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BODY MASS INDEX, NUTRITION AND PARENTAL MIGRATION: FROM BIRTH TO ADOLESCENCE

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Body mass index, Nutrition and Parental Migration: From Birth to Adolescence

THESIS FOR DOCTORAL DEGREE (Ph.D.)

At Karolinska Institutet

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In the name of God, the beneficent, the merciful

To my mother and the memory of my late father

&

To my family

تقدیم به خانواده ام

به مرحوم پدرم

وبه مادرم

SUMMARY

Childhood overweight and obesity is a major public health problem of the recent century. The aim of this thesis was to investigate the impact of parental migration background on childhood overweight and obesity and lifestyle in relation to socioeconomic position, and the possible role of factors such as perinatal characteristics and breastfeeding in BMI development among offspring of immigrant parents.

The relation between parental migration background and risk of childhood overweight and obesity was studied among 2 589 children of a Swedish birth cohort (BAMSE) where 22 % (n = 561) had at least one foreign-born parent (Study I). At age 8 years, 20 % of children with native Swedish parents and 26 % of children with at least one foreign-born parent were overweight or obese. In a multivariate logistic model, adjusting for parental education, physical activity and compliance with nutritional recommendation, children of immigrant parents had 33 % higher odds of overweight and obesity compared with Swedish peers. When both parents were immigrants, the number increased to 70 %. Offspring of parents from Latin America and Asia had significantly higher odds of overweight and obesity than Swedish peers.

In the same population, we studied the association between parental migration background and risk of low physical activity among offspring (Study I). Controlling for parental education, overweight and compliance with nutritional recommendations, offspring of immigrant parents had 30 % higher odds of low physical activity than Swedish peers. The odds increased to 67 % when both parents were immigrants. Moreover, low parental education was associated with low levels of physical activity, regardless of parental migration background.

The relation between parental migration background and compliance with nutritional recommendations was also studied in Study I. The compliance with nutritional recommendations was assessed using a scoring model which estimated the average fulfillment of nutritional recommendations. Compliance with nutritional recommendations among offspring of immigrant parents was better than among Swedish peers. In subgroups, only children with an immigrant father showed better compliance. Higher consumption of fruit and vegetables and unprocessed meats were healthy aspects of diet among children of immigrant parents, opposed by unhealthy aspects such as low consumption of milk and dairy and high consumption of sweets. Furthermore, high parental education was associated with a high dietary score, regardless of parental migration background.

The relation between maternal migration background, perinatal characteristics, and BMI development was studied in a longitudinal follow-up from birth to age 12 years in Study II. There were no significant differences in pregnancy outcome with regard to birth weight and weight for gestational age between offspring of immigrant vs. Swedish mothers. However,

BMI development was different in the two groups adjusting for maternal and perinatal characteristics. Children of immigrant mothers had a slower BMI development than Swedish peers up to age 5 years, followed by a steeper pattern afterward.

The relation between maternal migration background and duration of breastfeeding, and BMI development was evaluated in a longitudinal study from age 2 to 16 years (Study III). Comparing children breastfed for short periods or not at all with exclusively breastfed ones, a steeper BMI development was observed among offspring of Swedish mothers but the opposite was observed among offspring of immigrant mothers. The observed variations in BMI development patterns were compatible with ages at adiposity rebound.

In conclusion the results of this thesis underline the risk gradient for childhood overweight and obesity, and adverse lifestyles among Swedish born children with immigrant parents. This thesis also demonstrates diverse patterns in BMI development by parental migration background which starts at early childhood. However, the diversities in risk of overweight and obesity, and also BMI development was not fully explained by parental education as indicator of socioeconomic position, perinatal characteristics and duration of breastfeeding. More studies are needed to explore underlying driving forces and their possible interaction with regards to parental lifestyles, cultural background, and different indicators of socioeconomic position, psychosocial environment and acculturation.

LIST OF PUBLICATIONS

I. **Mohsen Besharat Pour**, Anna Bergström, Matteo Bottai, Inger Kull, Magnus Wickman, Niklas Håkansson, Alicja Wolk, Tahereh Moradi
Effect of parental migration background on childhood nutrition, physical activity, and body mass index
Journal of Obesity. 2014 Jun 1; 2014:406529. doi: 10.1155/2014/406529

II. **Mohsen Besharat Pour**, Anna Bergström, Matteo Bottai, Jessica Magnusson, Inger Kull, Magnus Wickman, Tahereh Moradi
Body mass index development from birth to early adolescence; effect of perinatal characteristics and maternal migration background in a Swedish cohort
PLOS ONE. 2014 October 10; 9 (10). doi:10.1371/journal.pone.0109519

III. **Mohsen Besharat Pour**, Anna Bergström, Matteo Bottai, Jessica Magnusson, Inger Kull, Tahereh Moradi
Age at adiposity rebound and body mass index trajectory from early childhood to adolescence; differences by sex, breastfeeding, and maternal migration background
Submitted Manuscript

CONTENTS

LIST OF ABBREVIATIONS

BMI	Body Mass Index
IOTF	International Obesity Task Force
WHO	World Health Organization
GWAS	Genome Wide Association Studies
FTO	Fat mass and obesity-associated gene
BAMSE	Name of a Swedish birth cohort; abbreviation for: Barn/children, Allergy, Miljö/environment, Stockholm, Epidemiology
FFQ	Food Frequency Questionnaire
PIN	Personal Identification Number
NNR	Nordic Nutrition Recommendations
SEP	Socio-Economic Position
BW	Birth Weight
ICD	International Classification of Diseases
OR	Odds Ratio
PUFA	Polyunsaturated Fatty Acid
SFA	Saturated Fatty Acid
SEI	Swedish Socio-Economic Index
SCB	Statistics Sweden

1 INTRODUCTION

Childhood overweight and obesity is a major public health problem worldwide, with 42 million preschool children affected in 2013 and a projection of 70 million children being affected in 2025. There is a 17-fold variation in the prevalence of childhood overweight and obesity among different world regions, and 5-fold variation among European countries. Besides affecting physical and mental health and quality of life in childhood, overweight and obesity often extend into adulthood where they are at risks for metabolic and cardiovascular diseases, and some cancers, diseases of public health concern.

The prevalence of childhood overweight and obesity increased at an alarming rate globally during the last two decades of the previous century. Almost all countries have experienced an epidemic of childhood overweight and obesity, albeit at differing rates. In the new millennium, the prevalence of childhood overweight and obesity is still high in many regions and countries, especially low and middle income countries. However, promising evidence indicates a steady state in the trends of prevalence, particularly in high income countries. While genetics and culture appear to be contributing factors, a rapid pace of changes in prevalence points to the importance of environmental factors in the development of childhood overweight and obesity.

A rising flow of international migration, mainly from low and middle income countries to high income countries, has made health-related matters relating to immigration globally important. In 2014, over 1.6 million foreign-born people were residents of Sweden, which accounted for 16.5 % of total population. Taking into account those born in Sweden of two immigrant parents, immigrants represented 21.5 % of the total population of Sweden. Population trends suggest that the numbers of both first and second generation immigrants are growing and to some extent do affect the growth of the total population of Sweden.

Public healthcare providers in Sweden are faced with a multicultural population with a higher risk of childhood overweight and obesity among minority subpopulations. This risk gradient is partially attributed to established risk factors for developing overweight and obesity, mainly socioeconomic factors. However, there may be other factors which play a role in the development of childhood overweight and obesity or established risk factors that affect the immigrant population differently from the general population. Studies among immigrants, especially those distinguishing different generations, can provide evidence for public health interventions with regard to high risk groups as well as determining risks among those groups.

The aim of this thesis is to investigate the impact of parental migration background on childhood overweight and obesity and lifestyle, and the possible role of factors such as perinatal characteristics and breastfeeding among offspring of immigrant parents.

2 BACKGROUND

2.1 CHILDHOOD OVERWEIGHT AND OBESITY

2.1.1 Definition and measurement

Childhood overweight and obesity is defined as excess body fat in children, to an extent that impairs health [1-3]. Since excess body fat is a consequence of an imbalance between energy intake and energy expenditure in a way that causes excess body energy to accumulate in the form of fat or adipose tissue, overweight and obesity are also considered to be diseases of positive energy balance [4].

Based on the definition of overweight and obesity, there are two important components that should be taken into account: the adiposity measurement method and identifying the cut-off points that are associated with increased health risks [1]. The recommended and most widely used adiposity measure in clinical and epidemiological studies is body mass index (BMI), calculated as weight in kilograms divided by height in meters squared (kg/m^2) [1, 3, 5]. An advantage of using BMI as an adiposity measure is that it is easy to measure; furthermore it has been shown to be valid in identifying overweight or obese children [3, 6, 7]. One of the established cut-offs for assessment of childhood overweight and obesity specifically used for international comparisons is proposed by the International Obesity Task Force (IOTF) [1, 3, 8]. The IOTF cut-offs for childhood overweight and obesity are age and sex specific values on centile curves that correspond to adult BMI values of 25 and 30 kg/m^2 respectively [8].

2.1.2 Health consequences

Overweight and obesity in childhood are associated with adverse physical and psychological consequences in both the short and long term. The short-term health effects include metabolic disorders, such as type 2 diabetes mellitus, dyslipidemia and metabolic syndrome, cardiovascular diseases, such as hypertension and atherosclerosis, musculoskeletal disorders and sleep apnea [9]. In addition, childhood overweight and obesity are considered to be associated with body dissatisfaction, low self-esteem, depression, social rejection and lower quality of life [9-11].

Overweight or obese children often become overweight or obese adolescents and adults, most likely due to tracking unhealthy lifestyles [12]. In this case, they carry a higher risk of e.g., metabolic disorders, cardiovascular diseases, mortality and some cancers [13, 14].

2.1.3 Epidemiology

According to the World Health Organization (WHO), the prevalence of childhood overweight and obesity has increased at an alarming rate, for instance the number of overweight or obese preschool children globally increased from 32 million to 42 million between 1990 and 2013, with a projection of 70 million in 2025 [15].

Almost all studies that traced the prevalence of childhood overweight and obesity through the 1980s and 1990s reported an upward trend in many different world regions [16]. In the new millennium the trend in childhood overweight and obesity has been shown to be continuing in many regions [17]. However, there is more recent evidence that the trend of childhood overweight and obesity has stopped or even reversed in some, mainly developed, countries such as Sweden, the United States, Australia and Japan [18, 19].

There are considerable variations in the prevalence of childhood overweight and obesity by world region. The latest available surveys show that the prevalence of overweight and obesity, using the IOTF criteria, in school age children ranged from 1.6 % in Africa to 27.7 % in America, and concurrently 10.6 % in Southeast Asia, 12.0 % in West Pacific, 23.5 % in East Mediterranean and 25.5 % in Europe [16]. Similar variations in prevalence of childhood overweight and obesity exist at a country level. For instance, in a multicenter study in Europe the prevalence of overweight and obesity among children aged 2-9 years ranged from 8.3 % in Belgium to 42.3 % in Italy, and was 10.2 % for Sweden [20].

In Sweden there is currently no nationwide representative data source that specifically traces the prevalence and trend of childhood overweight and obesity [21, 22]. However, available data shows that Sweden has a lower prevalence of childhood overweight and obesity compared with many other European countries, especially in Southern and Western Europe [5, 23]. According to the latest surveys, the prevalence of childhood overweight including obesity using the IOTF criteria was estimated to be 10.2 % in preschool children (age 5-6 years) [20] and 17-24 % in school age children (age 10-11 years), with a higher prevalence among boys [22].

2.1.4 Etiology

2.1.4.1 Genetic

Studies on familial patterns of overweight and obesity as well as twin and adoptive studies indicate the important role of genetics in childhood overweight and obesity [24-26]. Genome wide association studies (GWAS) have also identified the fat mass and obesity-associated gene (FTO) on chromosome 16 as a susceptibility gene of obesity [27, 28]. It has been shown that in children and adolescents each additional FTO risk allele increases the risk of overweight and obesity by 1.27- and 1.35-fold, respectively [27].

2.1.4.2 Environment

There is compelling evidence that environmental factors, including lifestyle, interplay with genetics in the etiology of overweight and obesity, i.e., gene-environment interaction. Migrant studies were among the first to provide such evidence [29]. It has been shown that the higher prevalence of overweight/obesity among children of immigrants, as compared with children in the parents country of origin (who would be assumed to have similar genetic predispositions) is explained by changes in environmental exposures in the new host country

[30, 31]. This finding is also supported by comparisons of the risk of overweight/obesity in different generations of immigrants [32].

In addition, dramatic increases in the prevalence of childhood overweight and obesity during the past decades indicate that environmental factors most likely play a critical role, since it is unlikely that rapid changes occur in genes [5]. Therefore, there is a consensus that a "genetic predisposition" is expressed when exposed to an "obesogenic environment" [5].

The obesogenic environment is considered to be a combination of "the surroundings, opportunities, or conditions of life" that have a promoting influence on obesity in individuals or populations [33]. This definition encompasses physical, economic, political and sociocultural environment. Moreover, diet and physical activity are considered to be "key mediators" for promoting the influence of an obesogenic environment [33]. In particular, the sociocultural environment has a strong effect on attitudes, beliefs, and values regarding diet and physical activity. This must be taken into account as an important factor in planning preventive programs for childhood overweight and obesity [5]. Country of birth, as a proxy for background culture, and SEP are among the determinants of sociocultural environment [33].

2.1.5 Risk factors

The core problem of overweight and obesity is an imbalance between energy intake and expenditure. There are many biological, environmental and social risk factors that have been considered to play roles in the imbalance of energy in favor of energy excess [34, 35].

Early life factors such as birth weight and other antenatal exposures affect the risk for childhood overweight and obesity. There is convincing evidence that birth weight is positively associated with BMI later in life [36]. In the same manner, maternal adiposity, gestational diabetes and gestational weight gain are associated with overweight and obesity among children [37, 38].

A higher rate of weight gain during infancy is positively associated with a risk of overweight and obesity in children as well as total and central adiposity in adult [39-42]. An early age at adiposity rebound is considered to be a risk factor for overweight and obesity later in life [43].

Breastfeeding is generally considered to be a protective factor for childhood overweight and obesity [44, 45]; however, there are some contradictory results [46-48]. In school age children, consumption of sweetened soft drinks, skipping breakfast, low levels of physical activity and a sedentary lifestyle are risk factors for overweight and obesity [49-55].

Psychological situations such as depression, stress and anxiety, as well as short sleep duration, have also been considered as possible risk factors [50, 56-59]. In addition, the risk of childhood overweight and obesity varies with ethnicity, country of birth and socioeconomic position [60-64].

2.2 MIGRATION

Migration has been defined as individual or population movement, either within a country or across country borders [65]. As it causes changes in environment, migration influences most aspects of an individual's life, including lifestyle and health issues [59]. Moreover, immigrants may introduce new risks or protective factors to a host country, and thus multicultural society may influence public health in different ways [66]. On the other hand, migration provides a good genetic and environmental contrast to study risk factors of diseases as well as determinants of health [67].

2.2.1 Immigrants in Sweden

Sweden is one of the world's most welcoming countries to immigrants. In 2014, almost 16.5 % of Sweden's 9,747,355 inhabitants were foreign-born (n = 1 603 551). Concurrently, around 12.3 % of the total population were born in Sweden from either two foreign-born parents (5 %; n = 488 655) or one foreign-born parents (7.3 %; n = 710 313) [68]. This indicates that currently 28.8 % of Swedish inhabitants have an immigrant background, though the definition of foreign background by Statistics Sweden includes only foreign-born individuals and Swedish-born individuals with two foreign-born parents (21.5 %).

Sweden has experienced several waves of migration over time. The net flow of migration before 1930 was emigration, mainly to North America. During this period of time, immigrants to Sweden were mainly Swedish returnees. After 1930 the net flow of migration in Sweden changed "from a land of emigration to a land of immigration" [69]. The driving forces for immigration have varied over time and include the Second World War, labor market demand in Sweden and trouble in other parts of the world. Immigrants have come from different regions and cultures. During and after the Second World War, refugees from neighboring countries were the main immigrating group. The post-war labor market in the 1950s and 1960s attracted immigrants from Nordic countries, Southern Europe as well as Turkey. During the 1970s and 1980s, when the labor market was no longer attractive, the immigrant pattern changed to refugees mainly from Latin America and Asian countries. During the 1990s and early 2000s, immigrants were mainly asylum seekers from disintegrated Soviet Union countries and former Yugoslavia as well as refugees from the Middle East and Africa due to the Iraq war and civil war in Somalia. Information on asylum seekers since 2010 shows that a majority of immigrants come from Middle East and African countries; at the top of list are Syria, Somalia, Eritrea, Afghanistan, Serbia and Iraq, accounting for almost 70 % of asylum seeking in this period [70].

The trend of immigration into Sweden has been upward during the past decades. It seems that population growth in Sweden is mainly influenced by immigrants, given fairly stable numbers of childbearing (Figure 1). Besides the increasing number of foreign-born immigrants (1^{st} generation), there is also an increase in the number of Swedish-born children who have one or two foreign-born parents (2^{nd} generation) (Figure 2).

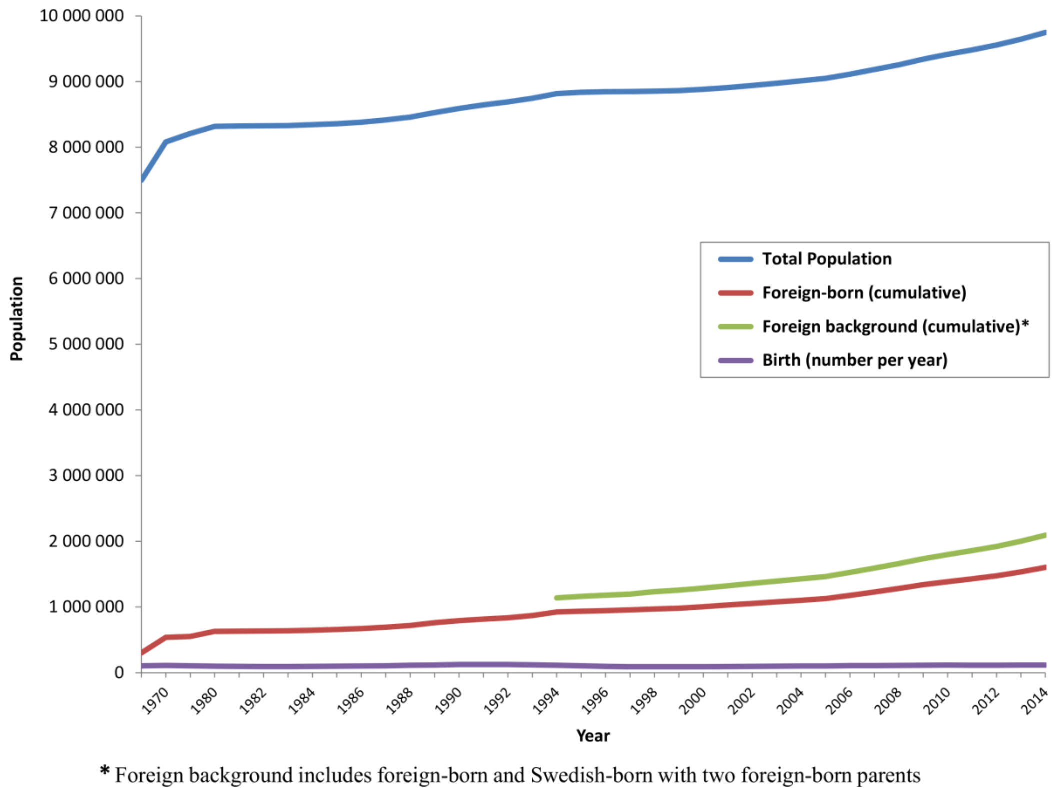

Figure 1: Population in Sweden between 1960 and 2014 (Source: Statistics Sweden).

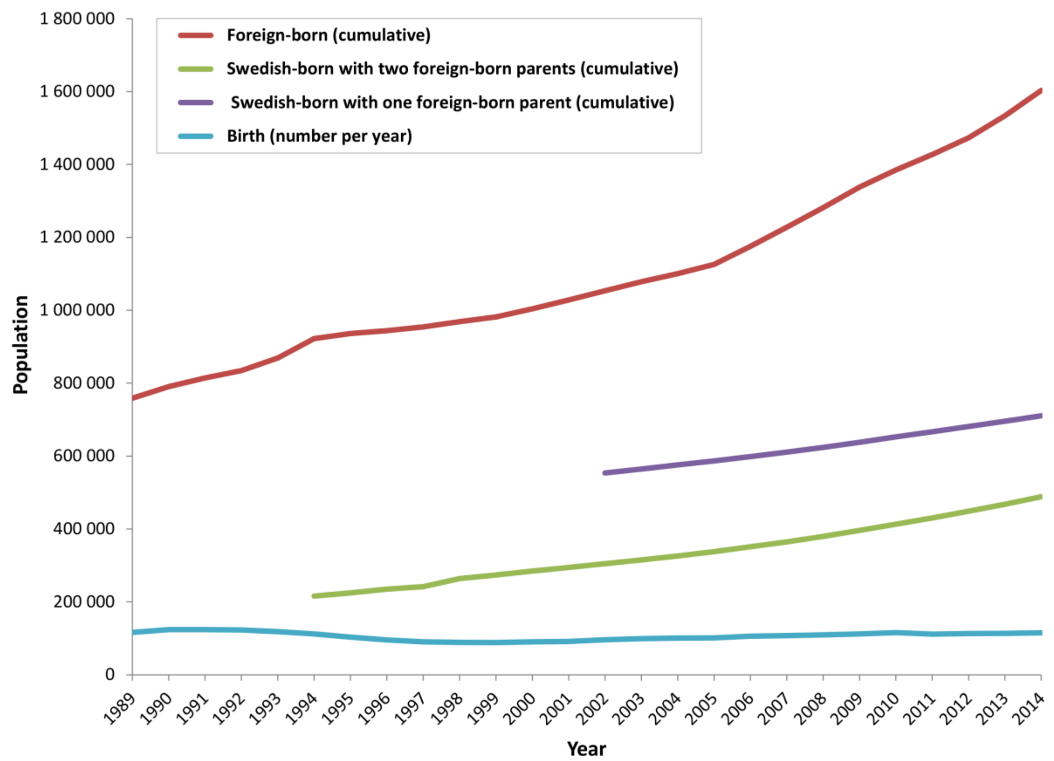

Figure 2: Population of first and second generation immigrants in Sweden between 1989 and 2014 (Source: Statistics Sweden).

2.3 RATIONALE FOR STUDIES

Migration and the consequent multicultural society create new challenges for public healthcare providers. Sweden today is a more multicultural country than ever and there is a greater need to study differences in health outcomes considering cultural background and socioeconomic diversities. Childhood overweight and obesity is a public health priority and considered to be "one of the most serious public health challenges of the 21st century". Although emerging evidence shows a leveling off in former rapidly growing obesity numbers among Swedish children, this is not the case among children with migration background [71]. Indeed, a leveling off of the trend for prevalence of childhood overweight and obesity in the general population, while the numbers remain high among minority subgroups, indicates that public health achievements in other subgroups are counterbalanced and even masked by high prevalence of overweight and obesity in minority subgroups. This is a threat of a steady state in childhood overweight and obesity, which could be turned into an opportunity. Further, this indicates the necessity of interventions tailored for high risk groups "since the power of the 'obesogenic environment' will probably continue to be strong" [72].

Studies on immigrant minorities may help in identifying target groups with a higher risk of childhood overweight and obesity. Moreover, such studies can elucidate risk factors such as lifestyle among high risk groups. Illuminating the relative role of general risk factors such as socioeconomic position and those specific to cultural background can guide public health efforts in designing effective interventions for the general population as well as group-specific interventions. In addition, the interventions should be timely to yield optimal results in general, an issue which should be specifically considered and addressed in studies among immigrants.

Previous Swedish studies that considered childhood overweight and obesity in relation to migration background are mostly among first generation immigrants or a mixture of first and second generation immigrants [73-75]. Information on offspring of immigrants (2nd generation) is scarce, but they are intuitively different from the earlier generations in different aspects including, but not limited to, acculturation of their family with regard to lifestyle and even socioeconomic position of family. This gap of information for Sweden, a country with a long immigration history, has already been elaborated in the review of the European literature by Labree et al. [76]. There is a need for studies of differences in childhood overweight and obesity, as well as determinants of lifestyle and sociocultural factors among a large and growing population of immigrant's children.

3 AIM

3.1 GENERAL AIM

The overall objective of this thesis was to investigate the impact of parental migration background on childhood overweight and lifestyle in a time span from birth to adolescence.

3.2 SPECIFIC AIMS

The specific aims of the described studies in this thesis were:

- To investigate the impact of parental migration background on the risk of being overweight, levels of physical activity, and compliance with nutritional recommendations among their children (Study I)

- To investigate the impact of maternal migration background on pattern of BMI development of their children from birth to early adolescence in relation to perinatal characteristics; with particular interest in timing of BMI changes (Study II)

- To assess the relation between maternal migration background and duration of breastfeeding and pattern of BMI development of their children from ages 2 to 16 years; with particular interest in explaining BMI changes (Study III)

4 SUBJECTS AND METHODS

“It is common sense to take a method and try it. If it fails, admit it frankly and try another. But above all, try something.” Franklin D. Roosevelt (1882-1945), 32nd US president

4.1 SUBJECTS

The papers included in this thesis are based on the BAMSE birth cohort. In addition to information collected through parental questionnaires and clinical examinations within the BAMSE project, information on height and weight has also been retrieved from school health records. Information on maternal and prenatal characteristics was gathered through linkage to the Swedish Medical Birth Register (MBR) via each child’s unique Swedish personal identification number (PIN) (papers II & III).

4.1.1 BAMSE birth cohort

BAMSE (Swedish abbreviation for: Children (barn), Allergy, Environment (miljö), Stockholm, Epidemiology) is an ongoing prospective Swedish birth cohort conducted by the Institute of Environmental Medicine, Karolinska Institutet, in collaboration with Stockholm County Council. The cohort was designed to study risk factors for allergic diseases with regard to heredity, socioeconomic conditions, environmental factors, and diet.

The cohort recruited all infants born between February 1994 and November 1996 in four districts in central and northwestern Stockholm (inner city, Solna, Sundbyberg, Järfälla). The selected districts included municipalities which were representative of different socioeconomic positions (Figure 3) [77].

During the recruitment period, 7 221 infants were born in the catchment area. However, 1 733 infants were either not accessible at all (n = 477) or actively excluded (n = 1 256) from the study because the family planned to move within a year of the study start, the family had a seriously ill child, parents had insufficient knowledge of the Swedish language, or the family already had a child enrolled. The parents of the 5 488 eligible infants received a baseline questionnaire, when the infants were about 2 months old.

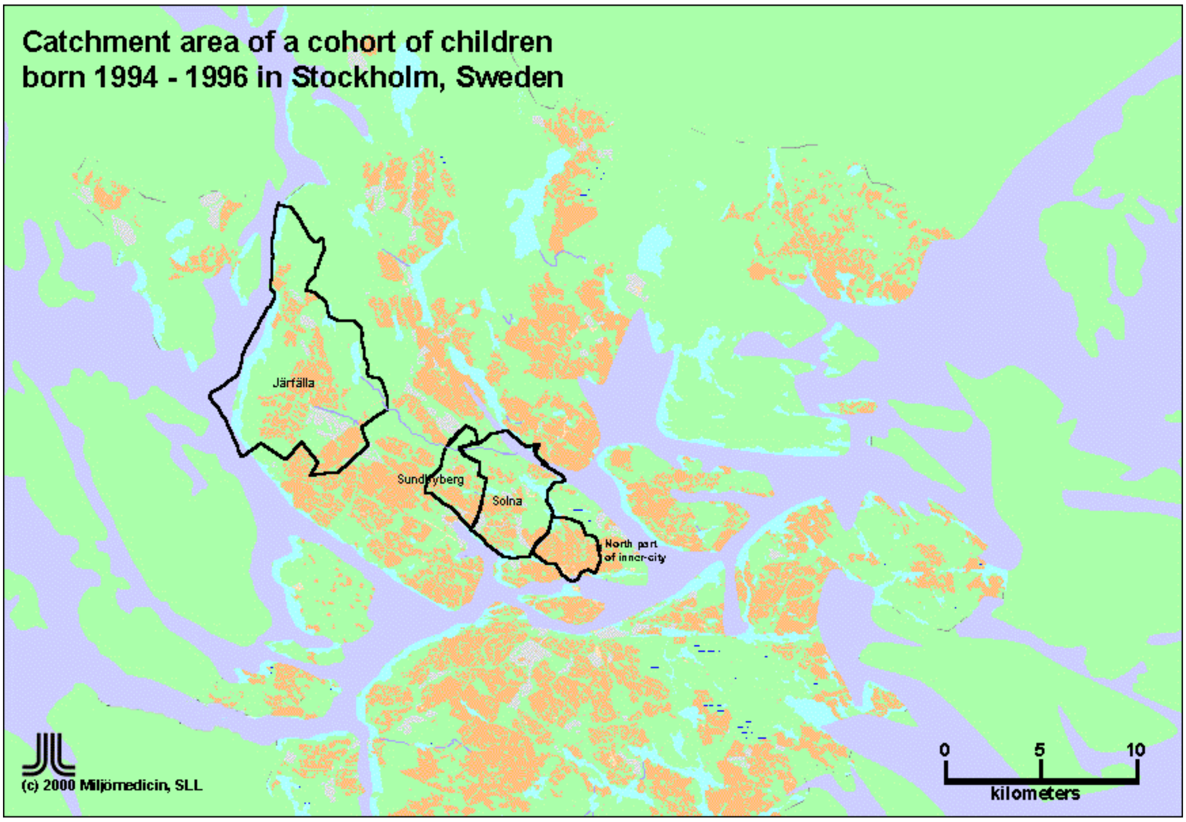

Figure 3: Catchment area of BAMSE cohort.

The BAMSE cohort started with 4 089 infants whose parents responded to the baseline questionnaire. These children were followed by repeated questionnaires sent to the parents when the children were approximately 1, 2, 4, 8, 12, and 16 years. In addition, at ages 12 and 16 years, the children themselves answered questionnaires. Response rate has remained high and 78 % of the original cohort participated in the 16-year follow-up. Figure 4 shows a flow chart for the BAMSE birth cohort.

The baseline BAMSE questionnaire covered demographic information, parental education, perinatal period, lifestyle and possible risk factors for allergic diseases [77]. In the first follow-up questionnaire, parents were asked: “How long your child was exclusively breastfed (in weeks)?” and “How old was your child when she/he started receiving formula or complementary feeding (in months)?” In the 8-year follow-up questionnaire, parents were asked if they were born outside of Sweden, and if so, in which country.

All families who responded to the questionnaires at ages 4, 8 and 16 years were invited to clinical examinations including measurements of height and weight, blood sampling and lung function tests. Information on height and weight was obtained from 2 939 children at age 4 years, 2 630 children at age 8 years and 2 605 children at age 16 years.

At the clinical examination at age 8 years, the parents (together with their child) answered a semi-quantitative food frequency questionnaire (FFQ) concerning intake of 98 foods and beverages frequently consumed in Sweden. The FFQ asked about the frequency of consumption during the past year. The participants were asked how often, on average, they had consumed each food item. Eight categories of consumption were provided, ranging from never to three times per day or more. In total, 64 % of families filled out the FFQ (n = 2 614).

In the 12-year follow-up questionnaire, parents could consent to collection of information on height and weight measurements for their children from school health records, which also include data from child health centers. Based on parental consent (n = 2 887), data on height and weight were collected from school health records for 2 598 children (Table 1).

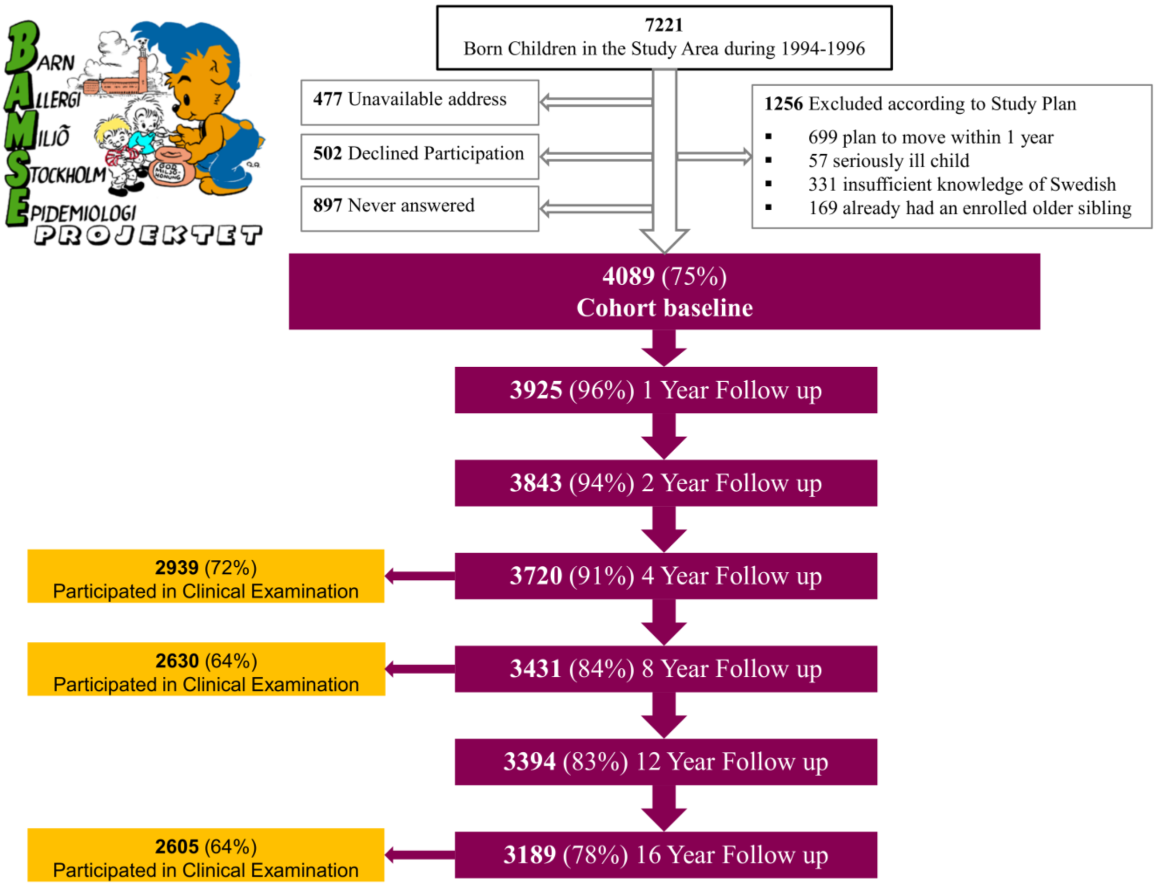

Figure 4: Flow chart of the BAMSE cohort.

4.1.2 Other sources of information

4.1.2.1 Child health centers and school health records

In Sweden, regular health monitoring of infants and children up to age 5 years is conducted in child health centers (barnavårdscentral). In the child health centers, children are examined, vaccinated and measured for weight and height by trained nurses in accordance with standard national protocols [78, 79]. The child health center services are free of charge and reach almost everyone, including children who are asylum seekers or illegal aliens [80].

The time schedule for weight measurement at child health centers is on a weekly basis during the first month of life, a monthly basis between 1 and 4 months, every other month up to 12 months of age, and thereafter at 18 months and at 2, 3, 4 and 5 years of age. The height of a child is usually measured at the same session with weight, however height measurements are recommended once or twice during the first 2 months of life, every month between ages 2-6 months and again at 6, 10, 12, 18 months and at 3, 4 and 5 years [78].

Reports from Stockholm County Council show that almost all children follow the regular time schedule of child health centers visits up to age 2 years and have at least one extra visit between ages 2 and 5 years [80].

When children start school, their records from child health centers are transferred to school health centers. The school health center consists of a school nurse and a school physician whose aim is to protect and enhance students' mental and physical health and promote healthy lifestyles. To achieve this goal, some of the essential core activities are health assessments and health visits [81].

Under the Education Act, all students in elementary schools are offered three health visits to the school health centers for routine health controls including measurements of weight and height. The first takes place during the first year of school and the other visits are in 4th and 7th grade [81], coinciding with average ages of 7, 10 and 12 years, respectively. Furthermore, children in 2nd grade are offered additional measurements of height and weight. The measured weights and heights are recorded in child health folders that also include records transferred from child health centers.

Based on parental consent, (n = 2 887), provided in the BAMSE follow-up questionnaire at age 12 years data on height and weight at 10 predefined ages [6 months (±2 weeks), 12 and 18 months (±4 weeks), 2, 3, 4 and 5 years (±6 months), 7, 10 and 12 years (-6 to +11 months)] were collected for 2 598 children (Table 1).

Table 1: Extracted data from school health records for children in the BAMSE cohort.

Source of data	Base of measurement time	Pre-defined age	Time span
Child health center	Age	6 months	±2 weeks
		12 months	±4 weeks
		18 months	
		2 years	±6 months
		3 years	
		4 years	
		5 years	
School health center	Grade	7 years	-6 to +11 months
		10 years	
		12 years	

4.1.2.2 *Medical Birth Register*

The Swedish Medical Birth Register was established in 1973 by the Swedish National Board of Health and Welfare as an act of Swedish parliament to prospectively collect antenatal and perinatal information on newborn infants at a national level. The register covers more than 98 % of all infants born in Sweden and is a valuable source of information for epidemiological studies of antenatal and perinatal events [82].

Since its establishment, some modifications have been made in methods of data collection to improve the quality of the register and its content; however, the basic structure has been unchanged. During 1973-1982 (first phase), data collection was based on summarized reports of medical records in a standard form prepared by secretaries at obstetric clinics. From 1982 onward (second phase), data collection was directly based on three main sources: antenatal care of mother, delivery records and records from pediatric examinations of newborns [82].

The modifications applied to the register were based on repeated quality evaluations by comparison of data from the register with original medical records. More recent quality evaluations showed that the quality of maternal and perinatal variables used in this thesis in the recruitment period of the BAMSE birth cohort (1994-1996) was high [82]. These data include maternal weight, height and age at early pregnancy, gestational age, birth weight and height, parity and complications during pregnancy (preeclampsia/eclampsia, diabetes, anemia, placental diseases, renal and liver diseases).

4.2 METHODS

4.2.1 Definitions of Outcomes

4.2.1.1 *Overweight and obesity (Study I)*

Overweight and obesity was defined as age and sex specific BMI corresponding to adult BMI $\geq$ 25 kg/m^2 [8] and treated as a binary variable (yes/no). Weight and height measurements for calculation of BMI were retrieved from clinical assessments included in BAMSE at age 8 years.

4.2.1.2 *Physical activity (Study I)*

Physical activity was defined based on frequency of participation in any organized exercise or sport activity (excluding physical education sessions in school) and treated as a binary variable (participation in organized activities, low < 1 per week or active ≥ 1 per week). The information regarding participation and frequency, if any, was retrieved from the follow-up questionnaire in BAMSE at age 8 years.

4.2.1.3 Nutritional status (Study I)

Nutritional status of the children was assessed by comparison of food consumption and dietary score.

4.2.1.3.1 Food consumption

Food items (n = 98) in the FFQ at the 8-year follow-up of BAMSE were categorized into 10 dietary groups including fresh fruits, fruit products (juice, jam, marmalade, stewed fruit, and fruit soup), vegetables, cereals, potatoes, cakes and sweets, milk and dairy products, egg, fish and meat. The meat group was further subdivided into four subgroups: pork, beef and lamb, chicken and other poultry, and processed meats. To harmonize the time scale of consumption of food items, we transformed frequency of consumption per serving unit into average weekly consumption for all groups. Average weekly consumption of food items included in each dietary group was summed up into average weekly consumption of the dietary group. This average weekly consumption of the dietary groups was used for comparison of food consumption.

4.2.1.3.2 Dietary score

A dietary score was defined based on compliance with the Nordic Nutrition Recommendations (NNR) 2004 [83].

The NNR-2004 is the 4th revision of officially approved nutritional recommendations in the Nordic countries (Sweden, Norway, Denmark, Finland, and Iceland) which are based on scientific evidence, recommendations at international and national levels as well as expert reports. The NNR-2004 includes recommendations on total energy, macro- and micronutrients, as well as physical activity. The NNR-2004 is considered to be an important basis for nutrition policy and planning a healthy diet which satisfies the physiological requirements while reducing the risk of diseases [84].

A scoring model was developed to assess compliance with nutritional recommendations (Figure 5). The model estimates how far the average intake of a nutrient deviates from its recommended level on a scale from 0 to 1. Average nutrient scores in six groups of nutrients (carbohydrates, fibers, fats, proteins, vitamins and minerals) was added up to a dietary score (possible range 0-6) for each child that approximated overall compliance with recommended intakes. Based on mean values of dietary score in the study population (4.8 ± 0.2, range: 4.0-5.3), children were categorized into high (dietary score > 4.8) and low (dietary score < 4.8) groups.

The average nutrient intakes were calculated based on information of food consumption from completed FFQs at age 8 years. The calculation of average nutrient intake was performed by multiplying frequency of consumption of food items with nutrient content per serving unit, using “standard composition tables” from the Swedish National Food Agency database, with further adjustment for energy intake.

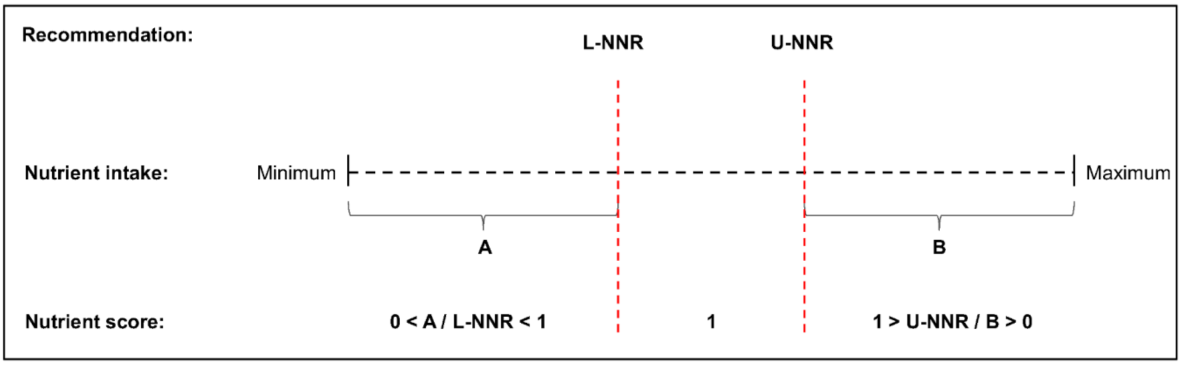

Figure 5:. Scheme for calculation of nutrient scores, based on the Nordic Nutrition Recommendations (NNR). Nutrient intakes between the lower Nordic Nutrition Recommendations (L-NNR) and upper Nordic Nutrition Recommendations (U-NNR) scored 1. A relative score was calculated for nutrient intakes below the L-NNR using the equation A/L-NNR, and a relative score for nutrient intakes above the U-NNR was calculated as U-NNR/B, where A is the nutrient intake for a hypothetical observation below L-NNR and B is the nutrient intake for a hypothetical observation above U-NNR.

4.2.1.4 BMI changes over time (Studies II & III)

The pattern of BMI changes at different ages from early childhood through adolescence as a continuous variable, or the "BMI trajectory", was another outcome of interest (Studies II and III). Weight and height measurements of the children in BAMSE cohort were retrieved from school health records for calculation of BMI at predefined ages (Study II). School health records provide measured data on weight and height for several time points at appropriately spaced time intervals. In study III, we also considered the weight and height measurements of the children in BAMSE follow-up clinic visits at age 16 years.

4.2.2 Definitions of exposures

In all three studies included in this thesis, the main exposure of interest was parental country of birth, as a proxy for parental migration status. In addition, duration of exclusive breastfeeding in the first 6 months of infancy was another exposure of interest (Study III). Information on parental country of birth and duration of breastfeeding was retrieved from follow-up questionnaires of BAMSE at ages 8 years and 12 months, respectively.

4.2.2.1 Parental country of birth

Due to different approaches in the included studies, a variety of classifications were applied for parental country of birth. In all classifications, children with parents born in Sweden were used as a reference group.

4.2.2.1.1 <u>Classification by maternal origin</u>

Based on maternal country of birth, a child was categorized as offspring of a Swedish mother, if the mother was born in Sweden, and offspring of an immigrant mother, if the mother was born outside of Sweden. This classification is used when maternal attributes were the main interest and were taken into account (Studies II & III) (Table 2).

4.2.2.1.2 Classification at family level

Based on parental country of birth, children were categorized as below:

- Offspring of Swedish parents: if both parents were born in Sweden
- Offspring of immigrant parents: when at least one of the parents was born outside of Sweden

Furthermore, offspring of immigrant parents were sub-classified as below, based on which parent was born outside of Sweden:

- Both parents immigrants: both mother and father were born outside of Sweden
- Only mother immigrant: mother was born outside of Sweden and father was born in Sweden
- Only father immigrant: father was born outside of Sweden and mother was born in Sweden

This classification was used when both parents were of interest and was taken into account (Study I) (Figure 6).

4.2.2.1.3 Classification by world regions

This classification was also at a family level, taking both parents into account, but based on the major world regions where the parents were born. Classification of world regions was based on definition of the United Nations Population Division [85], which defines six major areas (Africa, Asia, Europe, Latin America and the Caribbean, Northern America and Oceania). In this classification, we considered possible variations: parents could be from the same or from different major regions. There were no combinations of parents in which both father and mother were born in Northern America or Oceania. Further, there were too few subjects in many of the possible variations of families with parents born in different regions to be categorized as separate groups. Moreover, though the classification was based on major regions of birth of the parents, we considered the children whose parents were born in Sweden as a separate group in this classification for comparison and as a reference group. Finally, based on parental country and major world region of birth, the children were classified as below:

- Swedish: both parents were born in Sweden
- African: both parents were born in African countries
- Asian: both parents were born in Asian countries
- European: both parents were born in European countries (other than Sweden)
- Latin American: both parents were born in Latin American countries
- Mixed excluding Sweden: parents were born in different regions, neither of which was Sweden
- Mixed including Sweden: parents were born in different regions, with one of parents born in Sweden

This classification was used when we intended to scrutinize the data with regard to origin of immigrant parents and look at differences, if any, by world regions (Study I) (Figure 6).

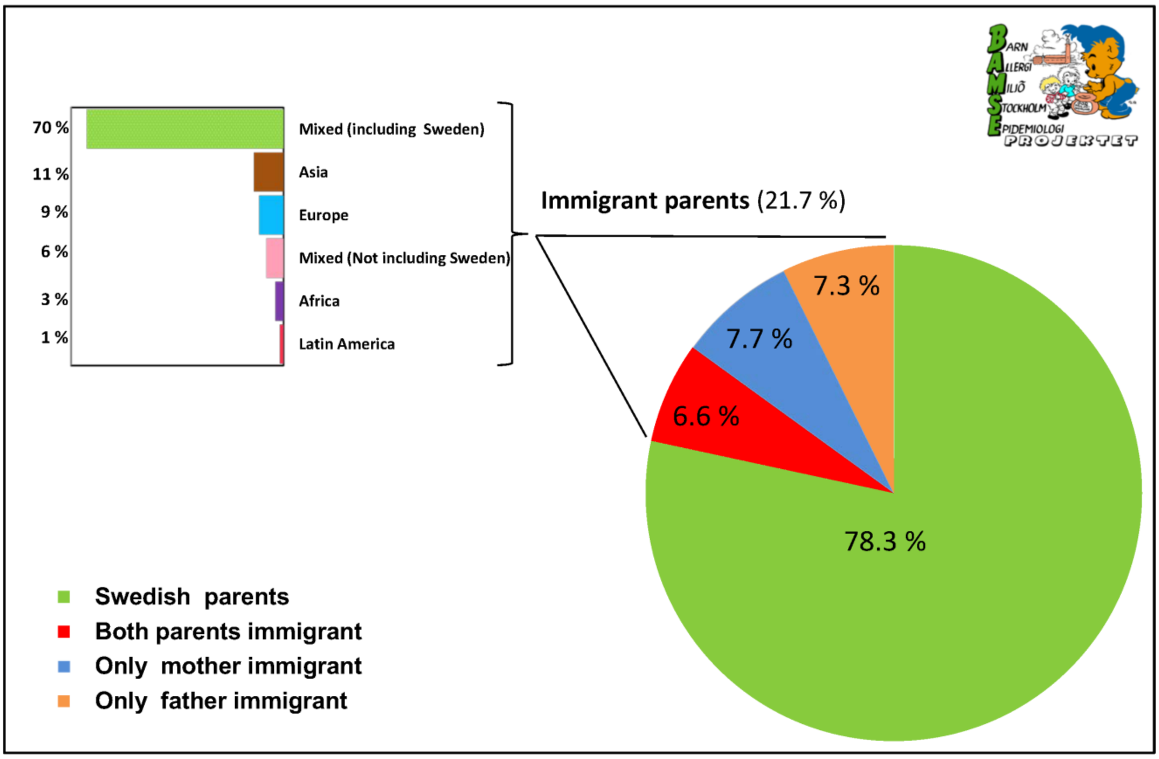

Figure 6: Distribution of parental country of birth by world regions and at family level among children in BAMSE birth cohort

4.2.2.1.4 <u>Classification by geographical distance to host country</u>

This classification was based on maternal origin, taking into account the geographical distance from the maternal country of birth to the host country, Sweden. The underlying assumption in this classification was that countries and regions that are geographically close to each other, such as the Nordic countries, share some cultural and lifestyle factors that might influence the outcome of interest. Therefore, based on maternal country and major world region of birth, as well as distance from Sweden, the children were classified as below:

- Swedish: mother was born in Sweden
- Scandinavian: mother was born in Finland, Norway or Denmark
- European: mother was born in a European country except Sweden and Scandinavia
- Outside European: mother was born in a country outside Europe

We used this classification when possible differences, if any, between countries or world regions were of interest, but we were not able to scrutinize the data due to few subjects at this level (power limitations) (Study II).

4.2.2.2 Breastfeeding and maternal migration status

Based on the recommendations from the WHO and NNR [83, 86], duration for exclusive breastfeeding was set to the first 6 months of life and the children were categorized into the below groups:

- Never/Short breastfed: never or less than 2 weeks of exclusive breastfeeding
- Partial breastfed: exclusively breastfed for more than 2 weeks but less than 6 months
- Exclusively breastfed: exclusively breastfed for at least 6 months

Since maternal country of birth was another exposure of interest alongside breastfeeding, we integrated the levels of the two exposures and constructed a combined variable with 6 possible levels, as below:

- Exclusively breastfed offspring of Swedish mothers
- Exclusively breastfed offspring of immigrant mothers
- Partially breastfed offspring of Swedish mothers
- Partially breastfed offspring of immigrant mothers
- Never/Short breastfed offspring of Swedish mothers
- Never/Short breastfed offspring of immigrant mothers

This combined variable was used for analysis whenever breastfeeding and maternal migration status were exposure of interest (Study III), using exclusively breastfed offspring of Swedish mothers as the reference group.

4.2.2.3 Time (age)

In longitudinal studies, the pattern of changes in outcome at different time points is interesting. Actually, in these studies, time (age) is considered an exposure which predicts the outcome and may have even interact with other exposures of interest. In studies II and III, we considered the age of children as an exposure predicting BMI at different time points. In addition, we checked for interactions between age and maternal migration status, which was another exposure of interest. The age of the children was age at measurement of height and weight either in child health centers, school health centers or BAMSE follow-up clinics. These ages included birth, 6, 12 and 18 months, 2, 3, 4, 5, 7, 10, 12 and 16 years.

The age (time) variable in studies II and III was treated as a continuous variable due to unequally spaced intervals and missing data at different time points.

4.2.2.4 Age at adiposity rebound

Age at adiposity rebound is the start of the second phase of normal growth in adipose tissue that takes place between ages 3 and 7 years. In the first phase, adiposity increases up to 12 months and, after that, it decreases while body length continues to increase. The first adiposity phase is reflected in BMI growth curves as a rapid increase in BMI, peaking between 6 and 12 months, followed by a rapid decrease. The second phase of adiposity starts when the BMI has reached its nadir. While the first phase of adiposity is due to change in the adipocytes' volume, the second phase is due to the adipocytes' proliferation, and beginning of permanent adiposity, which could predict later growth patterns and overweight [87].

In study III, we considered age at the lowest estimated BMI from BMI developmental curves as average age at adiposity rebound for different groups. We compared ages at adiposity rebound in children grouped by breastfeeding and maternal migration status.

4.2.3 Definitions of explanatory variables

4.2.3.1 Parental education

Parental education was used as an indicator for SEP in this thesis and in all included studies the estimates have been adjusted for parental education. Information on parental education was retrieved from the baseline questionnaire in the BAMSE cohort. The definition and classification of parental education was based on the highest level of education attained (in years) either by both mother and father (Study I) or by mother only (Studies II & III).

Thus, parental education was classified as (Study I):

- ≤ 9 years (Elementary school)
- 10-12 years (High school)
- > 12 years (University education)

As there were too few mothers with only elementary education, they were pooled with high school group and maternal education was classified as (Studies II & III):

- ≤ 12 years
- > 12 years

In either classification, parents with university education (> 12 years) were seen as the reference group.

4.2.3.2 Maternal early-pregnancy BMI

Information on weight and height measurements of the mother at the first visit to the antenatal clinic, around week 12-14 of gestation, was retrieved from MBR. This information has been used to calculate maternal BMI at early pregnancy. The estimates in studies II and III were adjusted for maternal BMI, which was treated as a continuous (Study II) or a categorical explanatory variable (Study III). In the latter case, maternal BMI was classified based on international cut-off points [88] as:

- Underweight (BMI < 18.5 kg/m^2)
- Normal (BMI 18.5-24.99 kg/m^2)
- Overweight/Obese (BMI ≥ 25 kg/m^2)

4.2.3.3 *Maternal age*

Estimates in studies II and III were adjusted for maternal age at early pregnancy (years) which was retrieved from MBR and treated as a continuous variable.

4.2.3.4 *Maternal smoking during pregnancy*

Estimates in studies II and III were adjusted for maternal smoking during pregnancy. Information on smoking habits of the mother during pregnancy was retrieved from the baseline questionnaire of the BAMSE cohort. The mothers were classified into smokers, who had smoked at least one cigarette per day at any time during pregnancy, and non-smokers.

4.2.3.5 *Weight for gestational age*

Estimates in studies II and III were adjusted for weight for gestational age. Weight for gestational age is a practical classification of infants which takes into account both birth weight (BW) and gestational age [89]. Information on birth weight and gestational age were retrieved from MBR. Based on information of birth weight and gestational age, and using Swedish reference curves for normal fetal growth [90] the children were classified as:

- Small for gestational age (SGA): BW < 10th percentile given the gestational age
- Large for gestational age (LGA): BW > 90th percentile given the gestational age
- Appropriate for gestational age (AGA): 10th ≤ BW ≤ 90th percentile given the gestational age

4.2.3.6 *Complications of pregnancy*

Clinical conditions during pregnancy that could possibly affect intra-uterine growth of the fetus [91, 92] were retrieved from MBR using the Swedish version of International Classification of Diseases (ICD-9). These included placental disorders (641A-641C and 656H), anemia (648C), diabetes (648A and 648W), chronic renal and liver diseases (646C and 646H), preeclampsia and eclampsia (642E-642 H). Complications of pregnancy were seen as having any of these diagnoses during pregnancy and were treated as a binary variable (yes/no). Estimated BMI in study II was adjusted for complications of pregnancy.

4.2.3.7 *Parity*

In study II, estimates were adjusted for parity as a continuous variable. The data on parity has been retrieved from MBR, with information provided by Statistics Sweden.

4.2.3.8 *Lifestyle factors*

In study I, due to interrelations between lifestyle and overweight as well as parental migration background, the estimated odds ratios were mutually adjusted for physical activity, dietary score and overweight.

4.2.4 Study design & study population

Epidemiological studies can be classified into two main branches: experimental and observational. In experimental studies, the researcher has control of, and influences, exposure. Randomized clinical trials and field trials are examples of experimental studies. In observational studies, the researcher merely observes the exposure and outcome without any control or influence over them. Cohort, case-control and cross-sectional studies are prototypes of observational studies.

Based on timing of information, observational studies can be categorized into longitudinal and cross-sectional studies. Cohort studies and most case-control studies are longitudinal since the information pertains to two or more different time points [93]. By contrast, in cross-sectional studies information is gathered from a single time point. In other words, such studies provide a "snapshot" of the status of a population with regard to possible exposure and outcome. Cross-sectional studies can provide information on prevalence of exposure and outcome, however, in special cases where exposure is constant (e.g., blood groups or country of birth) they may be considered a good proxy for longitudinal information and estimated association of exposure and outcome [93]. A special case of longitudinal studies is when the outcome is observed at several time points in the same subject, so-called repeated measurements. In the latter case, the observations of the same subject over the time are not independent and require special analytical methods that take into account this dependence or "correlation" between observations [94].

In addition, based on the temporal relations of collected information on exposure and outcome, longitudinal studies are either prospective or retrospective. In prospective studies, information on exposure is gathered before the outcome is measured, and thus is less likely to be affected by the outcome. In contrast, in retrospective studies exposure information is gathered when the outcome has happened and might be prone to recall bias.

All studies in this thesis are observational. Study I is a cross-sectional study at age 8 years. Studies II & III are prospective longitudinal studies of repeated measurement of BMI. In study II, the children were followed from birth to age 12 years, and in study III, the children were followed between ages 2 and 16 years.

4.2.4.1 Study I

The study is a cross-sectional study among 2 589 children from the BAMSE birth cohort at an average age of 8 years with complete information on diet, physical activity, body mass index (BMI), and parental country of birth and level of education (Figure 7 and Table 2).

4.2.4.2 Study II

The study is a prospective longitudinal study among 2 517 children from the BAMSE birth cohort who had provided information on maternal country of birth and measurements of weight and height from at least two out of eleven measurement time points between birth and age 12 years (Figure 7 and Table 2).

4.2.4.3 *Study III*

The study is a prospective longitudinal study among 2 278 children from the BAMSE birth cohort who had provided information on maternal country of birth, breastfeeding and measurements of weight and height from at least two out of eight measurement time points between ages 2 and 16 years (Figure 7 and Table 2).

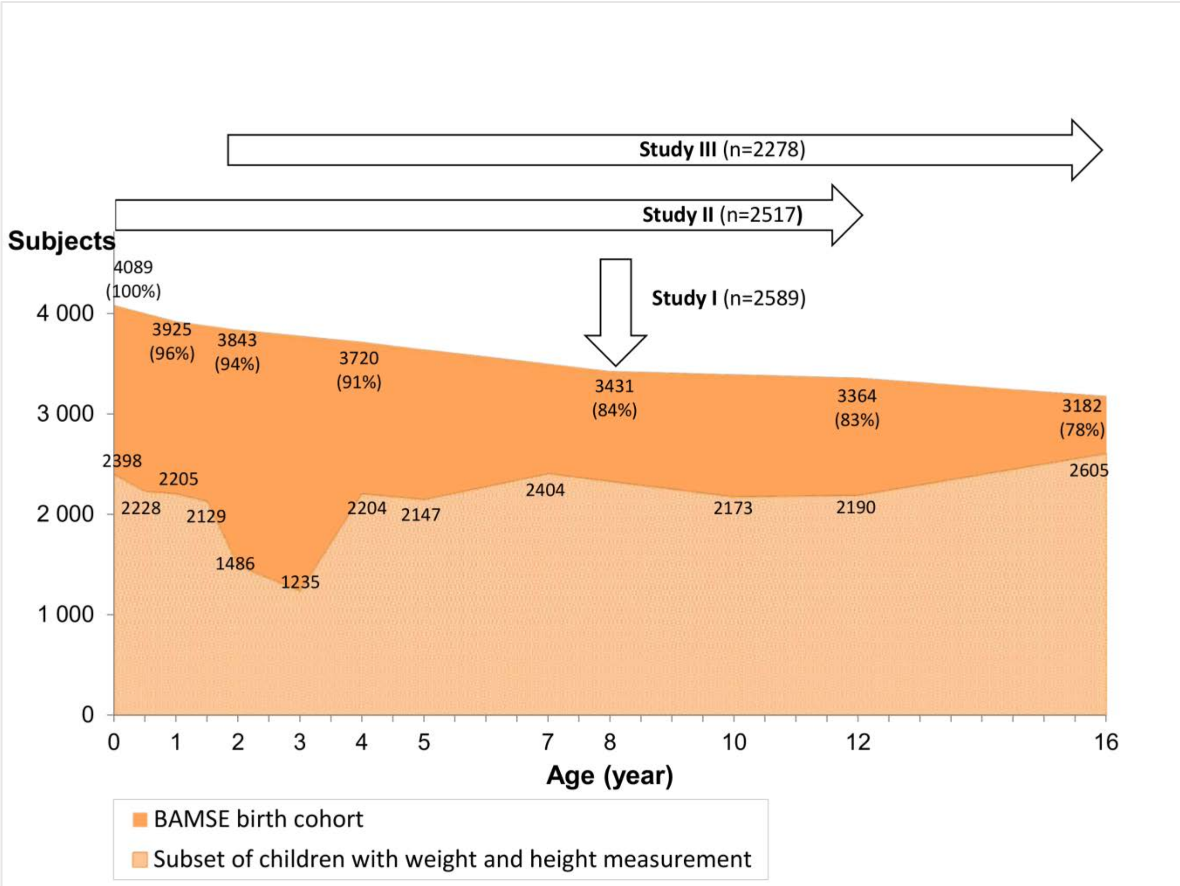

Figure 7: BAMSE birth cohort in relation to study I, II and III in this thesis.

4.2.5 Statistical analysis

4.2.5.1 *Descriptive statistics*

Comparison of means of continuous variables was performed using a *t*-test. The proportion of categorical variables was compared using a chi-square test whenever applicable throughout this thesis.

4.2.5.2 *Logistic regression*

Logistic regression is a commonly used regression model for analyzing associations between exposure(s) and a binary outcome. In this regression model, we are modeling the logarithm of the odds of the outcome, namely *logit* transformation of the outcome.

We used a logistic regression model to analyze association between parental migration background and overweight, physical activity and dietary score among offspring. We estimated odds ratios (OR) with 95 % confidence interval (CI) for the association, controlling for parental education and lifestyle (Study I) (Table 2).

4.2.5.3 Mixed linear model analysis for repeated measures data

Longitudinal studies with repeated measures data allow direct assessment of changes in an outcome and its predictors over time. However, in repeated measures data, repeated observations from the same individual are more similar to each other than observations from other individuals and are influenced by one another; in other words they are dependent, or correlated, to each other. This violates the basic assumption of independency of observations in ordinary regression models. Moreover, variation in outcome often differs at different time points, which also violates the assumption of constant variation in standard regression techniques. Statistical models used for analyzing longitudinal repeated measures data should therefore take into account the dependent nature of the observations as well as heterogeneous variability in the data.

The mixed model is one of a suitable statistical approach for repeated measures data that takes into account dependency of repeated measures over time and heterogeneous variability. Mixed models consider two different sources of variation for the outcome: between-individual and within-individual variations that can randomly vary in different observations, or the so-called random effect. The name of the model references mixing together both fixed effects, predictors that are assumed to be the same in all subgroups such as sex, and random effects, predictors that are assumed to vary between subgroups such as age (time). Consequently, the mixed model provides estimates that for some predictors vary randomly from one individual to another, random coefficients, which account for heterogeneity in the data and are subject-specific. Besides taking into account the correlation in repeated measures and heterogeneity in the data, a mixed model can handle missing data, which is inevitable in longitudinal studies, assuming a random distribution of the missing data. The model uses only available information for subjects with missing information.

A mixed linear model for repeated measures data was used when the outcome of interest was continuous, such as BMI, and the model estimated the change in the mean of the outcome over time by a combination of population characteristics, fixed effects that were assumed to be shared by all subjects, and subject-specific characteristics, random effects that are specific for each individual.

We used mixed linear model analysis for repeated measures data to estimate BMI changes over time in children grouped by maternal migration background (Studies II & III) and breastfeeding (III) (Table 2). We considered a random intercept and random slope to capture differences in baseline and changes over the time at an individual level, respectively. We used a polynomial function of time (age) to capture non-linear changes in BMI over time. Estimated BMI over time was plotted and graphically presented for ease of communication.

4.3 ETHICAL CONSIDERATION

Parents of the children in BAMSE cohort were informed and gave written consent before inclusion of their children in the study. Collection of information on weight and height measurements of the children from school health records has been done based on parental approval through written informed consent at the 12-year follow-up of the BAMSE cohort.

Maternal and perinatal information of the children in BAMSE cohort was retrieved through linkage of the BAMSE cohort to MBR via unique Swedish PINs by Statistics Sweden and Swedish National Board of Health and Welfare. The PINs have been replaced with serial numbers.

The included studies in this thesis have been granted ethical approval by the regional board of the Ethics Committee in Stockholm; Dnr: 2011/792-32 (Studies I & II), Dnr: 2010/1474-31/3 and Dnr: 2011/2037-32 (Study III)

Table 2: Overview of Studies included in this thesis

Study			I	II	III
Design			Cross sectional	Longitudinal	Longitudinal
study population			**2589**	**2517**	**2278**
Swedish Parents			2028	2181	1979
		Girls (%)	47.9	49.1	48.4
		Boys (%)	52.1	50.9	51.6
	Education (years)	≤ 12 (%)	46.3	55.6	55.5
		>12 (%)	53.7	44.4	44.5
Immigrant Parents			561	336	299
		Girls (%)	52.8	51.8	51.2
		Boys (%)	47.2	48.2	48.8
	Education (years)	≤ 12 (%)	44.9	58.1	58.3
		>12 (%)	55.2	41.9	41.8
Age (years)			**8**	**0-12**	**2-16**
Main Exposure			- Parental migration background	- Maternal migration background - Age (time)	- Maternal migration background - Duration of breastfeeding - Age (time)
Main Outcome			- Overweight and obesity - Physical activity - Compliance with nutritional guidelines	BMI development	BMI development
Explanatory variables			Parental education, BMI status, physical activity and dietary score	Maternal age, education, early pregnancy BMI, smoking during pregnancy, complications of pregnancy, weight for gestational age, parity and breastfeeding	Maternal age, education, early pregnancy BMI, smoking during pregnancy and weight for gestational age
Statistical analysis			Logistic regression	Mixed linear model	Mixed linear model

5 RESULTS

"However beautiful the strategy, you should occasionally look at the results." Winston Churchill (1874-1965), Prime Minister of the United Kingdom

5.1 DOES PARENTAL MIGRATION MATTER? (STUDY I)

Study I was planned to assess current status of overweight and obesity, and lifestyle factors among Swedish-born offspring of foreign-born parents (second generation immigrants) compared with counterpart children of Swedish parents [76]. In addition, we assessed the association between parental migration background and overweight and obesity, low physical activity and nutrition among the children. The study population (n = 2 589) consisted of 561 children with at least one parent born outside of Sweden and 2 028 children with both parents born in Sweden. Immigrant mothers were from 61 countries, most frequently Finland, Iran, Poland, Chile, Thailand and Germany. Immigrant fathers were from 72 countries, including Finland, Iran, Iraq, Germany, USA, UK, Chile, Poland, Turkey, Norway, Syria and Greece.

5.1.1 Overweight and obesity

In the study population, 21.5 % of the children were overweight or obese. The prevalence of overweight and obesity among offspring of immigrant parent was higher than among offspring of Swedish parents (26 % vs. 20 %, respectively) and highest in the subgroup of children with two immigrant parents (31 %).

Offspring of immigrant parents had more than 30 % (OR = 1.33, CI 1.1-1.7) higher odds of overweight and obesity compared with offspring of Swedish parents. When both parents of a child were immigrants, the odds rose to 70 % (OR = 1.70, CI 1.2-2.4). These results were consistent in different strata of parental education (Table 3). We observed a sex gradient in overweight and obesity in the subgroup with two immigrant parents, with significantly higher odds among girls than boys.

At the level of world regions, the odds of overweight and obesity was higher among offspring of parents from Asia (OR = 3.0, CI 1.8-5.1) and Latin America (OR = 9.7, CI 1.9-50.2) compared with offspring of Swedish parents. Because of too few subjects in many regions, assessment at a country level was not possible. However, results for countries with at least five subjects were compatible with results at the world region level.

5.1.2 Physical activity

Almost a quarter of children (24 %) in this study had low physical activity (participation in organized activities less than once a week). Overall, low physical activity was more prevalent among offspring of immigrant parents than offspring of Swedish parents (28 % vs. 23 %, respectively). The subgroup of children with two immigrant parents had the highest proportion of low physical activity (34 %).

Overall, having an immigrant parent was associated with an increase in odds of low physical activity by 30 % (OR = 1.30, CI 1.05-1.62) in children. This increase in odds doubled when both parents were immigrants (66 %); however it was significant only among girls (Table 3). In addition, we observed an association between parental education and levels of physical activity, which was independent of parental migration background.

Compared with offspring of Swedish parents, offspring of parents from Asia as well as the mixed (excluding Sweden) group had almost two times higher odds of low physical activity.

5.1.3 Nutritional status

5.1.3.1 Food consumption and nutrient intake

Offspring of immigrant parents had significantly higher consumption of fruits, vegetables, beef and lamb, chicken and poultry and egg, as well as lower consumption of potatoes, processed meat, and milk and dairy than offspring of Swedish parents. Children with two immigrant parents had the highest consumption of fruit and unprocessed meats and the lowest consumption of processed meat and milk and dairy products; they also had higher consumption of cakes and sweets.

This dietary pattern among offspring of immigrants was reflected in their calculated nutrient intake as significantly higher intake of sucrose, dietary fiber, vitamins C, B6 and E, folic acid, and polyunsaturated fatty acids (PUFA) (omega-3 and omega-6), and lower intake of saturated fatty acids (SFA) vitamins A and D, calcium, and iron. However, there was no difference in mean energy and macronutrient intakes, including total carbohydrates, fats and protein, between offspring of immigrants and Swedish parents.

5.1.3.2 Compliance with nutritional recommendations and dietary score

A higher proportion of offspring of immigrant parents fulfilled recommendations for nutrient intake regarding dietary fiber, SFAs, and PUFAs, whereas a lower proportion did regarding protein, vitamin A, iron and zinc, as compared with Swedish peers. However, regardless of parental migration background, a low proportion of children in our study population fulfilled nutrient recommendations for dietary fiber, SFAs, PUFAs and vitamin D (Table 4).

Overall, a higher proportion of offspring of immigrant parents had dietary scores above the mean compared with offspring of Swedish parents (57 % vs. 50 %, respectively). Being the child of immigrant parents increased the odds of high dietary score by 30 % (OR = 1.3, CI 1.1-1.6), particularly among boys (OR = 1.5, CI 1.1-1.9). However, in sub-classes of children the increase in odds was only significant among children with an immigrant father and Swedish mother (OR = 2.2, CI 1.6-3.0) (Table 3). These results were consistent in different strata of parental education. In addition, we observed a positive association between parental education and high dietary score which was independent of parental migration background.

There were diverse estimates in different world regions with regard to odds of high dietary score; however, due to the low sample size at the level of world regions, most of these

Table 3: Odds ratio (OR) and 95% confidence interval (CI) of dietary score, low physical activity and overweight, by parental migration status

			Dietary score[a]		Low physical activity[b]		Overweight[c]	
Parental migration status	**Sex**	**subjects**	**OR[d]**	**95% CI**	**OR[d]**	**95% CI**	**OR[d]**	**95% CI**
Swedish (Ref.)			1.00		1.00		1.00	
Immigrant	Girls	296	1.17	0.90–1.54	1.19	0.89–1.60	**1.37***	1.01–1.85
	Boys	265	**1.46****	1.11–1.92	**1.46***	1.07–2.00	1.29	0.94–1.79
	Total	561	**1.31****	1.08–1.58	**1.30***	1.05–1.62	**1.33***	1.07–1.66
Both parents	Girls	97	0.96	0.63–1.47	**1.67***	1.07–2.60	**2.12*****	1.36–3.31
	Boys	74	1.16	0.72–1.87	1.59	0.93–2.70	1.20	0.68–2.12
	Total	171	1.05	0.76–1.44	**1.66****	1.18–2.32	**1.70****	1.20–2.40
Only mother	Girls	95	0.82	0.53–1.25	0.73	0.43–1.24	0.95	0.56–1.61
	Boys	105	1.18	0.79–1.77	1.26	0.78–2.02	1.46	0.92–2.33
	Total	200	1.00	0.74–1.34	0.97	0.68–1.37	1.19	0.84–1.68
Only father	Girls	104	**2.08****	1.32–3.26	1.27	0.81–2.00	1.17	0.73–1.89
	Boys	86	**2.35*****	1.47–3.74	1.63	0.99–2.67	1.18	0.70–2.00
	Total	190	**2.19*****	1.59–3.03	**1.39***	1.00–1.94	1.18	0.83–1.67

Values given in bold are statistically significant; Ref. =reference category

[a] Dietary score based on compliance with Nordic Nutrition Recommendation for intake of carbohydrate, fat, protein, vitamins, minerals and fiber.

[b] No participation or less than once per week in any organized activity

[c] Age- and sex-adjusted BMI ≥25 kg/m^2

[d] Adjusted for parental level of education (≤9, 10–12 and >12 years) and mutually adjusted for dietary score, low physical activity and overweight

OR and 95% CI was significant: * p<0.05, ** p<0.01, *** p<0.001

estimates were non-significant. Nevertheless, children with one Swedish and one immigrant parent had significantly higher odds of high dietary score compared with children with both parents born in Sweden (OR = 1.4, CI 1.2-1.8).

Table 4: Proportion of 8-year-old children in BAMSE cohort who complied with the Nordic Nutrition Recommendation (NNR), by parental migration background

			Fulfill NNR (%)	
Nutrient		**NNR**	**Swedish**	**Immigrant**
Carbohydrate		50–60 %E	72.2	70.6
	Sucrose	≤10 %E	58.5	55.4
	Dietary fiber	≥3 g/Mj/d	7.1	**11.1****
Total fat		2535 %E	79.8	78.1
	Saturated fat	≤10 %E	4.7	**7.3***
	MUFA	10–15 %E	69.4	66.1
	PUFA	5–10 %E	8.1	**11.6***
	Omega-3	1 % E[a]	3.1	**6.2*****
Protein		10–20 %E	97.8	**95.4*****
Vitamins	A	≥400 µg/d	100.0	**99.5*****
	D	≥7.5 µg/d	9.4	7.5
	E	≥6 mg/d	79.0	82.5
	C	≥40 mg/d	98.1	98.4
	Thiamin (B1)	≥0.9 mg/d	98.6	98.8
	Riboflavin (B2)	≥1.1 mg/d	99.3	99.8
	B6	≥1 mg/d	100.0	99.8
	Folic acid	≥130 µg/d	100.0	100.0
Minerals	Calcium	≥700 mg/d	94.7	93.1
	Iron	≥9 mg/d	85.1	**80.6****
	Magnesium	≥200 mg/d	99.9	100.0
	Zinc	≥7 mg/d	99.6	**98.4****
Number of children			2028	561

Values given in bold are statistically significant;
%E=percentage of energy intake;
MUFA=mono-unsaturated fatty acid; PUFA=polyunsaturated fatty acid
[a] for calculation we considered the range of 0.5–1.5 %E
Compliance with NNR was significantly different in children of immigrant than of Swedish parents (chi-squared test): * p<0.05, ** p<0.01, *** p<0.001

Overall, a higher proportion of offspring of immigrant parents had dietary scores above the mean compared with offspring of Swedish parents (57 % vs. 50 %, respectively). Being the child of immigrant parents increased the odds of high dietary score by 30 % (OR = 1.3, CI 1.1-1.6), particularly among boys (OR = 1.5, CI 1.1-1.9). However, in sub-classes of children the increase in odds was only significant among children with an immigrant father and Swedish mother (OR = 2.2, CI 1.6-3.0). These results were consistent in different strata of parental education. In addition, we observed a positive association between parental education and high dietary score which was independent of parental migration background.

There were diverse estimates in different world regions with regard to odds of high dietary score, however, due to the low sample size at the level of world regions, most of these estimates were non-significant. Nevertheless, children with one Swedish and one immigrant parent had significantly higher odds of high dietary score compared with children with both parents born in Sweden (OR = 1.4, CI 1.2-1.8).

5.2 WHEN DOES THE CHANGE TOWARD OVERWEIGHT START? (STUDY II)

Study II was planned to assess BMI development from birth to age 12 years, controlling for maternal and perinatal factors, among offspring of immigrant and of Swedish mothers. Study population (n = 2 517) consisted of 336 children of mothers who were born outside of Sweden and 2 181 children of native Swedish mothers. In this study, we were interested in possible time points that could indicate a change toward overweight.

Looking at crude data at different ages we observed that at age 2 years a higher proportion of offspring of Swedish mothers were overweight than offspring of immigrant mothers, whereas at age 12 years a higher proportion of offspring of immigrant mothers were overweight (Table 5).

Table 5: Prevalence of overweight by maternal migration status in different ages.

Age (year)	Number of children			Overweight proportion (%)		
	Total	Swedish	Migrant	Swedish	Migrant	*P*-value
0	2 398	2 086	312	-	-	-
0.5	2 228	1 937	291	-	-	-
1	2 205	1 915	290	-	-	-
1.5	2 129	1 849	280	-	-	-
2	1 486	1 280	206	**10.2**	**5.8**	**0.046**
3	1 235	1 064	171	12.7	8.8	0.146
4	2 204	1 912	292	11.9	9.6	0.256
5	2 147	1 858	289	13.9	12.5	0.496
7	2 404	2 088	316	16.0	19.3	0.145
10	2 173	1 883	290	16.4	20.7	0.067
12	2 190	1 884	306	**13.8**	**20.9**	**0.001**
Total	2 517	2 181	336			

In a preliminary analysis adjusted for maternal and prenatal characteristics, we observed no association between maternal migration status and pregnancy outcomes with regard to birth weight and weight for gestational age (Table 6).

Table 6: Odds ratio (OR) of pregnancy outcomes by maternal migration status

	Swedish	Immigrant		
Pregnancy outcomes	OR*	OR*	95 % CI	*P*-value
Birth weight				
Low birth weight (< 2 500 g)	1	1.04	0.26-4.10	0.96
High birth weight (≥ 4 000 g)	1	0.82	0.58-1.17	0.27
Weight for gestational age				
SGA	1	0.93	0.56-1.54	0.77
LGA	1	0.88	0.60-1.31	0.53

SGA = small for gestational age; LGA = large for gestational age.
* Adjusted for sex, maternal BMI, age, education, smoking and complications during pregnancy and gestational age (only for birth weight).

Through the mixed linear model analysis controlling for maternal and perinatal characteristics, we observed that maternal migration status was not associated with BMI at birth (*P*-value = 0.24). However, we observed a significant BMI change over time (*P*-value < 0.0001) as well as significant interaction between time and maternal migration status (*P*-value = 0.0002), indicating differing patterns of BMI changes over time by maternal migration status, even when there were no significant differences at birth.

Graphical presentation of the BMI predicted by the statistical model revealed that offspring of immigrant mothers has followed a slower BMI development before age five, which turned to a steeper BMI development afterward compared with offspring of Swedish mothers (Figure 8).

Replicating the analyses for subgroups of offspring of immigrant mothers born at different geographical distances from Sweden revealed similar results. However, among the outside-Europe subgroup the shift in BMI pattern occurred earlier and followed a steeper pattern than in those from Scandinavian or European countries, whereas the European subgroup followed a slower BMI pattern than other subgroups up to age 12 years.

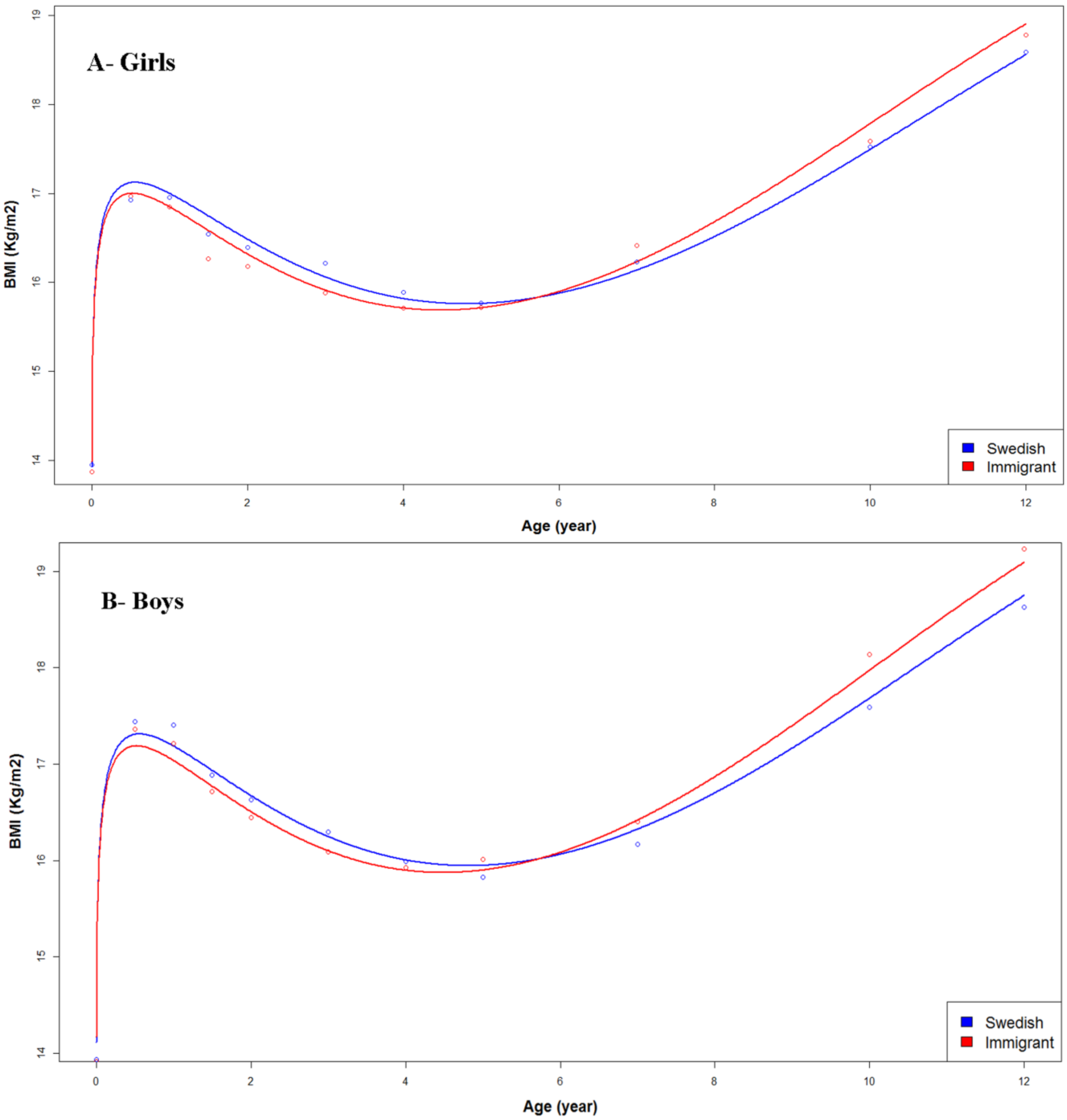

Figure 8: Predicted BMI changes from birth to age 12 years adjusted for maternal and perinatal characteristics among **girls (A)** and **boys (B)** born between 1994 and 1996 in Stockholm (Circles represent crude means of BMI).

5.3 DOES BREASTFEEDING MATTER? (STUDY III)

Study III was planned to assess the association between breastfeeding and BMI development from age 2 to 16 years among offspring of immigrants and of Swedish mothers. The study population (n = 2 278) consisted of 299 children of mothers who were born outside of Sweden and 1 979 children of native Swedish mothers. In this study we investigated if breastfeeding could explain changes in BMI toward overweight in children grouped by maternal migration status.

There was no association between breastfeeding and maternal migration status, and mean BMI at age 2 years in analyses stratified by sex and adjusted for maternal age, education, early pregnancy BMI status, smoking during pregnancy and weight for gestational age (*P*-value: girls = 0.887 and boys = 0.914). However, we observed significant changes of BMI over time (*P*-value < 0.0001 for both girls and boys) as well as significant interaction between age (time), breastfeeding and maternal migration status, indicating different BMI development over the time with regard to the groups (*P*-value: girls = 0.0036 and boys = 0.000).

Graphical presentation of estimated BMI from the statistical model showed that never/short breastfed children of Swedish mothers followed a steeper pattern than exclusively breastfed counterparts, whereas never/short breastfed children of immigrant mothers experienced a slower pattern than their exclusively breastfed counterparts (Figure 9).

While the pattern of BMI changes with regard to duration of breastfeeding was inconsistent among offspring of Swedish and of immigrant mothers, the estimated age at adiposity rebound for different groups showed consistent results. The estimated ages at adiposity rebound was suggestive that earlier rebound is followed by a steeper BMI development and vice versa, later rebound is more likely followed by a slower BMI development in both sexes (Table 7).

Table 7: Estimated age at adiposity rebound (year) by breastfeeding[*] and maternal migration status.

Breastfeeding status	Maternal migration status			
	Swedish		Immigrant	
	Girls	Boys	Girls	Boys
Exclusive	4.3	5.1	4.1	3.9
Partial	4.9	5.0	4.6	4.7
Never/Short	3.8	4.3	4.5	4.6

[*] Duration of exclusive breastfeeding during first 6 months of life.

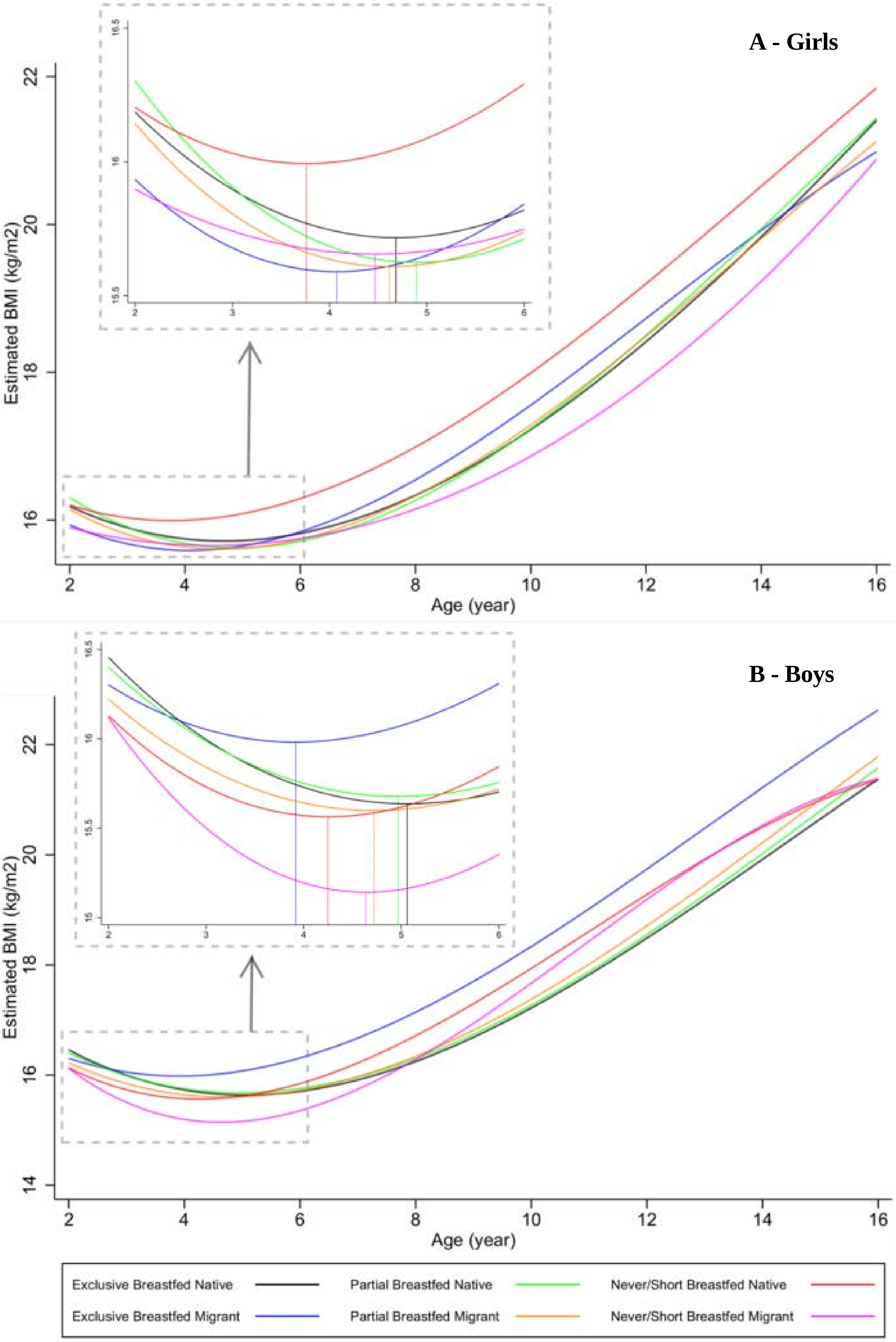

Figure 9: Predicted BMI changes from age 2 to 16 years (main panel) and age at adiposity rebound (internal panel) by breastfeeding and maternal migration status among **girls (A)** and **boys (B)** born between 1994 and 1996 in Stockholm.

6 DISCUSSION

"The aim of argument, or of discussion, should not be victory, but progress." Joseph Joubert (1754-1824), French writer

6.1 METHODOLOGICAL CONSIDERATIONS

6.1.1 Study design

The studies included in this thesis are observational. However, all data was collected in a prospective manner i.e., information on exposure is recorded before outcome occurs. This is a great advantage in epidemiological studies, especially longitudinal studies, making misclassification of exposure unlikely and, independent of outcome, non-differential.

The first study in this thesis was cross-sectional and like other cross-sectional studies is prone to misinterpretation of results due to lack of information on the temporal order of exposure and outcome. This is due to the fact that we have information on assigned exposure and outcome from the same time point [93]. However, in our study we were assured that assigned exposure – parental country of birth – was prior to outcomes of interest: overweight, physical activity and nutritional status of their children at age 8 years, and unlikely to be affected by outcomes.

Two of the studies in this thesis were longitudinal studies with repeated measurements of the outcome. One of the major methodological problems in such studies is missing data, which could be related to either missing subjects (dropouts) or missing some measurements from subjects (intermittent missing data).

Missing subjects in cohort data, especially closed cohorts with a fixed membership like the BAMSE cohort, can violate the validity and precision of the study in the long run, if a large proportion of subjects drop out. Besides reducing the sample size, the question arises about selection bias i.e., if the dropout of subjects was related to the association between exposure and outcome. Nevertheless, there is no defined cut-off for acceptable proportion of dropouts in a cohort study. Given the long follow-up time of BAMSE and proposed response rate of 70 % to 75 % by Rothman [93], BAMSE cohort has a high response rate even at age 16 years (78 %), In addition, for each study we did comparisons between included subjects and baseline BAMSE cohort (Studies I-III) to ensure absence of missing by design. Therefore, we believe that our results are valid.

Missing some observations in a specific subject in a longitudinal study with repeated measurements is inevitable. Here, the mechanism behind missing some observations is important and should be investigated to ensure that the missing was not informative, i.e., dependent on observed or unobserved data. However, it is more likely that intermittent missing of some observations is at random, i.e., not dependent on parental migration status.

Moreover, the method of statistical analysis used in studies II and III could handle missing at random [94].

6.1.2 Validity (systematic errors)

The validity of results in epidemiological studies depends on how possible sources of systematic errors and bias in design or analysis have been managed. Theoretically, systematic errors can originate from three main sources and are classified as selection bias, information bias and confounding.

6.1.2.1 Selection bias

Selection bias refers to the situation where association between exposure and outcome is different among selected subjects and those not selected [93]. This definition is theoretical, as in practice we do not know about association between exposure and outcome in non-selected subjects and cannot compare it with findings in the study population. However, presence of selection bias may be inferred from dependency of the selected population on some variables under study and has to be interpreted accordingly. In other words, detection of selection bias and interpretation of results with an assumed selection bias is an inferred, rather than an observed, issue [93]. Similarly, due to unknown associations in unselected populations, we cannot explicitly judge in which direction our results are hypothetically influenced by bias; it can be in any direction, either underestimation or overestimation. Thus, selection bias means that the results are applicable only on the study population and cannot be generalized to whole population.

In all studies included in this thesis we used members of the BAMSE cohort as the study population. Our results might be biased if selected baseline BAMSE members are different from unselected (excluded/decliners) with regard to the main outcome (overweight and BMI) and exposure (parental country of birth).

The observed prevalence of overweight and obesity in our study population at age 8 years (21.5 %) (Study I) was similar to the reported prevalence at a national level in the corresponding calendar year [95] as well as reports from different parts of Sweden for children in the same age range [21, 22, 96, 97]. In addition, a survey among families who were excluded from the cohort, for any reason, has shown that they only differed from included families as regards smoking habits [77].

However, one of the exclusion criteria of the BAMSE cohort was “sufficient parental knowledge of Swedish language”. Based on this exclusion criterion, 331 subjects were excluded among 7 221 infants born during the recruitment period. Our estimates would be biased if prevalence of overweight as well as low physical activity among excluded immigrants was higher or lower than among included immigrants. One probability is that lack of knowledge of Swedish language was related to low education as an indicator of socioeconomic position, which is compatible with the observed smoking habits among excluded subjects. A previous study has shown that high proportions of children of immigrant parents who live in deprived suburbs are overweight and physically inactive [55]. Therefore, we could expect that our estimates would be attenuated. On the other hand, poor knowledge of Swedish language might be related to a short period of residence in Sweden due to recent arrival. Since newly arrived immigrants come to Sweden with diverse motivations, SEP and educational background, it is unlikely that their heterogeneity would differ from what we had in our study population.

All in all, we cannot totally exclude selection bias, which may affect the prevalence of outcome and associations. However, we believe that any such selection bias would affect our estimates toward attenuation, which would strengthen our positive findings whereas non-significant associations should be interpreted with caution.

6.1.2.2 Information bias

Information bias could be expected if there were measurement errors for continuous variables or classification errors for categorical variables. In the latter case, it is important to explore whether misclassification of the variable (exposure or outcome) is related to other variables or not, to understand in which direction our results would have been affected.

In case of a relationship between a misclassified variable, either exposure or outcome, and some other variable, the misclassification is regarded as differential. Differential misclassification might lead to under- or overestimation of the true association based on type of relation. For instance an outcome misclassified to be more likely among an exposed group leads to overestimation and among an unexposed group leads to underestimation, and similarly for a misclassified exposure.

If the misclassification of a variable, either exposure or outcome, was not dependent on the other variable, the misclassification was regarded as non-differential. Non-differential misclassification is usually considered less problematic, since it can only lead to a dilution of the true association.

6.1.2.2.1 Exposure

6.1.2.2.1.1 PARENTAL COUNTRY OF BIRTH

Parental country of birth may hardly ever be afflicted by measurement errors since it is unique information that normally cannot be subject to recall bias. However, constructed groups based on parental country of birth might be subject to misclassification.

We lack information on important aspects of parental migration including age at migration and duration of stay. These could provide us with clues with respect to motivation for migration and how long parents had been exposed to the new society, as a proxy for level of integration into the host country (acculturation). All of these may affect the classification of immigrant parents and consequently our results.

For instance, immigration at early childhood might be due to adoption. Without such information, an adoptee who has been raised by Swedish parents and most likely follows

Swedish norms and lifestyles, would be considered an immigrant parent when bearing a child. This could shift the results toward an average Swedish population, which would lead to underestimation in comparisons between offspring of immigrant and of Swedish parents. Given that about 60 % of adoptees in Sweden are girls [98], there might be particular cause for concern in studies II and III, where the children were classified only by maternal migration status. Moreover, that would be a concern in study I, in regards to the subgroups of children with one immigrant parent and one Swedish. However, considering that 1-1.5 % of the total population are adoptees [99], we do not believe that this would affect our results significantly.

Similar reasoning may be applied as regards the duration of stay in the host country. A longer duration of stay in the host country may more likely be accompanied with more cultural influences from the new society. Crudely mixing immigrant parents without accounting for their duration of stay may lead to diluted results (Studies I-III).

6.1.2.2.1.2 BREASTFEEDING

Duration of exclusive breastfeeding was asked of parents when the children were on average 12 months old. Close timing between exposure and questioning minimizes recall bias and erroneous reports of duration for exclusive breastfeeding (Study III).

6.1.2.2.1.3 TIME (AGE)

In studies II and III, we lacked information on exact ages at measurements of height and weight. Therefore the predefined ages were based on schedules of routine examination in child health centers and school health centers. Invitation for measurements in child health centers is based on age of children, whereas in school health centers it is based on grades rather than specific ages. Moreover, some ages of the measurements in child health centers are compatible with ages for routine vaccinations, which almost all parents make sure to attend.

For each age, a time span was considered to cover the probable ranges of age at measurements. These probable time spans were narrow during the first 2 years (±weeks), a bit wider at preschool ages (±months) and very wide at school ages (-6 to +11 months) (refer to part 4.1.2.1: Child health centers and school health records). This variation in age may introduce a source of bias, most likely in older children, but is unlikely to affect offspring of immigrant parents and Swedish parents differently. Moreover, the choice of statistical model and assignation of a random effect for the time served to take into account such variation. Nevertheless, interpretation of the results should be done with caution, especially for the upper ages.

6.1.2.2.1.4 AGE AT ADIPOSITY REBOUND

Although age at adiposity rebound is not used as an ordinary exposure to analyze its association with an outcome, we considered it to be an exposure, since we graphically look at its relation to different BMI development patterns. Actually, it was a statistically estimated value rather than a measured variable. Furthermore, by definition it is a subject-specific age that should be extracted from each individual BMI curve, whereas an estimated age at adiposity rebound was derived from BMI curves of different groups as the average age at adiposity rebound for each group, which should be interpreted with caution (Study III).

6.1.2.2.2 Outcome

6.1.2.2.2.1 BMI & Overweight (Studies I-III)

Calculation of BMI was based on height and weight measurements according to standard guidelines [79] and performed by trained nurses, either in child health centers and school health centers (birth to age 12 years, Studies II and III), or BAMSE follow-up clinics (age 8 and 16 years, Studies I and III). This setting for BMI assessment makes measurement errors unlikely. Classification of overweight was based on the BMI cut-offs of the IOTF (Study I). In this classification, BMI cut-offs were age- and sex-adjusted BMI, in 6-month intervals, corresponding to adult BMI $\geq$ 25. The age of children in study I was on average 8 years (7-9 years) and it is unlikely to vary between offspring of Swedish and immigrant parents. Therefore, we do not believe there was any misclassification with regard to overweight and obesity among the children.

6.1.2.2.2.2 Physical Activity (Study I)

In this thesis, physical activity at age 8 years was measured subjectively based on parental report on participation of their children in any organized exercise or sport activity (club activities). Although subjective methods like questionnaire reports due to feasibility, ease of administration and low cost are the most commonly used methods in large scale epidemiological studies, they are criticized for low accuracy. Moreover, the type of activity in question, “organized exercise and sport activity”, constitutes a small part of all possible physical activities such as free play in the neighborhood, school time activities and transportation to school, especially in children at age 8 years (Study I). However, based on available data, participation in club activities was considered to be a proxy for physical activity behavior among the children. Since any participation in club activities might be considered an active behavior based on previous literature [54], classification of the children to low active and active was done. It is possible that children have been misclassified with regard to physical activity. In other words, there might be children who were classified as low active while they are active in leisure time and neighborhood play, and vice versa. Nevertheless, there is no reason to believe that this might have been happened differently for offspring of immigrants vs. Swedish parents. Overall, misclassification of physical activity cannot be excluded. However, if any misclassification has occurred, it would most likely be non-differential and lead to underestimation of the true association.

6.1.2.2.2.3 Nutritional Status (Study I)

All epidemiological studies that have diet as a component of interest, either exposure or outcome, face a challenge for assessment of dietary intake due to the complexity of human diet, a multi-dimensional variable with regard to culture, composition, amount and time variations. A variety of assessment methods have been developed to capture dietary intake including short-term recalls, dietary records and the food frequency method, which each have their cons and pros.

Dietary intake data in this thesis was based on FFQ, which is a retrospective method of reporting average long-term dietary intake. The underlying principle in this method is that habitual intake of diet over the long term (here 12 months) is conceptually important, rather than intake in the short term [100]. Although the food frequency method is widely used in large scale studies, some considerations with regard to information provided through FFQs should be taken into account.

First, like other retrospective methods, FFQ relies on memory and is prone to recall bias, though multiple-choice answers, as in our FFQ, may reduce such problems. In addition FFQ is demanding with regard to cognitive ability, which is subject to individual variations, since it requires long-term memory (*generic memory*) as well as the ability to average dietary intake over a long period. Moreover, the reported intakes might be affected by social norms that incline people to over-report socially desirable foods, for instance healthier foods (*social desirability bias*).

On the other hand, technical limitation might be considered, such as asking about a predefined limited number of food items, especially in our study population of subjects with dissimilar cultural backgrounds (Study I). In this situation, open-ended questionnaires might guarantee that culturally specific foods which contribute to nutrient intake are unlikely to be missed [100]. However, the open-ended questionnaire is time-demanding with regard to coding and grouping the foods and still subject to arbitrary grouping, which may not be compatible with the perceptions of the responder [100]. Another recommended solution is to add specific foods mostly consumed by minority subgroups to the FFQ designed for the general population. However, it has been considered that a FFQ with acceptable coverage of popular food items and generically designed questions would reasonably capture dietary intake in all minority subgroups [100].

Overall, it seems that assessment of dietary intake by FFQ is accompanied by some degree of inherent uncertainty or measurement error that may be aggravated in a culturally diverse population. However, it is difficult to address how bias affects the results, as it depends on which contributing factor is the prominent driving force of the bias. For instance, recall and social desirability are more likely to affect different subgroups of the population in the same way then lead to a dilution of measured intake. On the other hand, we might not have captured dietary intake from culturally specific foods not represented in the questionnaire, which would affect culturally diverse subgroups of the population differently, possibly leading to underestimation of intake particularly in offspring of immigrant parents. However, we believe that using a reasonably comprehensive FFQ (98 food items) with generic questions concerning food ingredients of mixed dishes provides an acceptable coverage of dietary intake in all minority subgroups. This is supported by our observation that there was no difference in total energy and major macronutrient intakes between offspring of immigrant and Swedish parents.

Finally, based on habitual intakes of the nutrients we constructed a dietary score to approximate how the dietary intakes, overall, fulfilled the nutritional recommendations. Since the score is built upon intakes that were subject to uncertainty, it may have been prone to measurement errors. Hence, there is potential for misclassification of subjects to high and low dietary score, but with the same probability for children of Swedish and immigrant parents and thus non-differential, leading only to possible dilution of observed association. All in all, the observed associations with regard to dietary score should be interpreted with caution.

6.1.2.3 Confounding

The goal of epidemiological studies is to find genuine association between exposure and outcome. However, in the real world, it is rare to find such a genuine association and more often the association is distorted by a third factor, a confounder. By definition a confounder should be an independent cause or a cause related to both exposure and outcome, to be able to distort their association. In the presence of an uncontrolled confounder, the observed association between exposure and outcome might be partially, or even totally, due to a confounding factor or being hidden by a confounding factor. In any case, the observed association is not a genuine association of exposure and outcome. Uncontrolled confounding leads to misleading results and should be controlled.

Control for confounding can be performed in the study design (e.g., by randomization, restriction and matching) or in analysis (e.g., by stratification and regression models). The advantage of using regression models is the possibility to control for several confounders simultaneously.

In this thesis, several possible confounders were identified based on previous literature and subject matter knowledge and controlled for in analysis.

Sex and SEP are important confounders in epidemiological studies, related to most exposures and outcomes. We controlled for sex by adjustment in analysis in studies I and II, and by stratified analysis in study III.

Different indicators of SEP have been used in epidemiological studies based on the research questions and availability of information including, but not limited to, education, occupation, income, and area of residence. It has been shown that disposable income in Swedish context strongly predicts breastfeeding at 6 months [101], but we lack such information (Study III). In Sweden a socioeconomic index (SEI) has been developed by Statistics Sweden (SCB), taking into account occupation, educational and position at work. Despite the good combination of different indicators of SEP in SEI, there were some obstacles for using SEI in this thesis, particularly when the exposure of interest was parental migration background. First, there were many missing values for SEI, especially among immigrant parents in our study population. Second, there was a discrepancy between SEI and education specifically for immigrant parents, for instance many highly educated parents had disproportionately low SEI. Third, in studies where the outcome was BMI change over time, we were interested in a more stable indicator for SEP while occupation and position at work could be subject of change over time. On the other hand, health awareness, which could affect lifestyle and health outcome, is more closely related to literacy and level of education than occupation and income, especially in Sweden with a free healthcare system for children. Moreover, attained level of education is a stable and standard indicator for SEP that is easy to measure and comparable between different studies. Thus we adjusted all analyses in this thesis for parental education as an indicator of SEP.

In the study of association between maternal migration background and BMI development from birth through early adolescence (Studies II and III), maternal and perinatal characteristics that might differ among exposure groups and could also affect the outcome were possible confounders. Therefore, we adjusted the analysis in study II for maternal age, early pregnancy BMI, and smoking during pregnancy, complications of pregnancy, birth weight, gestational age, parity and duration of breastfeeding. Similarly, in study III the analysis was adjusted for maternal age, early pregnancy BMI status, smoking during pregnancy, birth weight and gestational age. However, analysis in study III was restricted to children who were born from uncomplicated single pregnancies, with parity omitted from possible confounders after statistical ascertainment.

Although we tried to control for confounding, there might be unmeasured confounders which should have been considered. *Puberty* is related to body growth and might be differ among children depending on parental migration background. However, results of sensitivity analyses confined to ages considered as unlikely for onset of puberty support the observed pattern of BMI changes (Studies II and III). *Parental BMI* (Study I) and *paternal BMI* (Studies II and III) might have confounded our results. However, we lack information on parental BMI when the children were at age 8 years (Study I). Moreover, sensitivity analysis among a subset of children with two immigrant parents yielded similar results as analysis among offspring of immigrant mothers (Study II). *Physical activity* is a well-established confounder for BMI, but we lack precise information of physical activity at different ages, except a subjective measure of participation in club activity at age 8 years (Study I), which might have an impact on BMI changes over time (Studies II and III).

Even controlling for all possible confounders, observational studies may inherently include unknown or *residual confounding* that affects the results, due to either unconsidered confounders or measurement errors in considered confounders.

6.1.3 Precision (random error)

The precision of a study is simply: how certain are we that our estimate for an association is not due purely to chance? Since chance is considered an outcome of a random process, precision is defined as the lack of random error. Random error is variability in the data after eliminating possible sources of systematic error [93].

In practice, random errors mainly stem for sampling variability and are reflected in confidence intervals around point estimates of the association. An increase in study size in the absence of systematic errors improves the precision of a study. In design of a study sufficient sample size can be calculated using statistical formulas. These formulas take into account expected magnitude of the association, prevalence of outcome, significant level (alpha), and expected power (1-beta) of the study as well as relative size of compared groups when they are unequal, like our studies. For instance, the number of subjects in the BAMSE cohort was based on calculation of sample size to reach scientific power [77]. However, in studies with a specific number of available subjects, such as those included in this thesis, it can be performed the other way round by calculating the power of the study given the sample size.

Power calculation for study I indicated that, considering the prevalence of outcomes in our sample, we had more than 80 % power to detect an odds ratio of 1.3 at a significance level of 0.05 given the unequal size groups.

There are different approaches for power calculation in longitudinal studies, each with their own technical complexity. However, several measurement points (Study II = 11 and Study III = 8) provided us with enough observations (Study II = 18 670 and Study III = 14 377) to detect a difference of 0.2 in mean BMI at a significance level of 0.05 with more than 80 % power. Moreover, the applied statistical model has the advantage of handling missing observations by using all available information.

6.2 FINDINGS AND INTERPRETATION

6.2.1 Main findings

6.2.1.1 Study I

In this cross-sectional study among Swedish-born children with different parental migration background, we observed that offspring of immigrant parents had higher odds of being overweight and less physically active, whereas they complied with nutritional recommendations better than offspring of Swedish parents. These findings were independent of and consistent over different levels of parental education. We also observed that parental education, regardless of migration background, was associated with physical activity and high dietary score.

In addition, we observed that among offspring of immigrant parents, the odds of overweight and low physical activity increased to the double when both parents were immigrants, with girls worse off. At a regional level, children of immigrant parents from Asia and Latin America had higher odds of overweight and low physical activity than Swedish peers.

Moreover, we found that offspring of immigrant parents had higher consumption of fruits, vegetables, and unprocessed meats than Swedish peers, i.e., a healthier diet, opposed by lower consumption of milk and dairy products. In both cases, children with two immigrant parents were on the extreme side, in addition, they had a higher consumption of sweets than Swedish peers.

Considering guidelines for nutrient intake, we found that a small proportion of children, regardless of parental migration background, followed the recommended levels for dietary fiber, SFAs, PUFAs and vitamin D. However, offspring of immigrants had relatively better compliance than offspring of Swedish parents with regard to the recommendations for dietary fiber, SFAs, and PUFAs, but not for protein, vitamin A, iron and zinc.

6.2.1.2 Study II

In this longitudinal study following children from birth to age 12 years we found that, despite comparable pregnancy outcomes, there were different BMI development patterns with regard to maternal migration background. Offspring of immigrant mothers followed a slower BMI pattern than Swedish peers, in early childhood up to age 5 years, which reversed to a steeper BMI development afterward. The observed prevalence of overweight at different ages among children by maternal migration background was compatible with patterns of BMI development.

6.2.1.3 Study III

In this longitudinal study, we observed that BMI development pattern from age 2 to 16 years differed among groups of children diverse by breastfeeding and maternal migration background. We found it noteworthy that BMI development in never/short breastfed children showed completely different patterns among offspring of Swedish and immigrant mothers, as compared with exclusively breastfed children. A steeper BMI development was observed among offspring of Swedish mothers with never/short duration of breastfeeding, whereas a slower BMI development was found among such offspring of immigrant mothers, in comparison with exclusively breastfed peers.

The observed inconsistency of BMI development patterns with regard to duration of breastfeeding among offspring of Swedish and immigrant mothers could be explained by estimated ages at adiposity rebound. The data suggested that an early age at adiposity rebound was followed by a steeper BMI development and vice versa.

6.2.2 Interpretation of findings

6.2.2.1 Childhood overweight, lifestyle and sociocultural factors

Higher risk of overweight and obesity among children with parental migration background compared with children of Swedish parents (Study I) was consistent with the results of studies from the USA, and the UK and other European countries [54, 102-107]. This has also been shown in Swedish studies [55, 71, 74]. In contrast, only one study from northern Greece has reported a lower prevalence of overweight for children with migration background than among native counterparts [108]. However, this study was carried out in a region, where the native-born children had a high prevalence of overweight and obesity (25.8 % and 12.7 %, respectively) and among few subjects (n = 276).

Our finding that children of immigrant parents have a higher risk of overweight and obesity than their Swedish peers could possibly be explained by known risk factors such as low physical activity, unhealthy dietary habits, family SEP, and cultural factors related to parental country of origin, which can affect attitude, lifestyle and behaviors of the parents and, consequently, children [109].

Higher prevalence of low physical activity among offspring of immigrants than those of Swedish parents, which is in line with other studies [75], may contribute to their higher odds of being overweight. However, adjusting for level of physical activity did not influence the association between parental migration background and childhood overweight. This indicates that the impact of parental migration background on childhood overweight is not confounded by levels of physical activity. Parental attitude, availability of facilities and their affordability might account for the prevalence gap in physical activity between children of immigrant and of Swedish parents [109], all of which can be influenced by parental SEP. The finding that low parental education is associated with low physical activity, regardless of parental migration background (Study I) shows the importance of SEP as a determinant of physical activity, which is in line with previous studies [74, 110].

Unhealthy dietary habits may account for the risk of overweight among children with immigrant parents. However, we observed an overall better compliance with nutritional recommendations among children of immigrant parents than Swedish counterparts. Thus, one may expect a better outcome with regard to overweight. Despite a better compliance with nutritional guidelines among children of immigrant parents, their dietary habits were a mixture of both healthy and unhealthy aspects. For instance, the higher consumption of sweets among the subgroup with two immigrant parents, which also had the highest odds for being overweight compared with Swedish peers, could be seen as a clue for the role of unhealthy dietary habits in childhood overweight. The highest odds of high dietary score in the subgroup of children with immigrant fathers only, with no significant risk of overweight, provides further support for importance of healthy dietary habits on preventing childhood overweight. Our result was also suggestive that SEP is a strong predictor for compliance with healthy diet (Study I), which is compatible with previous studies [111].

Nevertheless, the highest odds of dietary score in the subgroup of children with the lowest proportion of highly educated parents (only father immigrant) should be interpreted with caution. They might be considered a sign of misreporting of dietary intake (social desirability bias), which seems unlikely since the dietary score is compatible with null risk of overweight among these children. There is also a possibility that parental education would not be a perfect, or sufficient, indicator for SEP in relation to dietary habits and that other indicators, such as income, correlate better with dietary habits. On the other hand, it might be interpreted as synergism between healthy dietary habits from the home countries of both mother and father.

The relative roles of family SEP versus cultural background in explanation of the diversity in the risk of childhood overweight is controversial. Kuepper et al. in a cross-sectional study among 1 979 children at age 6 years detected a two-fold prevalence difference for overweight between children of non-German and German parents. However, they reported that this difference in childhood overweight can be described completely by maternal education and sedentary lifestyle, and suggested "high risk environments rather than high risk ethnic groups [112]". In contrast, Saxena et al. in a study among 5 689 children and young adult (2-20 years) in UK found that higher prevalence of overweight and obesity among some ethnic groups is not related to social class, and concluded that "ethnicity and sex are stronger determinants than social class" [107] with regard to childhood overweight. To a certain extent, these controversial results might be related to the use of different indicators for SEP and different contexts. For instance, in the German study, maternal education was an indicator for SEP and the nationality backgrounds of non-German children were mainly Turkish and from other European countries, whereas in the UK study, social class was defined based on the occupation of the head of household and the ethnic groups were mainly from Asian countries.

Such controversies and possible influences of cultural background [54, 109] suggest that it would be better to consider the cultural backgrounds of the parents alongside family SEP, both in general and particularly in a Swedish context, which is more likely to have diversity in migration background.

Rasmussen et al. in evaluation of a 24-year trend of overweight prevalence among young men at age 18 years found that the increased trend was related to low parental education and rural residence, but not immigration [113]. Besides substantial differences between subjects' age and childhood age range, the source of data was conscript data, in which subjects with immigrant backgrounds were likely less represented. Moreover, there were studies that shown the opposite [62].

In a Swedish context, it has been shown that the impact of parental migration background on childhood overweight cannot be overlooked [71]. Similarly, our finding reinforces the impact of parental migration background on childhood overweight (Study I) and BMI development (Study II). Increased risk among children with two immigrant parents compared with those with only one immigrant parent provides further support for the role of parental migration background (Study I).

However, it should be underlined that observed association between parental migration background and childhood overweight might be dependent on selected SEP indicators. It has been shown that the results of applying different indicators of SEP, e.g., education and income, are not necessarily the same, especially in the context of diverse ethnic background, and using a combination of different SEP indicators would be preferable for interpretation of the results [114]. Nevertheless, we lack additional indicators for SEP, and the findings, particularly regarding diet and physical activity, which might be influenced by income, should be interpreted with caution.

The impact of parental migration background on increased risk of overweight among offspring might be explained by their cultural background. Parental attitudes and behaviors, which are mainly culturally defined, with regard to body size, physical activity and dietary habits might predispose their children to overweight [109]. In some cultural contexts being overweight is perceived as a sign of health and affluence among parents and consequently among their children [115-118]. Similarly, among some ethnic groups physical activity does not have enough cultural value to be considered as an acceptable daily activity [119]. Among children, the lack of cultural value for physical activity among parents and even restriction of participation in physical activity [118] are often augmented by sedentary lifestyles such as watching TV or screen-based games as a symbol of affluence, which is a prevailing cultural value [109]. Eating patterns of the children, as regards for example types of available food, portion size and feeding styles, could be affected by dietary habits, attitudes and food preference of the parents, which are usually culturally and traditionally oriented [111].

Unfortunately, we lacked information or statistical power to look at some aspects of migration such as assimilation or regional diversities, which could illuminate our findings. Nevertheless, it should be kept in mind that immigrant parents are a heterogeneous group from different countries with diverse sociocultural backgrounds [66]. Therefore, a general rule may not be applicable to all. Furthermore, cultural background is a wide spectrum which could contain both advantageous and disadvantageous health aspects, e.g., higher consumption of fruit and vegetables besides higher consumption of sweets. Moreover, cultural background can be influenced by cultural norms and values in the host country (acculturation), a process mainly dependent on elapsed time since migration and acceptance among immigrant population.

6.2.2.2 BMI development and perinatal factors

Our finding of different BMI development patterns with regard to maternal migration background (Study II) is consistent with results of a study among white, black and Hispanic children in the US with a fairly comparable design [120]. Given the plausible genetic differences between children with diverse genetic backgrounds, our observation underlines the role of an obesogenic environment alongside genetic susceptibility for developing overweight, especially as we did not find discernible differences in pregnancy outcome. Furthermore, the pattern of changes in BMI among offspring of immigrants compared with counterpart Swedish children indicates that the changes start at early childhood and gradually incline toward higher BMI. Since children in early childhood are mainly under the influence of parental attitudes, timing of the changes emphasizes the role of family in childhood overweight [121]. This has public health implications for planning effective preventive interventions.

6.2.2.3 BMI development and breastfeeding

Our observation of inconsistency between duration of breastfeeding and pattern of BMI development among children with diverse maternal migration background (Study III) is in line with the results of a study from the Netherlands [122]. Similar to our observation, a lower weight and height for age in non-breastfed children of immigrant mothers than in breastfed peers has been shown in a study among children of immigrant mothers in USA, which was interpreted by the authors as improved growth among breastfed children [123]. Such findings are not concordance with a protective effect of breastfeeding against childhood overweight.

In our data, it is unlikely to consider inconsistency in patterns comparing never/short versus exclusively breastfed children of immigrants and Swedish parents as an improved growth, because the same direction of changes is expected among Swedish children. In addition, exclusively breastfed children of immigrants had significantly steeper BMI development, as compared with Swedish counterparts, which could be interpreted as a pattern toward overweight.

On the other hand, estimated ages at adiposity rebound among different groups of children were more consistent with observed patterns of BMI development than duration of breastfeeding. The data suggested that among children of Swedish parents a short duration of breastfeeding was accompanied by an early age at adiposity rebound and vice versa, while among children of immigrant parents a short duration of breastfeeding was accompanied by a later age at adiposity rebound (Table 7).

Different ages at adiposity rebound may be explained by compositional content of formula or complementary feeding; particularly protein content, since it has been shown that protein intake in infancy is associated with age at adiposity rebound and later weight gain [124-130]. Differences in compositional content of complementary feeding between immigrant and native mothers is compatible with literature that show bottle feeding with sweetened drinks is more prevalent among immigrant mothers [131-133]. Moreover, it was in line with our observation of higher intake of sweets among children of two immigrant parents than children of Swedish parents, at age 8 years (Study I).

7 CONCLUDING REMARKS & FUTURE PERSPECTIVES

"I think and think for months and years, ninety-nine times, the conclusion is false. The hundredth time I am right." Albert Einstein (1879-1955), theoretical physicist

7.1 CONCLUSIONS

- Children of immigrant parents (2nd generation immigrants) have a higher risk of overweight and obesity, and being less physically active. The risk varied between immigrant groups and was significantly higher among children having two immigrant parents, and among children of immigrant parents from Asia and Latin America.

- Children of immigrant parents have a better compliance with guidelines for healthy diet. However, they have some poor dietary habits such as low consumption of milk and dairy products, and high consumption of sweets.

- There is a lack of compliance with nutritional recommendations for dietary fiber, SFAs, PUFAs and vitamin D in a high proportion of children, regardless of parental country of birth.

- Low parental education, regardless of country of birth, is associated with low levels of physical activity and a lower compliance with dietary recommendations.

- The pattern of BMI development among children of immigrant mothers is slower than Swedish peers before age five years, when it shifts to a steeper pattern afterward.

- The pattern of BMI development in relation to duration of breastfeeding differs between children of immigrant and of Swedish mothers. Duration of breastfeeding cannot fully explain the observed differences, but differences are consistent with the age at adiposity rebound. Compositional content of formula or complementary feeding (in particular protein content) might matter.

7.2 IMPLICATIONS

- Children of immigrant parents (2nd generation immigrants) should be seen as a target group in planning preventive interventions and programs for childhood overweight and obesity. However, immigrants are a heterogeneous group and that it is likely that we will have to use different strategies in parallel.

- Dietary interventions among children of immigrant parents should be targeted against poor dietary habits such as low consumption of milk and dairy products, and high consumption of sweets.

- Public healthcare providers should direct special attention toward the lack of compliance to nutritional recommendations for dietary fiber, SFAs, PUFAs and vitamin D in a high proportion of children, regardless of the parental country of birth.

- The importance of parental education in physical activity and healthy dietary habits should be highlighted and considered in the respective programs.

- A shift in the pattern of BMI development among children of immigrant mothers underlines the importance of early childhood on risk of overweight later in life. Moreover, it highlights the role of parental lifestyle and sociocultural background in childhood overweight.

- Compositional content of formula or complementary feeding (in particular protein content) might be important determinants of growth rate and consequently developing overweight and obesity later in life. Specific attention to compositional content of formula or complementary feeding may be helpful in early prevention of childhood overweight, particularly among children of immigrant mothers.

7.3 FUTURE PERSPECTIVES

Migration and the consequent multicultural society entail new challenges with regard to health issues which may pass through generations.

One key issue in migrant studies which should not be overlooked is the heterogeneity among minority groups with regard to country of birth, motivations behind migration, and sociocultural and lifestyle backgrounds, which all may influence the descending generations in different ways.

Efforts toward capturing and scrutinizing different aspects of heterogeneity such as traditional foods, cultural attitudes and values may lead to a better understanding of risk factors or beneficial factors regarding health outcomes.

In the same way, indicators of SEP should be carefully selected and investigated in detail for better understanding of the relative roles of socioeconomic factors and cultural backgrounds as driving forces for diversity in health outcomes. Using different indicators of SEP as combination may be a wise strategy. Nevertheless, different indicators of SEP may affect differently subpopulations. Then possible interaction between SEP and cultural background, as well as psychosocial environment should not be overlooked. In addition, the influence of cultural background may changes over time, therefore it is important to try to account for acculturation in migrant studies.

Hence, the future studies should focus on the situations for groups with different migration backgrounds that guide policymaking and planning interventions to improve the health status of minorities and the general population.

8 SUMMARY IN SWEDISH (SAMMANFATTNING)

Övervikt och fetma under barndomen är ett växande folkhälsoproblem. Syftet med denna avhandling var att undersöka betydelsen av föräldrars migrationsstatus för utvecklingen av övervikt och fetma, fysisk aktivitet och kost i förhållande till socioekonomisk position. Utöver detta studerades betydelsen av perinatala faktorer och amning i förhållande till BMI-utveckling bland barn till invandrare.

Studierna i denna avhandling baseras på material från en födelsekohort (BAMSE) bestående av 4089 barn födda i Stockholm 1994-1996. Barnen har följts med upprepade frågeformulär och undersökningar till 16 års ålder. I BAMSE har 22 % av barnen minst en utlandsfödd förälder.

Sambandet mellan föräldrars migrationsstatus och övervikt eller fetma, fysisk aktivitet och kost hos barnet vid 8 års ålder studerades bland 2589 från BAMSE (Studie I). Resultaten visade att 20 % av barnen med svenskfödda föräldrar var överviktiga eller feta, medan motsvarande siffra bland barn med utlandsfödda föräldrar var 26 %. Barn med invandrarföräldrar hade 33 % högre odds att vara överviktiga, jämfört med barn med svenskfödda föräldrar. Sambandet var starkare för barn med två utlandsfödda föräldrar samt för barn med föräldrar födda i Latinamerika eller Asien.

Barn med utlandsfödda föräldrar hade 30 % högre odds att ha en låg fysisk aktivitetsnivå, jämfört med barn med svenskfödda föräldrar. Sambandet var starkare för barn med två utlandsfödda föräldrar. Låg utbildning hos föräldrarna var kopplat till låg fysisk aktivitet, oberoende av föräldrarnas migrationsstatus.

Vi undersökte även hur väl barnets kostintag överensstämde med de nordiska näringsrekommendationerna. Barn med utlandsfödda föräldrar rapporterade en kost som i högre grad låg i linje med näringsrekommendationerna, jämfört med barn med svenskfödda föräldrar. Ett högre intag av frukt och grönsaker samt oprocessat kött var faktorer som bidrog till en högre följsamhet hos barn till invandrarföräldrar. Dock bidrog ett lägre intag av mjölkprodukter samt ett högre intag av sötsaker till en minskad följsamhet i denna grupp. Låg utbildning hos föräldrarna var kopplat till en låg följsamhet till näringsrekommendationerna, oberoende av föräldrarnas migrationsstatus.

Sambandet mellan mammans migrationsstatus och perinatala faktorer samt BMI-utveckling undersöktes i en longitudinell studie av 2517 barn från födseln upp till 12 års ålder (Studie II). Vi fann ingen signifikant skillnad i födelsevikt, med eller utan hänsyn till graviditetslängd, mellan barn med utlandsfödda föräldrar jämfört med barn med svenskfödda föräldrar. Däremot observerades en skillnad i BMI-utveckling, även efter justering för perinatala faktorer samt faktorer kopplade till modern. Barn till invandrarmödrar hade en lägre BMI-utveckling upp till 5 års ålder, för att efter 5 års ålder ha en högre BMI-utveckling.

Slutligen undersöktes sambandet mellan mammas migrationsstatus och amning samt BMI-utveckling i en longitudinell studie av 2278 barn mellan 2-16 års ålder (Studie III). Resultatet visade att barn med svenskfödda föräldrar hade en brantare BMI-utveckling, jämfört med barn med utlandsfödda mammor då ingen eller kort amning jämfördes med helamning.

Sammanfattningsvis visar resultaten i avhandlingen att det finns en ökad förekomst av övervikt och fetma hos svenska barn med utlandsfödda föräldrar och att denna utveckling startar tidigt i barndomen. Dessa skillnader kunde inte helt förklaras av skillnader i föräldrarnas utbildning, perinatala faktorer som födelsevikt, eller amningsmönster.

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