities and differences between the selected excerpts; (4) grouping similar statements into internally homogenous; (5) describing the essence of the similarity within each category; (6) naming the

categories; (7) comparing the obtained categories with regard to similar and different characteristics.

The analysis was undertaken in Vietnamese. The categories, subcategories and supporting quotations were chosen when all involved researchers had reached consensus. Quotations were presented verbatim in Vietnamese and translated into English.

4 RESULTS

4.1 Background information

4.1.1 Baseline and follow-up population

In the baseline survey 2,677 children participated and 2,602 (97.2%) remained at the follow-up (Table 1). The proportions of urban and rural children, children in age groups and boys and girls were almost unchanged over the three surveys.

Table 1. Number of children participating in the cohort and sub-cohorts.

		2013	2014	2016
Area of residence	Urban; n (%)	1,364 (50.9)	1,321 (50.5)	1,311 (50.4)
	Rural; n (%)	1,313 (49.1)	1,297 (49.5)	1,291 (49.6)
Sex	Boys; n (%)	1,430 (53.4)	1,398 (53.4)	1,391 (53.5)
	Girls; n (%)	1,247 (46.6)	1,220 (46.6)	1,211 (46.5)
Age sub-cohort	3 years; n (%)	765 (28.6)	751 (28.7)	745 (28.6)
	4 years; n (%)	875 (32.7)	859 (32.8)	854 (32.8)
	5 years; n (%)	886 (33.1)	860 (32.8)	857 (32.9)
	6 years; n (%)	151 (5.6)	148 (5.7)	146 (5.6)
Total		2,677	2,618	2,602

4.1.2 Socioeconomic status of families

The differences in socioeconomic status (SES) between the urban and rural area were considerable (Table 2).

Table 2. Socioeconomic characteristics of family in the baseline survey.

Variables	Urban	Rural
Mother's educational level		
Secondary school or less (%)	6.8***	57.6
High school education (%)	32.3***	28.6
Higher than high school (%)	60.9***	13.8
Mother's occupation		
Manual worker (%)	9.3***	73.4
Office staff (%)	56.7***	9.0
Business (%)	25.5**	14.0
Other (%)	8.5	3.6
Mother's age (mean)	28.1	25.5
Economic level		
Number of family assets in 2013 (mean)	8.8***	5.4

The stars refer to the comparison between urban and rural; ** $p<0.01$; *** $p<0.001$.

The mother's education and the family economy were higher in the urban than in the rural area. The main occupation for mothers was office staff (56.7%) in the urban area and manual worker (73.4%) in the rural area. Urban mothers were older than the rural.

4.2 Overweight and obesity

4.2.1 Overweight

The estimated prevalence of overweight by area, sex and age sub-cohort is shown in Table 3.

Table 3. Estimated prevalence (%) of children classified as being overweight according to the IOTF classification by urban/rural, boys/girls and age sub-cohort.

	Age sub-cohort	Number of children	2013	2014	2016	Difference (2016-2013)
All children		2,602	9.1	11.0	16.7	7.6[b]***
Urban total		1,311	13.3[a]***	17.4[a]***	25.6[a]***	12.3[b]**
Urban boys	Total	699	14.4[a]***	16.5[a]***	25.8[a]***	11.4[b]**
	3 years	169	7.1	10.1	22.5	15.4[b]***
	4 years	242	12.0	16.5	23.6	11.6[b]***
	5 years	232	21.6[c]*	19.8	32.8[c]***	11.2[b]**
	6 years	56	17.9	21.4	16.1	-1.8
Urban girls	Total	612	12.1[a]***	18.5[a]***	25.3[a]***	13.2[b]**
	3 years	140	12.1	17.9	32.1	20.0[b]***
	4 years	197	9.6	19.3	28.4	18.8[b]***
	5 years	228	14.5	19.3	18.9	4.4
	6 years	47	10.6	12.8	23.4	12.8
Rural total		1,291	4.8	4.5	7.7	2.9[b]**
Rural boys	Total	692	4.6	5.3	9.2	4.6[b]**
	3 years	245	4.5	6.1	11.4	6.9[b]**
	4 years	219	3.2	5.0	7.3	4.1[b]*
	5 years	204	6.9	5.4	9.3	2.1
	6 years	24	0.0	0.0	4.2	4.2
Rural girls	Total	599	5.0	3.5	6.0	1.0
	3 years	191	4.2	4.2	5.2	1.0
	4 years	196	4.6	2.6	6.6	2.0
	5 years	193	6.2	4.1	6.2	0.0
	6 years	19	5.3	0.0	5.3	0.0

The stars refer to comparison between: [a] urban and rural; [b]2016 and 2013; [c]urban boys and urban girls.
* p<0.05; ** p<0.01; *** p<0.001.

In all age sub-cohorts, overweight was more prevalent in the urban than in rural area and the prevalence of overweight increased with age in all groups, except rural girls in age sub-cohort 5 and urban boys and rural girls in age sub-cohort 6. The increase was higher in the urban than in the rural sites.

No significant difference was found between boys and girls, except in age sub-cohort 5 where the prevalence was higher for urban boys than for urban girls in the first and last surveys.

4.2.2 Obesity

Table 4 shows the pattern of obesity by area, sex and age sub-cohort during the 3-year follow-up.

Table 4. Estimated prevalence (%) of children classified as being obese according to the IOTF classification by urban/rural, boys/girls and age sub-cohort.

	Age sub-cohort	Number of children	2013	2014	2016	Difference (2016-2013)
All children		2,602	6.4	4.4	4.5	-1.9[b]**
Urban total		1,311	9.2[a]***	7.5[a]***	7.1[a]***	-2.1[b]**
Urban boys	Total	699	10.3	9.0	8.9	-1.4
	3 years	169	8.9	8.3	7.7	-1.2
	4 years	242	7.0	7.9	10.3	3.3
	5 years	232	15.5[c]**	11.6[c]**	9.5[c]**	-6.0
	6 years	56	7.1	5.4	3.6	-3.5
Urban girls	Total	612	8.0	5.7	5.1	-2.9
	3 years	140	4.3	6.4	8.6	4.3
	4 years	197	12.7	7.1	5.6	-7.1[b]*
	5 years	228	7.5	4.8	3.5	-4.0
	6 years	47	2.1	2.1	0.0	-2.1
Rural total		1,291	3.5	1.3	1.9	-1.6[b]*
Rural boys	Total	692	3.0	1.2	2.2	-0.8
	3 years	245	2.9	1.6	4.9	2.0
	4 years	219	2.7	0.5	0.5	-2.2
	5 years	204	3.9	1.5	1.0	-2.9
	6 years	24	0.0	0.0	0.0	0.0
Rural girls	Total	599	4.0	1.5	1.5	-2.5
	3 years	191	3.1	2.1	3.7	0.6
	4 years	196	4.1	2.0	0.5	-3.6[b]*
	5 years	193	4.7	0.5	0.5	-4.2[b]**
	6 years	19	5.3	0.0	0.0	-5.3

The stars refer to comparison between: [a] urban and rural; [b]2016 and 2013; [c]urban boys and urban girls.
* p<0.05; ** p<0.01; *** p<0.001.

As with overweight, the prevalence of obesity was higher in the urban than in the rural children. The obesity prevalence decreased with age in the age sub-cohort 4, 5 and 6, except for urban boys in age sub-cohort 4 where the prevalence increased. However, statistical significance was only found in girls of age sub-cohort 4 and rural girls in age sub-cohort 5. A non-significant tendency of increasing obesity was seen for urban girls and rural children in age sub-cohort 3.

Statistically significant differences between boys and girls were found only in age sub-cohort 5 in the urban area in all three surveys.

4.3 Changes in weight status during the 3-year follow-up

Table 5 and 6 show the changes in weight status among the studied children over the 3-year follow-up period. Among the children without overweight or obesity in 2013, 12.4% had developed overweight in 2016 (Table 5). In the group of children with overweight, 41.4% remained overweight and 46.8% changed into normal weight.

Urban children developed overweight about three times as often as rural, and stayed overweight twice as often. Significantly more rural children moved out of overweight than urban (66.1% vs. 40%).

There were no statistically significant differences between boys and girls regarding incidence or staying overweight. However, girls, both urban and rural, were more likely to move out of overweight than boys (48.7% vs. 33.7% in the urban children and 83.3% vs. 50% in the rural children).

The percentages of developing, staying and moving out of overweight for specific age sub-cohorts were unsystematic and almost all were not statistically significant.

Table 5. Estimated incidence and percentages of children developing, staying or moving out of overweight during the period 2013 to 2016.

	Age sub-cohort	Incidence		Weight status change		
		No of Nw children in 2013	% (n) children becoming Ow in 2016	No of Ow children in 2013	% (n) children staying Ow in 2016	% (n) children moving to Nw in 2016
All children		2,199	12.4 (272)	237	41.4 (98)	46.8 (111)
Urban total		1,015	19.9[a]***(202)	175	46.3[a]**(81)	40.0[a]*** (70)
Urban boys	All	526	19.8 (104)	101	49.5 (50)	33.7[b]* [,d]* (34)
	3 years	142	19.0 (27)	12	41.7 (5)	41.7 (5)
	4 years	196	20.9 (41)	29	48.3 (14)	27.6 (8)
	5 years	146	22.6 (33)	50	52.0 (26)	32.0 (16)
	6 years	42	7.1 (3)	10	50.0 (5)	50.0 (5)
Urban girls	All	489	20.0 (98)	74	41.9 (31)	48.7 (36)
	3 years	117	31.6 (37)	17	41.2 (7)	35.3 (6)
	4 years	153	20.3 (31)	19	63.2 (12)	26.3 (5)
	5 years	178	11.8 (21)	33	33.3 (11)	63.6 (21)
	6 years	41	22.0 (9)	5	20.0 (1)	80.0 (4)
Rural total		1,184	5.9 (70)	62	27.4 (17)	66.1[d]*** (41)
Rural boys	All	639	6.7 (43)	32	37.5 (12)	50.0[c]** (16)
	3 years	227	8.8 (20)	11	27.3 (3)	36.4 (4)
	4 years	206	6.3 (13)	7	14.3 (1)	85.7 (6)
	5 years	182	5.0 (9)	14	57.1 (8)	42.9 (6)
	6 years	24	4.2 (1)	0	0.0 (0)	0.0 (0)
Rural girls	All	545	5.0 (27)	30	16.7 (5)	83.3[d]*** (25)
	3 years	177	3.4 (6)	8	12.5 (1)	87.5 (7)
	4 years	179	6.2 (11)	9	11.1 (1)	88.9 (8)
	5 years	172	5.2 (9)	12	25.0 (3)	75.5 (9)
	6 years	17	5.9 (1)	1	0.0 (0)	100 (1)

Abbreviations: Nw = normal weight; Ow = overweight; Ob = obesity.

The stars refer to the comparison between: [a] urban and rural; [b]urban boys and urban girls; [c]rural boys and rural girls; [d]staying overweight and moving out of overweight. * p<0.05; ** p<0.01; *** p<0.001.

For obesity, similar tendencies were found. The share of children that developed obesity or stayed obese during the study time was higher for urban children than for rural, 4.1% vs. 1.4% and 36.4% vs. 15.6%, respectively. However, fewer urban children moved out of obesity 20.6% vs. 55.5% (Table 6). These differences were all statistically significant.

Table 6. Estimated incidence and percentages of children developing, staying or moving out of obesity during the period 2013 to 2016.

	Age sub-cohort	Incidence		Weight status change			
		No of Nw children in 2013	% (n) children becoming Ob in 2016	No of Ob children in 2013	% (n) children staying Ob in 2016	% (n) children moving to Ow in 2016	% (n) children moving to Nw in 2016
All children		2,436	2.7 (66)	166	30.7 (51)	39.2 (65)	30.1 (50)
Urban total		1,190	4.1[a]***(49)	121	36.4[a]**(44)	43.0 (52)	20.6[a]***(25)
Urban boys	All	627	5.4[b]* (34)	72	38.9 (28)	36.1 (26)	25.0 (18)
	3 years	154	5.8 (9)	15	26.7 (4)	40.0 (6)	33.3 (5)
	4 years	225	5.8 (13)	17	70.6 (12)	11.7 (2)	17.7 (3)
	5 years	196	5.6 (11)	36	30.6 (11)	47.2 (17)	22.2 (8)
	6 years	52	1.9 (1)	4	25.0 (1)	25.5 (1)	50.0 (2)
Urban girls	All	563	2.7 (15)	49	32.7 (16)	53.0 (26)	14.3 (7)
	3 years	134	6.0 (8)	6	66.7 (4)	17.6 (1)	17.7 (1)
	4 years	172	2.3 (4)	25	28.0 (7)	52.0 (13)	20.0 (5)
	5 years	211	1.4 (3)	17	29.4 (5)	64.7 (11)	5.9 (1)
	6 years	46	0.0 (0)	1	0.0 (0)	100 (1)	0.0 (0)
Rural total		1,246	1.4 (17)	45	15.6 (7)	28.9 (13)	55.5 (25)
Rural boys	All	671	1.6 (11)	21	19.1 (4)	42.8 (9)	38.1 (8)
	3 years	238	4.6 (11)	7	14.3 (1)	71.4 (5)	14.3 (1)
	4 years	213	0.0 (0)	6	16.7 (1)	33.3 (2)	50.0 (3)
	5 years	196	0.0 (0)	8	25.0 (2)	25.9 (2)	50.0 (4)
	6 years	24	0.0 (0)	0.0	0.0 (0)	0.0 (0)	0.0 (0)
Rural girls	All	575	1.0 (6)	24	12.5 (3)	16.7 (4)	70.8 (17)
	3 years	185	2.2 (4)	6	50.0 (3)	50.0 (3)	0.0 (0)
	4 years	188	0.5 (1)	8	0.0 (0)	12.5 (1)	87.5 (7)
	5 years	184	0.5 (1)	9	0.0 (0)	0.0 (0)	100 (9)
	6 years	18	0.0 (0)	1	0.0 (0)	0.0 (0)	100 (1)

Abbreviations: Nw = normal weight; Ow = overweight; Ob = obesity;
The stars refer to the comparison between: [a] urban and rural; [b]urban boys and urban girls; [c]rural boys and rural girls; [d]staying obesity and moving out of obesity. * $p<0.05$; ** $p<0.01$;*** $p<0.001$.

The differences between boys and girls, both urban and rural, in staying and moving out of obesity were not statistically significant. However, urban boys were more likely to develop obesity than urban girls.

The pattern of developing, staying and moving out of obesity between age sub-cohorts were unclear and with few exceptions, not statistically significant.

4.4 Parents' conception of child overweight

4.4.1 Results of the quantitative study

Among parents, 80.8% of the urban parents and 93.1% of the rural failed to correctly classify overweight including obesity (OWB) in their child, defined by IOTF classification as the standard. No statistically significant difference between mothers and fathers was found, but urban parents were more likely to correctly identify OWB for their child (19.2% vs. 6.9%).

4.4.2 Results of the focus group discussions

During the discussions, four categories emerged: concept, identification, causes and management of childhood overweight. These are presented below with identified subcategories and supporting quotations.

Category 1 describes mothers' opinions about childhood overweight. Some mothers preferred a chubby appearance of the child as it made them feel assured of the child's health. Others believed that an overweight child was just bigger than his peers and that there was no need to be worried about that. Most mothers, however, were concerned about the risks of health problems, such as cardiovascular diseases, diabetes et cetera, as well as risks of social impairments.

Category 1: Concept of childhood overweight.

Chubbiness is good

"Vietnamese mothers, from a psychological aspect, always want their children to look a little bit chubby. Only when the kids get compliments for their "cute" chubbiness do the mothers feel assured."

Overweight is a minor problem

"He's fatter than his peers, but he still runs and plays with his friends, has good appetite, gets good grades, has good handwriting, just like any other child. The only difference is that he is bigger."

Impairment of social interaction and health problems

"It feels bad to be fat. Slow actions, ugly appearance. Being fat in a crowd is embarrassing."

"It's more difficult for him (obese child) to be involved in physical activities with his friends. He gets tired very quickly and sweats a lot, which makes him even more reluctant to be active."

"I think diabetes, many cardiovascular diseases, high blood fat, liver fat... all of them have to do with overweight."

"Diabetes in children is more difficult to treat than in adults because it's very hard for children to be on a diet."

Category 2 describes the ways that mothers used to identify an overweight child. Some mothers based their assessment on the child's appearance or by comparing with the child's friends. Using growth charts was another way of assessment which they found simple to use. Some mothers got information about the child's overweight status from the television or doctors they trusted.

Category 2: Identification of childhood overweight

Mothers' own experience
"A child has a big bottom, round and fat face, moves slowly. In general, he is not as dynamic as other kids. That's how I tell the kid is obese."
"You can tell by comparing them with their peers. Their arms and legs are big. Their faces are fat and thick."
Using growth chart
"In the chart, there are lines going up and down, yellow lines, green lines. Yellow lines mean normal or risk group 1 or 2 or obese or malnourished. The charts are clear."
Using information from the media or health care system
"Watching TV, we can see that obesity is very common now, not only in Vietnam but also in the world. For Vietnamese standard, a 2-3-year-old weighing 13-14 kg is certainly overweight. Second graders (7 years old) normally weigh 20-21 kg but if it's 30 kg, it's definitely obesity."
"The school doctor or nurses at the community health centre warned me that he was overweight."
"Of course, I believe in doctors; that's why I bring my child to the hospital. You can Google symptoms on the Internet but you can't trust this information completely. You still need to visit doctors."
"Only doctors know how a child's normal development should be. We can't know such a thing. What doctors say during check-ups is the most accurate of all."

The factors contributing to overweight in children as understood and reported by the mothers formed Category 3. Mothers mentioned that eating too much, sedentary behaviours and familial susceptibility to weight gain could be reasons for becoming overweight. In addition, improvement in economy and a busy life, especially in urban areas, leading to children being more exposed to foods, were considered as causes of overweight by the mothers. Another cause emphasized by mothers was food containing growth stimulants. They explained that this was for business purposes since they make animals (chicken, pigs, cows etc.) and vegetables grow faster and quicker and that these chemicals could influence children eating these foods.

Category 3: Causes of childhood overweight.

Unhealthy lifestyle
"I (mother) notice that my child is quite obese. His appetite seems boundless. He likes to eat everything."
"It's probably because of their good absorption. Like my child, she eats quite moderately but is still bigger than her peers."
"Children in big cities always sit in one place, playing with phones or iPads. They don't run around and play."
"There's overweight in the countryside, but it's certainly more common in big cities. Urban children eat more and are less active. In the countryside, children can run around and play in the backyard, in the common playground."
"All my children are very active. They run around all day. As a result, they are all healthy. None of them is overweight."
Heritability
"Genes are also responsible. Like my family, everyone is big. We are sometimes jokingly called 'the bear family'."
"Genes have an impact but it's not that significant. Why is everyone in a family obese? It's also because of the diet they share, not just because of the family gene."
Negative impact of economic improvement and livelihood
"When families are wealthier, children can eat pretty much whatever they want, which may cause obesity."
"…Because I am too busy in our daily life. For example, I just give our child meat or fish without any vegetables because it's quicker that way. I have other chores to take care of."
"Cities are polluted with vehicle exhausts. Children don't have anywhere to play so they have to stay indoors all day. They have to watch TV and play games on phones and iPads for entertainment."
Food containing growth stimulants
"In urban areas, meat and vegetables in the daily diet usually contain unsafe hormones ("thuoc tang trong"). In the countryside, since families grow their own vegetables, raise their own livestock, the food is safer, cleaner. I think that's why obesity is less common in rural areas."

The fourth category contains mothers' perceptions of overweight management. The main approaches were slow reduction in food intake, both amount of food and foods high in fat or sugar, and encouraging the child to be more active, for example by swimming, running, playing badminton. Mothers found these ways difficult to implement because of overeating in overweight children and because they felt sorry that the child was on a diet. If the children were motivated, then management became more effective. Mothers sometimes found it challenging that grandparents had different views on how overweight should be controlled and that conflicts could be created.

Category 4: Management of childhood overweight.

Control of food intake and increase in physical activity

"The only way is to control his diet and increase the physical activity. Changing his diet from milk with sugar to milk without sugar, 3 bowls of rice to 2 bowls, 2 pieces of fried chicken to 1 piece. I don't want to make any radical change because he will crave food and eat even more if he gets the chance."

"I can make him stop eating now but after playing with his friends for a while, he eats even double or triple."

"It is quite miserable for my child to be on a diet because of obesity. I, as his mum, feel bad if I say no when he is still hungry. But if I let him eat he will become obese, even suffering from other things, disease and personalities."

Encouraging a child's self-control

"I recognized that my child was a bit overweight when she was in the third grade, so I started telling her to control her diet or else she would get fat. She understood and ate less without me forcing her."

"Going to art class, chess class - focusing on doing something will distract them from thinking about food."

Challenge by grandparents

"I live with my parents. When I recognized that my kid was overweight and told him to stop eating so much, my mom yelled at me: 'He's not fat. Just let him eat whatever he likes."

"I (mother) could not go home for lunch during workdays. When I came back in the evening, my mom told me: 'After picking my grandchild from school, I bought him 2 sausages and let him have 3 bowls of rice'. She felt happy that her grandchild had a great appetite. However, my kid is the one who suffers when he's obese".

"Everyday, although my child already eats at home, he (grandfather) still gives her 30 thousand dongs. She (child) always runs down to the school cafeteria, eating not only one but two sandwiches."

4.5 Factors associated with overweight and obesity

The associations of factors shown in the conceptual framework above and two weight variables were studied using logistic regression. The first was the weight, (normal, overweight or obese) in the baseline study. The second was the weight status change from the baseline survey to the 2016 survey. The results from the baseline study have been published in Paper I and are only briefly reviewed here. The results for the analysis of change are not yet published.

4.5.1 Baseline study

At baseline, both in the urban and rural area, the risk of being OWB was statistically significantly increased in children having less than 2 hours PA per day (OR=1.47; 95% CI 1.11-1.94 in urban and OR=2.06; 95% CI 1.36-

3.12 in rural) and children with obese parents (OR=1.38; 95% CI 1.02-1.87 in urban and OR=2.32; 95% CI=1.17-4.59 in rural).

In the urban area, statistically significant associations with OWB were found for being a boy (OR=1.7; 95% CI 1.30-2.23), for age (OR=2.28; 95% CI 1.28-4.07), for amount of food (OR=2.89; 95% CI 1.80-4.66) and for fast eating (OR=2.22; 95% CI 1.56-3.16).

In the rural area, the identified statistically significant factors were age (OR=2.73; 95% CI 1.66-4.50), frequently consumed fatty food (OR=7.64; 95% CI 4.29-13.63), fried food (OR=1.72; 95% CI 1.14-2.60), irregular snacks (OR=3.81; 95% CI 1.62-8.97), watching food advertisement (OR=3.32; 95% CI 2.13-5.17) and availability of snacks at home (OR=1.75; 95% CI 1.16-2.64).

4.5.2 Change during the follow-up period

Table 7-8 present the crude associations as Odds Ratios (OR) between OWB and the explanatory variables in the follow-up study at individual child and family level. The urban and rural areas were separately investigated.

In the urban area, increasing OWB risk was associated with large amount of food and frequent consumption of fatty food. The statistically significant negative associations were age sub-cohort, irregular snacks, family meals and PA (outdoors and indoors).

In the rural area, the risk of being OWB increased in children who frequently consumed fatty food, fried food and irregular snacks, large amount of food, increasing number of meals per day and increasing sedentary time. Protective factor was night-time sleep duration.

At the family level, in the urban area, family economy, mother's education and mother's age were positively associated with weight status change, increasing OWB. In the rural area, watching food advertisement and availability of snacks at home were significantly associated with risk of OWB.

Table 7. Results from simple logistic regressions of the binary variable indicating changing from normal to OWB or from overweight to obesity on independent variables describing mean values for the 2013, 2014 and 2016 surveys at the individual child level.

	Urban				Rural			
	n	**Perc (%)**	**OR**	**95% CI**	**n**	**Perc (%)**	**OR**	**95% CI**
Sex								
Female	612	17.3	Ref		599	5.5	Ref	
Male	699	17.3	1.00	0.75-1.33	692	7.2	1.33	0.85-2.10
Age sub-cohort								
3	309	24.3	Ref		436	8.5	Ref	
4	439	18.2	0.70	0.49-0.99	415	6.0	0.69	0.41-1.17
5	460	12.8	0.46	0.31-0.67	397	4.8	0.54	0.31-0.96
6	103	12.6	0.45	0.24-0.85	43	4.7	0.53	0.12-2.26
Amount of food								
Low	348	17.8	Ref		583	5.1	Ref	
Medium	688	13.7	0.73	0.51-1.04	490	5.9	1.05	0.63-1.75
High	248	25.4	1.57	1.06-2.34	203	10.3	1.92	1.09-3.41
Fatty food								
Low	158	10.8	Ref		833	5.2	Ref	
Medium	779	16.6	1.65	0.96-2.82	409	8.6	1.72	1.08-2.73
High	371	21.8	2.31	1.32-4.06	47	10.6	2.19	0.82-5.81
Fried food								
Low	752	19.2	Ref		803	5.1	Ref	
Medium	255	16.5	0.83	0.57-1.21	348	7.2	1.44	0.86-2.41
High	301	13.6	0.67	0.46-0.97	138	12.3	2.61	1.44-4.74
Irregular snack								
Low	849	19.2	Ref		527	5.3	Ref	
Medium	282	16.0	0.80	0.56-1.15	384	5.7	1.08	0.61-1.92
High	177	10.7	0.51	0.31-0.84	379	8.7	1.70	1.01-2.86
Eating speed								
Low	412	17.2	Ref		588	5.4	Ref	
Medium	545	17.3	1.00	0.71-1.40	414	6.5	1.21	0.71-2.07
High	333	17.1	0.99	0.68-1.45	284	8.5	1.60	0.93-2.78
No of meals/day								
Low	90	11.1	Ref		976	5.6	Ref	
Medium	557	18.1	1.77	0.89-3.54	237	7.6	1.38	0.79-2.39
High	664	17.5	1.69	0.85-3.37	78	12.8	2.46	1.20-5.05
Family meals								
Low	382	19.4	Ref		783	5.4	Ref	
Medium	434	19.6	1.01	0.72-1.43	221	7.2	1.38	0.76-2.50
High	495	13.7	0.66	0.46-0.95	286	8.7	1.69	1.00-2.83
Outdoor physical activity								
Low	383	19.5	Ref		34	5.9	Ref	
Medium	462	13.9	0.67	0.49-0.91	400	7.5	1.30	0.30-5.68
High	11	0.0	-	-	856	6.0	1.01	0.24-4.35

Table 7. (continued)

Indoor physical activity								
Low	441	19.7	Ref		431	1.9	Ref	
Medium	447	18.6	0.93	0.66-1.30	432	6.5	3.66	1.65-8.13
High	423	13.5	0.63	0.44-0.91	428	10.9	6.52	3.04-13.98
Sedentary behaviour								
Low	353	15.6	Ref		516	4.3	Ref	
Medium	465	18.9	1.26	0.87-1.83	401	9.2	2.28	1.32-3.94
High	492	17.1	1.12	0.77-1.62	373	6.4	1.54	0.85-2.80
Night-time sleep								
Low	794	16.9	Ref		432	10.4	Ref	
Medium	338	20.1	1.24	0.90-1.72	226	5.3	0.48	0.25-0.93
High	179	14.0	0.80	0.50-1.27	633	4.1	0.37	0.22-0.61

Perc = percentage; Ref = reference group.

Table 8. Results from simple logistic regressions of the binary variable indicating changing from normal to OWB or from overweight to obesity on independent variables describing mean values for the 2013, 2014 and 2016 surveys at the family level.

	Urban				Rural			
	n	**Perc (%)**	**OR**	**95% CI**	**n**	**Perc (%)**	**OR**	**95% CI**
Family economy								
Low	604	12.9	Ref		611	5.7	Ref	
Medium	591	21.2	1.81	1.33-2.46	344	8.1	1.46	0.87-2.44
High	112	21.4	1.84	1.10-3.06	291	6.2	1.09	0.60-1.95
Mother's education								
Secondary	87	6.9	Ref		727	6.9	Ref	
High school	408	14.7	2.33	0.97-5.57	362	5.8	0.83	0.49-1.41
University	762	19.4	3.25	1.39-7.60	175	6.3	0.91	0.46-1.78
Mother's age								
≤ 25 y	392	14.8	Ref		755	6.1	Ref	
>25-35 y	839	17.5	1.22	0.88-1.70	471	6.8	1.12	0.70-1.9
>35 y	79	27.9	2.22	1.26-3.91	64	6.3	1.03	0.36-2.95
Household size								
≤ 6 people	1,226	17.5	Ref		953	6.7	Ref	
>6 people	84	15.5	0.87	0.47-1.59	306	5.2	0.77	0.44-1.35
Watching food advertisement by mother								
Low	676	18.1	Ref		502	4.6	Ref	
Medium	298	16.1	0.87	0.60-1.26	440	6.1	1.36	0.77-2.41
High	323	17.7	0.97	0.69-1.38	292	11.0	2.56	1.47-4.47
Watching food advertisement by father								
Low	758	17.8	Ref		596	6.4	Ref	
Medium	243	15.2	0.83	0.56-1.23	402	5.7	0.89	0.52-1.52
High	259	17.8	1.00	0.69-1.44	195	8.2	1.31	0.71-2.41
Snack availability at home								
Low	308	19.8	Ref		847	5.8	Ref	
Medium	495	16.6	0.80	0.56-1.16	239	5.0	0.86	0.45-1.65
High	505	16.6	0.81	0.56-1.16	204	10.8	1.97	1.16-3.34
Parents' weight status								
No parents overweight	967	17.4	Ref		1,023	6.8	Ref	
At least one parent overweight	212	14.6	0.81	0.54-1.23	54	1.9	0.26	0.04-1.89

Perc = percentage; Ref = reference group.

4.5.3 Multiple regression and Determination Coefficient

Results from multiple logistics regressions (data not shown) indicate that in the urban area, all statistically significant variables except mother's age in the simple models were still statistically significant. In the rural area, age, large amount of food, indoor activity, sedentary time and night-time sleep duration remained statistically significant.

The Determination Coefficient (DC or Pseudo R^2) were small for all the simple models. The largest value observed for any model was 5.3%. The multiple models had somewhat larger DC but even the largest possible model, including variables at both the individual child and family levels, only reaches a value of 10.3% for the urban area and 18.7% for the rural.

4.5.4 Feeding practices and weight status

The mean levels of the reported scores for use of the three kinds of feeding practices: restriction, pressure to eat and monitoring, were statistically significantly different (p less than 5%) between mothers and fathers in both sites. Mothers used more practices of all kinds than fathers both in the urban and the rural area. The mean scores for the reported use of the methods were also systematically higher in the urban area than in the rural.

Statistically significant associations were found between the mothers reported use of pressure to eat and the child's baseline BMI. Higher scores for pressure to eat coincided with lower BMI. High scores for monitoring were accompanied by high child BMI. No statistically significant associations were found between restriction and child BMI. Corresponding associations were observed both in the urban and rural area.

5 DISCUSSION

5.1 Changes in prevalence of overweight and obesity during three-year follow-up

From 2013 to 2016 the estimated overweight prevalence within the cohort increased from 13.3% to 25.6% in the urban and from 4.8% to 7.7% in the rural area of Hanoi. The results are consistent with previous studies on Vietnamese preschool children (100-102) and provide additional evidence that the prevalence of overweight in preschool children is increasing, especially in big cities like Hanoi and Ho Chi Minh in Vietnam.

The prevalence of obesity in our baseline study conducted in 2013, 9.2% in the urban area, is higher than the prevalence of obesity among urban preschool children in 2007 (6.4%) (103), but lower than the corresponding prevalence in 2005 (16.3%) (104). The follow-up study indicated that the overall prevalence of obesity within the cohort decreased with age from 6.4% to 4.5%. We found that among children who were obese in the first survey 2013, 39.2% became overweight and 30.1% became normal weight. There were fewer changes in the opposite direction, which explains this decreasing prevalence.

The emergent development of overweight relates to dramatic economic and social changes. Vietnam experienced a long period of food shortage due to war (1945-1975) and post-war consequences, resulting in a high prevalence of underweight. The prevalence of malnutrition among children under 5 years of age was 51.5% in 1985 (105) and still 44.9% ten years later (105). Later, several programmes using media communication, education, training of proper nutrition for communities, programme for school nutrition et cetera, have been successfully implemented to reduce malnutrition (106). The prevalence of underweight among children under 5 years of age decreased to 17.5% in 2010 (66). Together with the reduction of undernutrition, overnutrition has emerged. Traditional Vietnamese diets where rice is the staple food and the main source of calories have been replaced by other food types (66). A survey on preschool children in Ho Chi Minh City in 2005 indicated that 98.1% and 12.7% of the children exceeded the Vietnamese recommendation for energy intake from protein and fat respectively (107). Several studies have reported positive correlation coefficients between BMI, overweight and intake of proteins (108-111).

Economic improvement today allows families to spend more money on food but the added food is not always healthy. A report from the General Statistic Office of Vietnam shows that the money used for food consumption per capita increased from $212.7 in 2010 to 298.7 in 2015 (112). The same report indicates that the government's revenues from chocolate in 2010 and 2015 were 157.8 and 299.2 million USD respectively. The corresponding figures for candy are 135.1 million USD in 2010 and 248 million USD in 2015 (112).

Comparisons of our findings with studies from other Asian countries face some problems due to different growth references, different age groups as well as a paucity of recent studies. However, a Chinese report found no statistically significant changes in prevalence of both overweight and obesity among 3-4 year old children between 2006 and 2014 (113). A review of 627 published articles and nutrition survey reports, using Thai growth reference, showed that the prevalence of overweight and obesity among preschool children was fluctuating unsystematically in the period 1995-2009 (114). A cross-sectional study by Rachmi et al. in children aged 2-4.9 years in Indonesia showed that the prevalence of OWB increased from 10.3% in 1993 to 16.5% in 2007 (115). It is natural that overweight and obesity prevalence and trends vary between countries due to differences in socio-economic, demographic, ethnic and cultural patterns.

In contrast to the stabilization of childhood obesity prevalence including preschool age in several developed countries (116-118), overweight is increasing in Vietnam and a similar tendency may be present also in other developing countries. A possible explanation is that low- and middle-income countries are entering a transition period with economic improvement which in combination with globalization, have modified the lifestyle towards more high energy-dense food intake and more sedentary behaviours. This tendency has been observed in high-income countries before.

5.2 Differences in prevalence of overweight and obesity between urban and rural areas

Our findings, a higher prevalence of both overweight and obesity in urban compared to rural areas, are consistent with other studies conducted in Vietnam (66, 119, 120) as well as in some other Asian countries (121, 122). It is also compatible with the tendency in several developing countries and with the WHO statement that "childhood obesity is one of the most serious public health challenges of the 21st century. The problem is steadily affecting

many low- and middle-income countries, particularly in urban settings" (123). In the follow-up study, we also found that urban children were more likely to develop overweight or obesity and nearly twice the proportion of urban children remained overweight or obese compared to rural. A lower percentage of urban children with overweight or obesity could move out of their excessive weight status than rural.

In Vietnam, like in other low- and middle-income countries, the urban environments share some characteristics. For example, there are many multinational supermarkets and restaurants which offer processed foods, snacks with high calorie content, candy and soft drinks. Furthermore, urban centres are densely populated with limited outdoor space, which could hamper PA. Urban people and children are more exposed to mass media marketing of food and beverages which can increase children's preferences for unhealthy foods. Urban and rural areas also differ in socioeconomic status. The average urban income per capita per month in 2012 was equal to $140, approximately double that in the rural areas (60). Data from 2009 showed that the urban population has a higher level of education with 37.4% completing high school compared to 13.8% in the rural areas of Vietnam (124). These differences are probably important when explaining the different overweight and obesity prevalence in urban and rural areas. In our qualitative study, mothers point to such explanations. One mother said that "Cities are polluted with vehicle exhausts. Children don't have anywhere to play so they have to stay indoors all day. They have to watch TV and play games on phones and iPads for entertainment."

In contrast, the tendency in developed countries is that overweight and obesity are more prevalent in rural areas (35, 125, 126). A report in 2011 from The National Advisory Committee on Rural Health and Human Services (NACRHHS) identified some factors that could explain the rural obesity development in USA: lack of parental knowledge about nutrition, less access to playground equipment, limited access to obesity prevention and treatment service (127). In addition, lower income in rural areas could increase the risk for overweight or obesity since energy-dense foods are often relatively cheap.

Developing countries, including Vietnam, might follow these patterns in the future.

5.3 Influence of factors at individual child and family levels on development of child overweight and obesity

5.3.1 Influence of factors at individual child level

Children's eating habits

Almost the whole energy intake of a human is via eating and drinking. An individual's energy intake therefore depends on the quantity of food, as well as the food energy content, both are related to the child's eating habits.

Overeating

We found that large amounts of food, as estimated by the parents, increased the risk of being overweight in urban children in the cross-sectional study, and the risk of becoming overweight in both urban and rural children during the three-year follow-up. Since details about the diet were not recorded in the study, we could not evaluate the actual caloric intake. However, Vietnamese children's eating habits with higher calories consumption than recommended for age, have been concluded in recent studies (107, 128). A higher caloric intake can be associated with a greater increase in child BMI and skinfold thickness (129, 130), though such relations are not always identified in other studies.

Another finding was that an increasing number of meals per day was associated with an increased risk of overweight in rural children. In Vietnam, preschool children normally eat three main daily meals. However, some families provide additional meals, one in the morning between breakfast and lunch and another in the afternoon between 3-4 p.m. These meals could lead to an increased amount of food that the child consumes per day. Attention should be paid to how much a child eats as well as the number of meals per day.

Unhealthy food

Frequent fat intake was associated with increased overweight development in both urban and rural areas. Similar associations have been shown in other studies (131, 132). Much fatty food is likely to contribute to overweight, since fat in comparison to protein and carbohydrates contains higher densities of energy. In addition, fluctuation of protein and carbohydrate are rapidly regulated as their rate of oxidation is equal to their intake, which is not true

for fat intake. Fat oxidation does not correspond with fat intake (133) and the balance of fluctuation in fat consumption is not similarly rapid compared to protein and carbohydrate.

We found that eating snacks irregularly was related to an increased risk of overweight in rural children, both in the baseline study and in the study of change during follow-up. In contrast, eating snacks irregularly appeared to reduce the risk of being overweight in urban children. The choice of snacks is dependent on the child's preference as well as parents' beliefs of what they find good for their child. Snacks could be healthy, such as different types of fruits, but also unhealthy. Urban-rural differences in snack type could be one explanation of the difference in association.

A positive association between intake of fried food and obesity has been reported in adults (134). Our findings suggest that this association also occurs in children. Frequent consumption of fried food was associated with higher increase in overweight. Frying food is common in Vietnam. Since oil is used, the energy density of the food is increased during the cooking procedure.

Eating at home was one factor found to decrease the risk of overweight in urban children in the present study. Similar results have been reported in USA and Germany (135, 136). Meals prepared at home are more likely to be healthy than food offered in restaurants (137). Several studies investigating the association between family meals and quality of dietary intake have revealed that increased frequency of family meals is related to an increased consumption of fruit, vegetables and calcium-rich foods, vitamins (A, C, B , E) and iron as well as a decreased intake of foods rich in fat (137, 138).

The quality of meals provided for Vietnamese children in kindergartens and in primary schools has been standardized by the Ministry of Education and Training to meet Vietnamese nutritional guidelines and can be expected to promote healthy growth. Special lunches are designed to be served to overweight or obese children with the purpose of managing their weight status. These actions have been implemented recently to control the increasing overweight and obesity problems in Vietnam.

Children' physical activity and sedentary behaviours

A key result in the baseline study was that PA more than two hours per day decreased the risk of being overweight. The protective role of PA was confirmed in the longitudinal study. In urban children, an inverse correlation between outdoor or indoor PA time and overweight was found. However, rural children who spent more time on indoor PA were more likely to be

overweight. One possible explanation is that indoor activities are less energy consuming. Playing inside the house normally means playing with toys or with peers and during this time, children can have something such as snack to eat. A positive correlation between indoor activity and snack eating was found in this study. The positive association between irregular snacks and overweight was also found in the rural area. In this case, a conflicting influence may occur which result in elimination of the protective effect of being physically active.

There is a paucity of Vietnamese studies investigating how much time children spend on PA. To our knowledge, one study only compared urban adolescent in Ho Chi Minh City in 2004 and 2009. In 2009 PA time was 63 and 38 minutes per day for males and females respectively, compared to 116 minutes and 81 minutes per day in 2004 (139). These results could be compared to the WHO recommendations of a minimum of 60 minutes PA, moderate to vigorous intensity, for children 5 to 17 years (3).

Increased sedentary time was associated with an increased risk of overweight in the rural children in the present study. This is in accordance with recent studies showing a direct relation between the prevalence of childhood obesity and the time used for television viewing (33-35). Increased consumption of snack food while watching TV has been reported as an additional risk factor (140). Since we also found a positive relation between sedentary time and snack eating in our study, this suggests that sedentary time is a factor that may not act alone but together with increased consumption of snacks.

There could be several reasons behind children's low activity, such as a lack of parents' monitoring, unsafe neighbourhoods and lack of space for children's playing. A study of high school children in urban Ho Chi Minh City found that poor access to recreational facilities increased the risk of overweight among adolescents (141).

Physical education is a compulsory subject at Vietnamese secondary and high school with 2 sessions each weak. Each session takes 45 minutes including various activities such as short running, fell running, badminton and high jump.

The positive influence of PA as well as negative influence of sedentary behaviours was recognized by mothers in our FGDs. They observed that urban children were inactive because of playing with smartphones or iPads while rural children's play more often includes running in the garden or playing at a common playground. The mothers emphasized that if parents do

not create chances for their kids to be active, it's very easy for them to become obese.

Other individual child factors

One finding in our study is that night-time sleep plays a protective role against overweight. Children with longer sleep at night show decreased risk of being overweight, both in urban and rural areas, though statistical significance was reached only in rural children. This finding is consistent with a longitudinal study of American children from birth to 9.5 years of age (142), a cross-sectional study on American preschool children in Illinois (143) and a case-control study of 6-7 year old children in Hong-Kong (144).

The American Academy of Sleep Medicine recommend that children aged 3-5 years should sleep 10-13 hours per day including naps, 9-12 hours for children 6-12 years old, and 8-10 hours for children 13-18 years old (145). Shorter sleep duration could influence weight status through increased opportunities for children to eat, especially at night time. One explanation may be that energy consumed at night-time is not utilized for PA and that the excess energy is then stored as fat in the body. Less sleep at night time could also influence children's PA as they might become tired when sleep duration is not adequate.

5.3.2 Influence of factors at family level

Family economy

One finding in our longitudinal study was that as the household economy increased, the corresponding odds ratio of overweight increased in the urban area. The result is in line with previous studies in Vietnam, Asia and other developing countries (100, 102, 103, 146-148) and suggests a potentially negative influence of economic improvement, at least above a certain level, on the weight status of the children.

A good family economy might create an obesogenic environment that encourages high energy intake and sedentary behaviour, for instance through TV viewing as well as playing with phones or iPads, especially in urban areas. High income parents might find it easier to afford to offer favourite foods, and these foods might not be necessarily good for their child's health. The overweight risk could be increased due to lack of parental knowledge about feeding. In addition, the mothers reported that it was difficult to refuse a child's food demands, especially for children in preschool age or under.

The results of the qualitative study emphasize the importance of the grandparents. In Vietnam, three generations (grandparents, parents and their children) often reside in one house. Taking care of the children including feeding them, is most often the mother's responsibility. However, grandparents, especially grandmothers or grandmothers in law, might influence the mother's parenting style because in the Vietnamese tradition elders in the family are always respected and their advice should be considered. Their experiences of poverty and lack of foods might make them prone to recommend overfeeding to the grandchildren. In combination with an improved economy the risk of overfeeding and overweight of the grandchildren can increase.

The obesogenic environment at family level in particular and community level at large can be influenced by the government's political and commercial policies such as trade, fiscal and agricultural policies, which affect availability and accessibility of foods. Addressing the obesogenic environment is one of the strategies recommended by the WHO to tackle childhood overweight and obesity (149).

Mother's education and age

The study shows that urban children, whose mothers have an education at university level, had an increased risk of being overweight. A possible explanation can be that parents with high education, especially in urban areas and big cities, often work long hours in business or desk jobs. In our study, over 80% of the urban mothers work in offices or in business. Well-educated parents may have less time for their family and children and therefore prefer processed food which increases the risk for weight gain. Another solution for dealing with insufficient time is that parents leave the care of their children to grandparents or in rare cases to housekeepers. A study conducted on Japanese preschool children showed that when grandparents take care of children the risk of being overweight increased by 60% compared to children taken care of by mothers (150).

Another effect of the lack of time may be that parents cannot support their children's PA or be a good model in that sense. A systematic review of studies on the relation between maternal working hours and overweight in children reported that the prevalence of overweight is higher in children to mothers with long working hours (151). The risk may be illustrated by a mother's statement in our FGD: "One of the reasons for obesity among urban children is that their parents have to work all day and don't have the time to take care of them. They (children) always stay indoors, they can eat whatever they like. That is why they become overweight."

In low- and middle-income countries, as well as historically in high-income countries, a positive correlation between well-educated parents and overweight in children has been seen (147, 152) while in high-income countries today, less educated parents have an increased risk of having overweight children (147, 153-155). The latter might be explained by an increased awareness of the child's healthy weight and consequences of excessive weight in children among educated parents in high-income countries.

Interestingly, we found an association between the mother's age and child overweight in the urban area. Overweight was more prevalent in children whose mother was over 35 than in children of young mothers (less than 25 years old). The reason for this is unclear and has not been discussed in other studies as far as we know. Our hypothesis is that urban middle age women may have achieved higher professional positions, demanding high efforts and time. As a result, the family economy may have improved, both factors increasing the risk of overweight in their children.

A Greek study found, in contrast to ours, an inverse relation between mothers' age and child overweight (156). The explanation suggested was that older mothers are better aware of child health and healthy weight (156). The differences between these results points to the importance of considering the context when analysing the effect of environmental factors on overweight.

In the present research, the conclusions about association with socioeconomic factors, family economic condition, mother's education and age, are mainly drawn for the urban area.

Food advertisement on TV

The investigated family's number of assets increased from 8.8 to 9.2 in the urban area and from 5.4 to 6.2 in the rural between 2013 and 2016. TV, one of the assets, is now common and some families have several TV sets. A survey conducted in 2014 indicates that the main source of nutritional information that mothers receive comes from TV, radio, newspaper, internet and leaflets, accounting for 56.3%, 23.8%, 20.6%, 14.7% and 9.4% respectively (157).

Television can affect the development of overweight, both through time spent watching, resulting in long sedentary time and because of the influence of food commercials for unhealthy foods. In the present longitudinal study, we found that the odds of child overweight increased over time in children with mothers frequently watching food advertisements in the rural area.

Lobstein et al. analysed data from surveys of advertising on TV conducted in eight European countries (UK, France, Germany, Denmark, Finland, Greece, Netherlands and Sweden), as well as USA and Australia. They found a positive association between the number of advertisements regarding sweets and fatty foods and child overweight (158). A systematic review in the UK indicated that children's preferences, purchase behaviour as well as consumption were altered by food promotion on television (159).

Foods available in the home

We found that availability of snacks at home was a risk factor of overweight in rural children. Both the cross-sectional and the follow-up studies showed that overweight was more prevalent in children who have easy access to snacks at home. We also found a positive correlation between availability of snack food at home and irregular snack consumption. The availability of snack food at home could encourage the child's consumption by allowing them to eat any time they wanted. Eating snacks may make children feel full and they might then refuse to eat healthy food in full meals. The resulting effect may increase the risk of becoming overweight.

Globalization and increased international trade are likely to lead to increased diversity of food in Vietnam. Parents and children will find it easier to buy unhealthy snack food such as chocolate, candies, biscuits and potato chips that traditionally have been unavailable.

Child feeding practice

Three types of feeding practices investigated in our study, were restriction, pressure to eat and monitoring. In both the urban and rural areas, there was a positive relation between child BMI and monitoring, while a negative relation between child BMI and pressure to eat was found. For restriction, there was no statistically significant association with child BMI. Similar relations have been reported in some studies (75, 160), but not in others (43, 161). It is not possible to interpret these findings as causal given the cross-sectional design. However, mothers of leaner children tend to pressure them to eat more, whereas mothers of heavier children try to monitor and restrict them. The hypotheses that can be formulated are supported by a study by Francis et al. which showed that mothers perception of their daughters being underweight was an important predictor of using pressure to eat (162).

The effects of feeding practices vary depending on the way they are executed (163-165). Several studies even indicate opposite effects than expected from the initial purpose of using them. Fisher et al. found in a two-year follow-up study that children whose parents restricted access to food at the age of 5, had

a higher degree of unnecessary eating at the age of 7 (166, 167) as restriction can affect the child's ability to self-regulate food intake (168). Evidence from other longitudinal studies shows that higher pressure to eat predicts lower child weight later in life (169, 170). It is suggested that feeding control needs to be considered carefully since it can have unwanted effects.

Parental overweight

We found that children of overweight or obese parents had increased risk of overweight. Such associations have been reported in other studies (144, 148, 171). A review of studies of genetics, body weight and human adiposity showed that 50 - 90% of the variation in BMI was explained by genetic factors (172). When both parents are obese, approximately 70% of their children will be obese. When one parent is obese, the prevalence decreases to 40 - 50%, and if neither parent is obese, it falls to less than 10% (173).

Increased risk of overweight and obesity is likely to be a result of both genetic and environmental influences. At the start of life, genetic predisposition initially orientates food preference for individuals, for example, the like or dislike for certain types of food. Genetic similarity could contribute to similarity in food preference between parents and children (174). However, genetic predisposition for food preference can be influenced by family environmental factors such as parental feeding practices, availability of food at home and parental eating behaviour.

5.4 Parents' conception of childhood overweight

The results on parents' ability to identify their children's weight status suggest that many parents fail to identify overweight in their children. Only 19.2% of the urban and 6.9% of the rural parents having overweight children as classified by the children's BMI reported their children as being overweight. Our results are in line with other studies on preschool children. For example, 79% of American mothers had an incorrect classification (175). These figures were even higher in UK parents where 98.1% of parents with an overweight child and 82.9% of parents with an obese child were unable to recognize the excessive weight (176). For Chinese mothers, the corresponding percentage was 89.2% (177).

The mothers in the qualitative study expressed that they evaluated the child weight status subjectively by comparing the child's body size with their peer or based on the child's appearance. The mother's own experiences are often

influenced by views about body image as well as ideals of beauty. If the mothers think that a chubby appearance signals a healthy child, they may consider overweight as normal. It should be noted that not all mothers or parents use their own experience to classify the child's weight.

Failing to correctly classify child overweight could influence the parents' engagement with their child's weight control and that could place children at risk of prolonged and increased overweight. It is not until mothers perceive their children as heavy, that they can take effective action.

5.5 Method comments

The study of the topic of this thesis is difficult from some methodological points of view. The phenomena under study, overweight and obesity, are defined using technical and arbitrary criteria. In a study of considerable size, like the present one, it is hardly feasible to directly measure adiposity as body fat composition. BMI is used as a proxy.

In the baseline study (Paper I) the WHO standard was applied for easier comparison with other studies in Vietnam using the same definition. However, the WHO standard has a discontinuity in cut-off points between the WHO standard from 2006 for children under 5 years old (68) and the WHO standard 2007 for children 5 to 19 years (92). As a result, the prevalence of overweight or obesity in the studied children will automatically increase. This does not reflect the real situation for an individual child. Since the IOTF cut-off points form a continuous function of age, these were used in the rest of the thesis.

However, there can still be differences in definition of cut-off points between studies and contexts. This must be kept in mind when interpreting and comparing results.

Most of the information used to explain variation in weight status is obtained from the mothers or caregivers, either through the answers in questionnaires or via the qualitative analysis of FGDs. Validations of the Birch questionnaire have been made in different contexts but the value for use of the instrument in Vietnam was not known. A study of validity, referred to in Paper III, showed that some parts of the questionnaire could quite well be used whereas the results from some questions should be very carefully interpreted.

The information obtained from the questionnaire, and some additional

questions, consists of the respondent's reaction on the question constructed and decided by the researchers. There was some background material behind these choices but they are still subjective. To have more "objective" information, which is less directed by the researcher, qualitative information was obtained in FGDs. Ideally such information shall not be more influenced by the researchers than what is necessary to keep the discussions within the topic. This was achieved to a varying extent in the present study but has generally been considered as satisfactory.

The qualitative approach has been used here to go deeper into what was already seen in the quantitative studies. A delicate matter is to analyse and present the results in an integrated way. A rather conventional approach has been used in the thesis for the quantitative results leaving some of the integration with the qualitative research to the reader. In this study generalization of the quantitative results can at best be made to the two areas from which the participating children were recruited.

Two types of logistic regression models have been used for the statistical analysis of associations. In the *simple models*, the statistical association between the outcome variable, indicating overweight, obesity or status change, and each single explanatory independent variable, were studied separately. These results have a value since they show the associations as they are in the real world, which means they are influenced and confounded, by a manifold of variables. Some of these are known and possible to take into consideration. Others, possibly quite many, have not been discovered or imagined.

Multiple models, including several explanatory variables, can serve different purposes. One is the ambition to study "adjusted" associations where confounding variables are assumed to be fixed, hence not influencing the sometimes so called "independent" associations between the outcome and individual explanatory variables. The usefulness of this can be questioned since the results then show a situation that can never occur in reality. This can be useful if we are specifically interested in one or few pre-defined explanatory variables.

It was considered too problematic to use overall models with an 'area variable'. The two areas are clearly different in too many aspects and complicated models with interaction terms would have complicated or even made it impossible to interpret the results in a useful way.

Another purpose of multiple analysis can be to study how a set of explanatory variables together are associated to the outcome variable that is the risk of overweight or obesity. We might then get meaningful ideas about how much the risk could change if interventions including several types of actions could be successfully applied. In public health, there is of course most often no single variable that alone is the key to the solution of the problem.

In the analysis, we have tried simple as well as multiple models. The findings of individual associations have their value. To prevent and manage overweight and obesity we need knowledge about risks at the individual child and family levels. However, it is important to see that factors at these levels do not explain large parts of the total variation in weight status and changes for the preschool children, underscoring the importance of the outer segment, the community level, of the conceptual framework (Figure 1).

6 CONCLUSIONS AND IMPLICATIONS

6.1 Conclusions

Overweight and obesity among preschool children is an emerging problem in Vietnam. The estimated overweight and obesity prevalences were considerably higher in the urban than in the rural area. Trends of increasing prevalence of overweight and decreasing prevalence of obesity with age were found in both areas, although stronger in the urban one.

Several factors, despite some differences between urban and rural areas, were found to be statistically significantly associated with OWB. These factors are eating habits, PA at the individual child level and socioeconomic conditions and food advertisement on TV at the family level. All associations were however, weak if considered as predictors of overweight and obesity as well as of weight status change.

Most mothers in the FGDs perceived that overweight in children can be related to health problems. They thought overweight was a result of combinations of several factors: unhealthy lifestyle, genetic susceptibility and improvement of economy. Hence, the methods for managing overweight, used by the mothers, are modifying child's eating habits and increasing PA. However, management is sometimes challenged by the large appetites of overweight children and the different views about child's healthy weight that grandparents can have. The mothers expressed trust in using health information on TV programmes, from the health care system and from growth charts, to recognise overweight problems.

6.2 Implications

Prevention of overweight and obesity need to be started early, even at preschool age. Activities and advice need to be different in urban and rural areas. Some suggestions at different levels are:

At the individual child level

Encourage children, especially children with obese parents, to eat healthy foods and eat at home, to be physically active and to have appropriate sleep time through child education at home and at schools.

Ensure healthy foods are available at home.

At the family level

Support parents and grandparents or caregivers to recognize correctly the child's weight status through providing guidance on healthy child size and use of growth charts by medical professionals.

Educate parents, grandparents and caregivers about child feeding practices by providing information or advice at health visits and group education.

At the community level

Actions at the individual child and family levels are important but have to be based on and strengthened by activities at the community level.

Enhance awareness of the risk**s** of childhood overweight and obesity and their consequences via public health TV programmes by professionals.

Make facilities available at schools and public areas to support physical activities of children.

Issue government regulations on the marketing of commercial food and tax policy on food to avoid children being exposed to unhealthy food.

ACKNOWLEDGEMENT

Words alone can hardly express my sincere gratitude to the following people, who have supported me and contributed in some ways to complete the project and the thesis:

First of all, special thanks go to my main supervisor, Professor Henry Ascher, for giving me useful guidance, suggestions as well as valuable comments throughout my doctoral study, research and writing of the thesis. I would like to thank you for helping me to deal with the paper work in the halftime seminar and the disputation. I am indebted to your generous time spent assisting me when I was away from home to study in Sweden. The fact that you and Anne Svanholm considered me as one of your family members during my stay in Gothenburg has truly touched me.

I would also like to express my deep gratitude to Professor Bo Eriksson, whom I have very much admired, for sharing your knowledge and experience, especially in research methodologies and statistical analysis. Thank you for always being inspiring and giving me effective encouragement when I got stuck in the scientific researching process and writing papers. Also, I am genuinely grateful that you have introduced and guided me around Sweden, which I now consider my second homeland.

Next, I would like to acknowledge Professor Max Petzold, the co-supervisor, for your scientific contributions throughout my whole research and helpful advice on my papers. I have greatly enjoyed working with you and learnt so much from your valuable opinion and knowledge.

To Professor Nguyen Thanh Liem, my co-supervisor and former director of National Hospital of Paediatrics, where I have been working at, I thank you for giving me the motivation to continue on at doctoral level. I highly appreciate your kindness in arranging my work at home so that I can assure my study in Sweden.

To Professor Nguyen Thi Kim Chuc, I truly appreciate and thank you for connecting me to the University of Gothenburg, as well as your support on my data collection and working on the filed sites.

To Professor Hai, director of National Hospital of Paediatrics, Professor Le Minh Huong, vice director of National Hospital of Paediatrics, and my colleagues, who have all taken care of my responsibilities in the hospital

during my doctoral study, I highly regard your help. I am most grateful to Professor Hai and his encouragement and support of my continuous training in Sweden.

To the teachers of the University of Gothenburg and the EPSO department, your teaching has been exceptionally helpful for the completion of my work and so I am thankful.

I would also like to thank all field workers, participants, especially children and their parents, who participated in the research, for their contribution to data collection.

As for my friends: Tran Khanh Toan, Nguyen Thu Huong and Viveca Larsson, I thank you for providing me with invaluable advice through various discussions. Specifically, Tran Khanh Toan has constantly aided me in statistical analysing process, which I am much obliged for.

Above all, special thanks go to my beloved family, who motivated me immensely in my hard times. They are the reason I could accomplish what I have done today. Without them, I would not have gone all the way to Sweden and overcome the challenges that I have faced.

Lastly, I wish to thank everyone even those not mentioned by name, who have had the willingness, kindness and patience to help me and in so doing have shown their love for me.

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