Health implications of dietary intake
in infancy and early childhood

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Umeå 2008
Detta verk skyddas under lagen om upphovsrätt (URL:1960:729)

Illustrations Staffan Lidman and Magnus Burstedt

Printed by Solfjädern Offset AB, Umeå Sweden 2008
The key to the child health lies........in all round improvement of the competence of the mother - her physical condition, her economic state, her health and nutrition and her education. Such attention to the mother must start not after she has become a mother, not even when she is about to become one, but when she is herself a child”
Goplan 1985
ABSTRACT

Introduction: Swedish children are the healthiest in Europe. Through regular visits to well-baby clinics, infants and young children are checked and parents given information and advice on diet and other relevant matters for their child. For a long time, adequate nutrition during infancy and childhood has been focused on encouraging proper nutrition, preventing malnutrition and deficiency states, and obtaining optimal growth. Today, malnutrition and deficiency states in infants and children are rare. But other public health problems have arisen. Nutrition early in life is now thought to influence health and diseases even in adulthood. Thus promotion of a healthy diet in early life is important for preventing public health diseases such as iron deficiency, cardiovascular disease, obesity, and dental caries.

Aims: This study investigates health implications of dietary intake in infancy and early childhood. More specific focus was on the associations between dietary fat intake and serum lipid levels in infants, early dietary intake, iron status, dental caries, and Body Mass Index (BMI) at 4 years of age. In addition, hereditary factors and changes over time were evaluated.

Methods: Before 6 month of age, 300 healthy infants were recruited from well-baby clinics in Umeå. This thesis is based on secondary analysis of a prospective study in these infants run from 6-18 months and a follow-up of 127 of the children at 4 years. Between 6-18 months and at 4 years, dietary intakes were assessed, anthropometric measures performed, and venous blood samples taken. At 4 years, a dental examination was also performed and anthropometric data and blood samples were collected from parents and included in the study.

Results: All but two infants were ever breastfed and at 6 months 73% were still breastfed. The quality of dietary fat was not within national recommendations. At 4 years, intake of vitamin D and selenium were below and intake of sugar and sweet products above the recommendations. In girls, but not boys, higher polyunsaturated fatty acid intake was associated with lower levels of total cholesterol, low-density lipoprotein cholesterol, and apolipoprotein B levels. Iron status of the children was generally good and no child had iron deficiency anaemia (IDA). Children’s haemoglobin (Hb) levels tracked from infancy to 4 years and correlated with their mother’s Hb. Fortified infant products and meat
were important sources of iron at both 12 months and 4 years. Children with frequent intake of cheese had less caries in this population with low caries prevalence. We found higher protein intake over time to be associated with higher Body Mass Index (BMI) at 4 years and high BMI at 4 years was associated with high BMI at 6 mo. There was also an association between the BMI of the child and that of its parents.

**Conclusions:** BMI of the child and parents (especially the father), and iron status at 6 months were predictors of these variables at 4 years of age. The quality rather than the quantity of dietary fat in infancy affected serum lipid values. Even in a healthy and well-nourished group of Swedish infants and young children, quality of food and intake of nutrients are important for current and later health of the child.
This thesis is based on the following papers referred to in the text by their Roman numbers (I-IV).

I. Öhlund I, Hörnell A, Lind T, Hernell O. Dietary fat in infancy should be more focused on quality than on quantity. *European J Clinical Nutrition 2007; Jun 20.* 10.1038/sj.ejcn.1602824


IV. Öhlund I, Hernell O, Hörnell A, Stenlund H, Lind T. BMI in 4-year-old children is associated with previous and current protein intake and the father’s BMI. *In manuscript.*
ABBREVIATIONS

apoA  Apolipoprotein A-1
apoB  Apolipoprotein B
BMI   Body Mass Index
Dfs   Mean decayed-filled surfaces - a definition of caries experience
E%   Percent of total energy
Fe    Iron
Hb    Haemoglobin
HDLC  High density lipoprotein cholesterol
ID    Iron deficiency
IDA   Iron deficiency anaemia
LDLC  Low density lipoprotein cholesterol
MCD   Milk-based cereal drinks
MCV   Mean corpuscular volume
MFC   Milk-based fortified cereals (drinks and porridge)
MUFA  Monosaturated fatty acid
PUFA  Polyunsaturated fatty acid
SAFA  Saturated fatty acid
S-Ft  Serum ferritin
TG    Triglycerides
TC    Total cholesterol
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Background

BACKGROUND

Diet and public health problems in a historical perspective

Nutrition during infancy and childhood has long been focused on meeting nutritional needs to prevent malnutrition and deficiency states and to obtain optimal growth. A transition from malnutrition to sufficient or even over nutrition has occurred in the north of Sweden during the last century (Figure 1).

Figure 1
The map shows the city of Umeå, located in the county of Västerbotten in the northern area of Sweden

The first Swedish guidelines on infant and childhood nutrition were produced in the 18th century (1). At the time, infant mortality was high, probably above 200/1000. Poor nutrition was identified as one cause. In northern Sweden, local doctors as well as Carolus Linnaeus (Carl von Linné) during his extensive travels reported low prevalence of breastfeeding and that breast milk from early age was replaced with whole cow’s milk causing high infant mortality (2).

In 1749, Swedish population statistics was born when “Tabellverket” started to collect demographic and mortality data. Observations made on high infant mortality prompted the Royal Swedish Academy of Sciences to ask the father of paediatrics, Nils Rosén von Rosenstein, to write some articles in calendars with information on children’s health and promotion of breastfeeding. These calendars were circulated to parents with the aim to improve the health care during infancy and early childhood. In 1764, Rosén published the first known textbook in paediatrics anywhere in the world (1). In it he stated that infant nutrition was important and mother’s milk was the best nutrition. However, if the mother, for some reason, was unable to breastfeed her baby he suggested using a wet nurse. A wet nurse needed to be healthy, well nourished, and have enough milk of good quality.

At the beginning of the 20th century, local doctors in the north of Sweden once again reported on poor living conditions including poor nutrition. These conditions resulted in tuberculosis, rickets, iron deficiency anaemia (IDA), gastrointestinal problems, caries, and high infant mortality. In 1901, the first charitable institution (Mjölkdroppen, “a drop of milk”) for protection of chil-
dren’s health with focus on nutrition was started in Stockholm (3). At the beginning of the 20th century, local doctors in the north of Sweden once again reported on poor living conditions including poor nutrition. These conditions resulted in tuberculosis, rickets, iron deficiency anaemia (IDA), gastrointestinal problems, caries, and high infant mortality. In 1901, the first charitable institution (Mjölkdroppen, “a drop of milk”) for protection of children’s health with focus on nutrition was started in Stockholm (3).

In 1929, the Odin study was started in Umeå, Sweden (4). The focus was on the prevalence of major diseases such as gastrointestinal diseases, oral health, and anaemia and how these diseases are influenced by diet. In the study group, 17,406 men, women, and children were included; 3,406 were school children. Major observations were that the diet was unbalanced, based on potatoes, milk, and barley bread and contained low amounts of vitamins and iron. Malnutrition and poor dental health were common in the northern area of Sweden. This was a contributory cause of the 1937 governmental proposition to start well baby-clinics, where health and dietary information and advices should be offered to parents. Prospective length and weight measurements were started to assess growth rate and thus identify poor growth and inadequate intake of a balanced diet. Later, growth charts were introduced to make it easier to assess growth and to identify more rapidly and accurately children with poor growth.

In 1938, another important reform – public dental clinics – was instituted by the Swedish Parliament. Sweden was the first country to start social dental care and the goal was “dental care for the people” (5). In the 1960s, caries prevention programmes were started with advice on oral hygiene habits that included reducing sugar consumption and using fluoride prophylaxis in children. In schools, dental nurses regularly administered fluorides to children.

In 1967, an epidemiological study on children was started in the Umeå area to study the relationship between diet and general and oral health (6). At the time, there were no Nordic or Swedish nutritional recommendations and the authors compared the dietary intakes with recommendations from the U.S. Food and Nutrition Board. The dietary intakes at 4 years were higher than or within recommendations for energy and nutrients except for low intake of vitamin D. The intake of fat was high, comprising 40-42% of the energy (E%). Consumption of sweets was negatively associated with oral health. Iron status had improved since the Odin study in 1929 and the prevalence of IDA was low (7). Height and weight did not differ between 4 year old boys and girls, but skin
fold thickness was higher for girls than for boys (8).

Further investigations of the children’s dietary intake and health were performed in the same area in the 1980s and no signs of nutritional deficiencies (IDA included) were found (9). In weaned infants at 6 and 12 months, the dietary fat intake was 29-33 E% and total energy intake at 12 months was 80% of the recommended daily allowance (RDA), although the growth was normal. For the first time, intake of vitamin D was reported to exceed the RDA to the degree that vitamin D supplementation was questioned. Milk-based fortified cereals was an important food source, responding for 56 E% at 6 months and 26 E% at 12 months (10). Longitudinal data on children followed from 12 months to 3 years showed associations between caries and consumption of sucrose-rich foods such as cakes, bread, and sweet soups. The dietary patterns at 3 years were already established at 12 months, patterns that suggested that future health would be influenced by early eating habits (11).

In 1980, the first Nordic nutrition recommendation (NNR) was published and then revised (1989, 1996, and 2004) due to new scientific data. At present a new revision is under discussion contributing to 2004 revision were new studies on energy requirements in infants (12, 13), associations between dietary fat, particularly saturated fat, and serum lipid levels in infants and young children (14), and the increasing prevalence of obesity in childhood (15) (16). The Swedish Nutrition Recommendations (SNR) are based on NNR and the first SNR was published in 1981 and the most recent in 2005. In addition to recommendations on nutrient intake, the SNR also includes recommendations on meal planning and physical activity.

**Dietary intakes and health in children**

**Energy and energy requirements**

Due to the rapid growth rate, the energy needs per kilo bodyweight are higher during infancy and early childhood than in adulthood. The diet should provide energy for total energy expenditure including basal metabolic rate (BMR), thermoregulation, and requirements for growth and physical activity. During the first 3 months of life, the cost of growth is highest, starting with 30-38% of the total energy need and decreasing rapidly to about 2% at 2 years (12). Later in childhood and adolescence, the cost of growth varies between 1-4% of total energy. If the energy intake for some reason becomes too low, the body has several defence mechanisms. One is to decrease physical activity. If that is not enough, decreased body temperature, weight loss, and reduced linear growth (17) may be used to adapt to a lower energy intake.

In the revised NNR-04, the recommendation on total energy intake was reduced both for infants and children younger than 3 years. The reasons behind the changes were new studies using the double-labelled water method, showing that previous estimation on
energy requirements (ER) for infants and children had been too high (13, 18, 19).

Fat, carbohydrate, and protein provide energy. Increasing the proportion of fat relative to carbohydrates and protein increases the energy density of the diet (20), which may affect the total energy intake (21). Although energy intake is within or even above the recommendation, it is not clear if Swedish children have an optimal nutrient intake in other respects or even an optimal diet. In 4 year old Swedish children, sweet products account for 25% of the total energy intake, often with low nutrient density (22).

Dietary fat

As mentioned, a diet with higher proportion of fat provides higher energy density and smaller volumes of food need to be consumed. Therefore, fat intake and growth are expected to correlate (23). Breast milk contains about 50 E% as fat and it is also high in cholesterol. Fat is necessary not only as a source of energy but also because it is a source of essential fatty acids and serves as carrier for absorption of fat-soluble vitamins.

Historically, a diet rich in fat has been recommended for infants and young children to ensure sufficient energy intake and adequate growth. In contrast, a diet rich in fat, particularly in saturated fat, is considered to have negative health effects in adults. The NNR (1980) encouraged adults to reduce fat intake and to increase dietary fibre intake (24). Unintentionally, fat intake decreased and fibre intake increased also among older infants and young children eating foods prepared by health-conscious parents. Some children presented at well-baby clinics and health care centres with diarrhoea. This phenomenon, called toddler’s diarrhoea, often resulting from a diet low in fat and rich in complex carbohydrates, became more common. As a consequence, more comprehensive information was given to parents on the importance of a diet with higher energy density than for adults for infants from weaning through the first 2-3 years. Compared to NNR 1996, the revised recommendations, NNR 2004 recommend a lower maximum intake of dietary fat for infants and children between 2-3 years of age but with no change for the age group 12-23 months (Table 1). Globally, there is no consensus on the need to reduce dietary fat in children. On the contrary, it has been questioned if a low fat diet is safe for infants and young children (12, 25-27). Some studies on dietary fat intake in infants and young children have shown intakes of about 45-50 E% at 4 months, 38-40 E% at 6 months (28), and 37 E% at 12 months (29, 30). In Finnish infants, dietary fat intakes <30 E% (26-27 E%) (23) has been used in an intervention study with no adverse effect on growth or nutrient intakes. The Bogalusa Heart study and a Norwegian study found that fat intake was replaced by sugar in low fat diets (31, 32). In Swedish children, the intake of dietary fat intake is 33 E% at 4 years (22, 33-36).
Table 1. Recommended intake of dietary fat in infants and young children, NNR 1996¹ to 2004²

<table>
<thead>
<tr>
<th>E%</th>
<th>NNR 96</th>
<th>NNR 04</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6-12 m</td>
<td>1-3 y</td>
</tr>
<tr>
<td>Total fat</td>
<td>35-45</td>
<td>30-35</td>
</tr>
<tr>
<td>SAFA³</td>
<td>na⁶</td>
<td>na⁶</td>
</tr>
<tr>
<td>MUFA⁴</td>
<td>na⁴</td>
<td>na⁴</td>
</tr>
<tr>
<td>PUFA⁵</td>
<td>na⁵</td>
<td>na⁵</td>
</tr>
<tr>
<td>n-6 fatty acids</td>
<td>≥4.5</td>
<td>≥3</td>
</tr>
<tr>
<td>n-3 fatty acids</td>
<td>&gt;0.5</td>
<td>&gt;0.5</td>
</tr>
</tbody>
</table>

¹ Nordic nutrition recommendations -96 (37) , ² Nordic nutrition recommendation -04 (24).
³Saturated fatty acids; ⁴Monounsaturated fatty acids; ⁵Polyunsaturated fatty acids; ⁶not specified

Iron

The diet is considered to have great influence on an individual’s iron status (38, 39). There are two types of iron in the diet: haem and non-haem iron. Haem iron is better absorbed than non-haem and in contrast to non-haem, not influenced much by other foods. Iron content and bioavailability vary confidentially between different food sources. The bioavailability of iron is influenced by inhibitors and promoters of its absorption. In the diet calcium, phytate, and tea decrease absorption, whereas meat, fish, and vitamin C enhance absorption (28, 40, 42). Meat with its high content of iron of high bioavailability (haem iron) also promotes absorption of non-haem iron, the meat factor. It was recently suggested that meat should be included in early complementary food in small amounts to improve iron status in infants (41). Whether calcium works as an inhibitor of iron absorption or not is debated. There is a potential risk of interactions between calcium and iron affecting absorption. An inhibiting effect has only been shown in single meal and short-term studies (43). Long-term studies with calcium supplements, on both adults and children, have not confirmed an association between high calcium intake and poor iron status (44-46).

In a cross sectional study of healthy 12 month old infants in Umeå, it was unexpectedly found that 26% were iron deficient as judged by serum ferritin (s-Ft values<12μg/l). This was in spite of sufficient iron intake. The high intake of phytate-rich cereals, i.e milk-based ce-
reals drinks (MCDs) and porridge of Swedish infants was suggested to be the culprit. In Sweden, MCDs, gruels, and porridges have long been part of the traditional diet in both adults and children. It is a very important part of the diet of infants and young children from 6 months (9,10,22). The manufactured commercial products are fortified with vitamins and mineral and the iron content is 1.2-1.3 mg per 100 ml. To investigate this, unexpectedly high prevalence of ID a long-term intervention study in infants (SINUS, Study on Infant Nutrition in Umeå, Sweden) was started in December 1995 (47). Healthy infants (n=300) were assigned to one of three study groups with weaning food varying in phytate content: regular infant cereals; low-phytate infant cereals or cow’s milk based infant formula; and regular porridge from 6 to 12 months. They were followed using dietary records, anthropometric data, and blood samples with focus on iron and zinc status from 6 to 18 months. No association between the phytate content and iron status was found and it was concluded that the infants were not iron deficient, rather the definition of ID and IDA in infants need to be revised. Furthermore, iron intake was found to affect Hb during infancy but not during the second year of life. In contrast, S-Ft levels were not affected by dietary iron intake before 12 months but was positively associated at 18 months (48). Hence iron metabolism develops during first year of life (48, 49). This study later formed the basis of the present study on infant and young child health.

In British toddler and young children iron status was positively associated with meat and fruit consumption and inversely with that of milk and milk products (50, 51). High milk intake was judged to displace iron-rich or iron-enhancing foods.

In Finnish 3-4 years old children, iron intake was 8.6-8.8 mg per day. Out of them 10 % had S-Ft below 10μg per litre (42).

Swedish children who start out with good iron status at 12 mo seems to maintain sufficient iron status at 18 mo even with low iron intake (52).

A Swedish national food survey in children was carried out 2003 (22). The main iron sources were meat fish and egg contributing 28.5 % of the iron intake and MCDs 14 %. This was confirmed by a recent study found meat products to contribute with 23 % and gruels with 17 % of total iron (34). Two other studies found iron intake in 4-y-old Swedish children close or within the recommendation (53, 54) which is 8 mg per day in infants and preschool children and based on the need to cover for basic losses and growth. Neither of the Swedish studies did analyse the associations between diet, except for iron content, and iron status in the children.

Cow’s milk

In many countries, including Sweden, cow’s milk is an important food in healthy eating providing many nutrients and is an important source of calcium and vitamins A and D. Historically, cow’s milk has been considered an important food source also for children although, as mentioned earlier, in the
past also associated with poor nutrition in infants in northern Sweden.

Cow’s milk is low in iron and the bioavailability is also low. In young infants, unmodified milk can cause blood loss from the intestinal tract and many studies have shown a negative effect of cow milk intake on iron status during the first year of life. In Icelandic infants, milk intake greater than 500 ml was associated with poor iron status which seemed to remain at 6 years (55). Therefore, many countries, European Society for Pediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN) and the WHO recommend that intake of undiluted cow’s milk should not be introduced before the end of the first year and then only in small amounts (28, 56). After one year of age, it is often recommended that milk intake should be limited to about 500 ml per day. The new recommendation to delay the introduction of cow’s milk in Swedish infants resulted in debate as many judged milk as an important food also for infants (57, 58). The Swedish guidelines from the National Food Administration (SLV) recommend that the introduction of milk as a drink should not start before 10-12 months of age. From 12 months, 500 ml of low fat milk is recommended, which includes milk added in cooking.

Milk and cheese are important foods for mineralization of the teeth and reduce the risk of caries development. This is exemplified by specific bioactive peptides in cheese and milk. Caseinophosphopeptide, derived from β-casein, increases calcium levels at the tooth interface and reduces caries (59). The caseinoglycomacropeptide and kappacin, peptides derived from κ-casein, inhibit adhesion and metabolism of mutans streptococci, respectively.

Carbohydrates

A diet containing adequate amounts of dietary fibre from cereals, potatoes, vegetables, fruit, and berries are considered important for children. Such a diet also provides vitamins and minerals. Although cereals contain phytate, an inhibitor of iron absorption, the inhibiting effect can be counter balanced by adequate amounts of iron and ascorbic acid which enhances the absorption (47). In infants, too high intake of complex carbohydrates might cause gastrointestinal problems and the bulk effect may result in low energy intake. NNR 2004 suggested that the intake of dietary fibre should be at least 10 g per day by school age (24). In the 2005, the US Food and Nutrition Board guidelines for children recommended the intake of total fibre in children aged 1-3 years be 19 g per day (60). The SLV 2008 suggests an intake of 2-3 g per mega joule (MJ) from one year of age which will be about 15-19 g fibre per day in preschool children (personal communication).

In a healthy diet, sucrose should be limited and not exceed 10 E% (24). High sugar intake is associated with health problems such as dental caries, risk of obesity, and dyslipidemias as well as a poor diet (61). Some studies have reported that diets with low fat content
may result in higher sugar intakes (31, 32). Recent studies report the intake of sucrose to be about 13 E% in 4 year old Swedish children (22). Sweet products such as soft drinks, sweets, ice cream, desserts, cakes, and biscuits account for 25 E%. Hence frequent consumption of sugar and sucrose-containing products has increased and seems to be introduced by the second half of infancy (11, 62).

**Health implications of the diet in the childhood population**

Today, the World Health Organisation (WHO) classify Swedish children as the healthiest in Europe (63). During free regular visits to well-baby clinics and public dental clinics, infants and children are checked and the parents are given information and advice on how to keep their child healthy (64, 65). Promotion of a healthy lifestyle in early childhood is important (66) and information on breastfeeding and weaning recommendations is part of the information given to parents (67). Infants born in 1997, 74% and 78 % were breastfed at six months of age in Sweden and in the county of Västerbotten, respectively (68).

Today nutrition during foetal and postnatal life are considered to have not only short term but also long term health consequences (69-71). Thus early nutrition affects iron status during infancy and childhood but also the risk to develop obesity and cardiovascular disease decades later through programming effects (72-74). In the present thesis association between early diet and risk indicators to cardiovascular disease, caries, obesity and IDA has been studied.

**Cardiovascular diseases**

Sweden has a high prevalence of cardiovascular disease (CVD) in the adult population (75). To prevent CVD in adults, much emphasis is put on known risk factors such as smoking, obesity, raised serum cholesterol, low physical activity, and poor eating habits (76). Studies have shown that the atherosclerotic process starts already in childhood. Fatty streaks and atherosclerotic lesions have been found in children, and childhood risk factors predict adult risk factors of cardiovascular disease (66, 77-79). Such risk factors are obesity, high blood pressure, high serum total cholesterol (TC), and high low-density lipoprotein cholesterol (LDL-C). These individual risk factors tend to cluster (66, 80). Promotion of a healthy lifestyle in early childhood is important (81) and includes regular physical activity, healthy eating, and non-smoking. Intervention studies have shown that health promotion programs reduce risk factors among school children (81, 82), and other intervention studies in infants have shown the possibility to reduce TC already during infancy with lasting effects into adolescence (83). However, in Swedish infants and young children, few studies have been performed (84, 85) on serum lipid levels and their relation to diet (35, 86).

**Iron deficiency**

ID, low s-Ft concentration, is globally the most prevalent nutritional disorder in young children and women. ID is the
only nutrient deficiency that is prevalent in both non-industrial and industrial countries. The WHO estimates that ID affects most preschool children and pregnant women in non-industrial countries and about 30-40% of preschool children in industrial countries (87). IDA, anaemia resulting from ID, is also a common nutrition disorder in infants and children. ID results from various causes such as poor or inadequate diet, infections, and other diseases (88). Growth and growth rate are linked to iron metabolism and iron status; in children, the highest prevalence of IDA is found between 6 months and 2 years of age, a time of rapid growth. Thus rapid growth during the first year is associated with poor iron status. For infants and adolescents, gender-related differences have been proposed to be biological and not only caused by differences in iron intake or losses through menstrual bleedings (89, 90).

Association between a mother’s and her child’s iron status has been described in areas with poor nutrition (91, 92). In a healthy, well-nourished, and iron-replete population, the child’s Hb-concentrations were associated with that of both parents (93). However, the prevalence of ID in children might be less than 2% in high-income countries like those in Scandinavia (48, 94, 95). In southern Sweden, the prevalence of IDA in healthy 2.5 year old children was 10%, with higher prevalence in immigrants than Swedish children (96). For preschool and school children, three studies were undertaken in the area of Umeå (county of Västerbotten) between 1930 and 1980 (4,7,9). In 1980, not a single case of IDA was found (9). However, in the same area during 1991-1992, about 26% of 12-month-old infants was reported to be iron-depleted using s-Ft <12 µg/l as definition, although IDA was rare (97).

Dental health

Dental caries is primarily the symptom of an infectious disease (98). Oral bacteria – i.e., mutans streptococci – produce acids through their metabolism of dietary carbohydrates, an action that demineralizes dental hard tissues. The disease became endemic in the western countries when sucrose consumption began to increase in these populations. The intake of sugars is the main known aetiological factor of dental caries but still many epidemiological studies fail to show that caries prevalence is explained by frequency or amount of sugar intake (99). This failure may be because caries resistance is enhanced by protective components. Fluoride is one well-known protective agent found in different concentrations in drinking water and in specific products such as toothpaste and tablets. Foods that increase calcium or phosphate concentration in the biofilm on teeth and intercrystal fluids counteract colonisation of bacteria and may reduce caries (59, 100) (101, 102). Although dental health in Swedish children has improved, it is still a public health problem and differs between social groups (103). Furthermore, caries prevalence is higher in overweight children (104) and in children with other diseases (105-108). Overall, the proportion of 3 year old and 6 year old Swedish children without caries has increased; however, because the magnitude has increased in
Background

the population of children with caries, the frequency of caries is skewed. Between 1985 and 2005, the prevalence of caries in Swedish pre-school children declined, but the decrease between 2000 and 2005 was low (109, 110). A goal for the WHO is that 80% of 6 year old children should be free from caries. In Swedish children, 73% of the 6 year olds are caries free (109). In the Umeå area, 54% of 4 year old children was caries free in 2002 (110) and Västerbotten county statistics show 79% of 5 year old children to be caries free in 2004.

Overweight

Body Mass Index [BMI, weight in kg/(height in m)²] is used as an estimate of overweight and obesity in adults and children. In adults, the cut-offs for underweight, overweight, and obesity are BMI < 18.5, ≥25, and ≥30 kg/m², respectively. Those cut-offs are not possible to use for children. As children’s body composition changes as they grow, the corresponding age and sex BMI cut-offs for overweight and obesity are adjusted and termed iso-BMI (111). Iso-BMI is not yet used to estimate underweight, but in a recent study a cut-off of BMI 17 at age 18 years is suggested to be used as an international definition of thinness in children and adolescents (112), and new cut-offs for thinness/underweight in small children will be introduced.

Children who are overweight compared with normal weight, spend more hours watching TV and playing computer games and less time with organised sports and other physical activities (113). Short-time health consequences of obesity are mainly psychological and social. Some studies on quality of life have shown increased psychological and psychiatric problems in obese compared to non-obese children (114) while others have not (115). However, it seems that girls, compared with boys, are at greater risk of psychological morbidity and that the risk increases with age (80). Being overweight or obese is part of the metabolic syndrome, posing an increased risk of developing cardiovascular diseases. Raised blood pressure, LDL-C and low s-triglycerides (TG), fasting insulin concentrations, and low high-density lipoprotein cholesterol (HDL-C) concentrations are also associated with overweight children (116). The Bogalusa Heart Study reported odds ratios in overweight schoolchildren of 2.4 for having elevated levels of TC, 4.5 for increased systolic blood pressure, and 12.6 for raised fasting insulin level (80).

Overweight and obesity have been increasing in children during the last decades, particularly among girls and in areas with low socioeconomic standard (16, 117). Sweden in no exception, overweight and obesity has increased among children (118) and is today one of the main health problems. About 15-20% of children are overweight and 3-5% are obese (16, 118-120). In the Umeå area, the prevalence of overweight doubled to 18% in schoolchildren 6-13 years old and the frequency of obesity increased fivefold to 5% between 1986-2001 (15). Among 4 year old children born 1998-199 in the county of Västerbotten, 16.7% of the boys were classified as overweight and 3.1% obese. Corresponding figures for girls were 22.1%
and 4.5 % (16). However, a recent study from Gothenburg, in the south-west of Sweden, indicates a decreasing trend in 10 year old children between 2001 and 2005, particularly among girls (121).

In summary, well-baby clinics and public dental clinics free of charge for children have been important for health promotion among Swedish children. Food habits are founded early in life and influence health and diseases even in adulthood, but there are many important things we do not know about Swedish infants and preschool children’s diet and health. There are questions about the associations between dietary intake in early life and public health problems such as serum lipid levels, iron status, BMI, and dental caries. Besides the current diet, tracking over time and associations between the parent’s and the child’s health needs to be evaluated.
OBJECTIVES

The general objective for the present study was to investigate some the health implications of dietary intakes in infancy and early childhood.

Specific objectives were to evaluate the following:

- associations between dietary fat intake and serum lipid levels in infants (paper I);

- haemoglobin values and iron status at 4 years of age and their associations with dietary intake and body growth, parental values and possible tracking of iron status variables from infancy to early childhood (paper II);

- associations between dietary intakes and dental caries, levels of mutans streptococci and lactobacilli in saliva (paper III); and

- body mass index (BMI) at 4 years of age and its association with dietary intakes from 6 months to 4 years, parental BMI, and changes over time. (paper IV)
DESIGN

This thesis report results from a longitudinal study originally focused on the effect of varying the phytate intake during infancy on iron and zinc status (47). Three hundred healthy term infants were recruited from well-baby clinics before 6 months of age and 234 were followed until 18 months. Recruited infants were all term with gestational age at birth between 38 and 42 weeks, birth weights >2500 g, and with no chronic illness or feeding problems. From those 234 children who continued to 18 months, we recruited 127 to a follow-up at 4 years which also included their parents. The study was conducted in Umeå which is a university town of 110 000 inhabitants located in northern Sweden (Figure 2).

Subjects and methods

Longitudinal study started in December 1995, including 300 infants

- Monthly five day food records from 6 mo to 18 mo
- Anthropometrics monthly 6-12 mo and bi-monthly 14-18 mo
- Blood samples collected at 6, 9, 12, 18 mo
- At 12 mo n=255 and at 18 mo n =234

“Dietary fat in infancy should be more focused on quality than on quantity” (Paper I)

Children who remained in the study until 18 mo were invited to a follow-up study at 4 y, together with their parents. This study included repeated five day food records, anthropometrics measurements, blood samples, and examination of dental health n= 127 children, 119 mothers, and 114 fathers
The follow-up started in 1999

Predictors of iron status in well-nourished 4-year old children (Paper II)

“Diet intake and caries prevalence in 4-year old children” (Paper III)

BMI in 4-year old children is associated with previous and current protein intake and the father’s BMI (Paper IV)

Figure 2 Flow chart for the different parts in the baseline study from 6 months to 18 months and the follow up study at 4 years. The methods used are described in the respective papers (I-IV)
Results

RESULTS

Food and nutrient intake
All but two infants were ever breastfed and at 6 mo 73%, at 12 mo 15%, and at 18 mo 2% were still breastfed. They were all on diversified diets at 12 months. At 12 mo, 99% of the 255 infants were eating some commercial baby foods, such as formula, MCDs, porridge, pureed fruit, and jars with main courses (Figure 3). These baby foods accounted for 46% of the mean energy intake at 12 months. All but two infants had been eating fresh fruit, berries, or commercial pureed fruit for babies. Formula, MCD, and baby-porridge were important food sources: at 12 month consumed by 96% and at 4 years by 73% of the infants and children. These products were important sources of iron, energy, and other nutrients. Of the home cooked foods prepared by the parents, potatoes were more common than rice and pasta, and meat was more common than fish. The majority (96%) of the infants ate some kind of sweet products such as candies, chocolate, jams, soft drinks, biscuits, fruit syrups, or sugar at 12 months ice cream excluded. The sucrose intake was 5 E%.

Of the infants, 97% were drinking milk and both full fat (n=224) and low fat products (n=200) were used. The consumed volume was between 1.5 ml to 1240 ml per day with a mean daily intake of 237 ml. Milk intake in infancy was negatively associated with formula and MCD intake but positively associated with consumption of porridges. The mean intake of full fat milk was lower, compared with low fat milk, 98 ml and 283 ml respectively.
Results

Figure 3 Food sources consumed by the infants at 12 months.* Includes candies, chocolate, sugar, cakes, jam, soft drinks, fruit syrup.
■ = commercial baby products □= home cooked foods.

At 4 years age, milk intake was higher in children not consuming MCDs and varied from 40 ml to 940 ml per day with a mean intake of 360 ml per day. Among these healthy infants and children, mean intake of energy and most nutrients was in agreement with or higher than current recommendations, but intake of vitamin D and selenium was low at 4 years (5.1μg and 20 μg respectively) as compared to NNR-04. Only data of energy and macronutrients are shown (Table 2).

The quality of dietary fat intake was not within the recommendations of NNR at 12 mo. Intake of saturated fatty acids (SAFA) was high and only 2 infants had a relative intake below the recommended upper level of 10 E%. Regarding intake of polyunsaturated fatty acids (PUFA), almost one-third of the infants had an intake below the recommended proportion of 5-10 E%. The proportion of SAFA and MUFA increased relatively more with increasing total fat intake than the proportion of PUFA (Figure 4). This situation remained at 4 years, but the proportion of SAFA had increased and that of PUFA slightly decreased. At 4 years, nobody was within the recommended quality of the dietary fat intake. All children had a SAFA intake >10 E% and only 10% reached a total PUFA intake within the recommended 5-10 E%.
Results

Table 2. Mean energy and macronutrient intake per day of the children who fulfilled the follow-up at 4 y. Intakes are described for 12 months, 17/18 months and 4 years.

<table>
<thead>
<tr>
<th></th>
<th>12 months</th>
<th>17/18 months</th>
<th>4 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Girls (n=62)</td>
<td>Boys (n=62)</td>
<td>Girls (n=54)</td>
</tr>
<tr>
<td>Energy (MJ)</td>
<td>3.7 (0.7)</td>
<td>4.1 (0.9)</td>
<td>4.1 (0.6)</td>
</tr>
<tr>
<td>Carbohydrate (g)</td>
<td>113 (20)</td>
<td>124 (25)</td>
<td>123 (18)</td>
</tr>
<tr>
<td>Carbohydrate(E%)</td>
<td>50.6 (4.1)</td>
<td>50.8 (3.7)</td>
<td>49.8 (4)</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>28.5 (6)</td>
<td>31.5 (7.8)</td>
<td>33.7 (6.5)</td>
</tr>
<tr>
<td>Protein (E %)</td>
<td>12.7 (1.9)</td>
<td>12.9 (1.9)</td>
<td>13.6 (1.6)</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>35.9 (7)</td>
<td>39.2 (11)</td>
<td>39 (7.8)</td>
</tr>
<tr>
<td>Fat (E %)</td>
<td>36.3 (5.1)</td>
<td>35.9 (4.3)</td>
<td>35 (3.8)</td>
</tr>
</tbody>
</table>

Numbers are mean (SD)

Figure 4. Relative intake of polyunsaturated fatty acids (PUFA), monounsaturated fatty acids (MUFA), and saturated fatty acids (SAFA) at different levels of total fat intake in Swedish infants at 12 months. All as percent of energy (E%).
Results

At 4 y dietary fat intake and sucrose intake were positively associated with each other (r=0.23, p=0.022). Furthermore, dietary fat intake was positively associated with energy intake (r=0.812, p<0.001). The mean intake of dietary fibre was 9.5 g per day with a range between 4.5 - 17 g per day. During the five recorded days, all children were eating meat, bread, and spreads as well as sweet products while 77% of the children were eating fruit and berries and 72% fish. Potatoes were still more common than rice or pasta. The main energy source was dairy products and these were responsible for 16.3% of total energy intake and sweet products for 15.7% (Figure 5). Dairy products were also the main source of protein intake and responsible for 30% of the mean daily protein intake. In a quarter of the children, MCDs were responsible for more than 17% of total energy and in a few cases even 40%.

**Figure 5.** Proportions of total energy intake from different foods sources in the 4 years old children. Median, 25th - 75th percentiles, min-values, and max-values.
To evaluate the accuracy of the reported energy intake in the present study, the intake data were compared with estimated average daily requirements (EAR) in the NNR 2004 at 12 months, 17-18 months, and 4 years. At both 12 months and 17-18 months, our intake data were higher compared with the EAR and this remained for boys at 4 years (Table 3).

The ratio of energy intake (EI) to basal metabolic rate (BMR) at 12 mo was 1.7 for girls and 1.75 for boys, at 17-18 mo it was 1.59 for girls and 1.55 for boys, and at 4 y it was 1.61 for both girls and boys.

Table 3. Reported energy intakes and estimated energy requirements (EAR) at 12 months, 17-18 months, and 4 years.

<table>
<thead>
<tr>
<th></th>
<th>12 mo</th>
<th>17 - 18 mo</th>
<th>4 y</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Girls</td>
<td>Boys</td>
<td>Girls</td>
</tr>
<tr>
<td></td>
<td>n=132</td>
<td>n=121</td>
<td>n=54</td>
</tr>
<tr>
<td>EI&lt;sup&gt;1&lt;/sup&gt;</td>
<td>3.7 (0.7)</td>
<td>4.1 (0.9)</td>
<td>4.1 (0.6)</td>
</tr>
<tr>
<td>EAR&lt;sup&gt;2&lt;/sup&gt;</td>
<td>3.5 (0.4)</td>
<td>3.8 (0.8)</td>
<td>4.0 (0.4)</td>
</tr>
<tr>
<td>EAr&lt;sup&gt;3&lt;/sup&gt;</td>
<td>3.4</td>
<td>3.6</td>
<td>na&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>1</sup> Energy intake, MJ per day  
<sup>2</sup>EAR calculated from actual kilo body weight with the use of NNR-04  
<sup>3</sup> EAR for the age group and sex, with predicted weight NNR-04  
<sup>4</sup> no specific EAR defined in NNR-04

**Dietary fat intake and serum lipids in infants**

**Paper I** reported dietary intake and serum lipids at 12 months. An important finding from this study was that dietary fat intake affected serum lipid levels differently in girls and boys, although neither total dietary fat intake, serum lipid levels, nor breastfeeding differed between genders. In girls, but not boys, higher intake of PUFA was significantly associated with lower levels of TC, LDL-C, and apo B levels. The mean total intake of saturated fatty acids (SAFA) was high (15.1 E%) and only two infants had a relative SAFA intake below the recommended upper level of 10 E%. Although the mean PUFA intake was 5.6 E%, almost one-third (29%) of the children were consuming less than the recommended proportion of 5-10 E% PUFA intake. PUFA intake was positively correlated with intake of commercial baby foods such as jars with main courses ($r=0.386$, $p<0.001$) formula and MCDs, ($r=0.291$, $p<0.001$). As a consequence, SAFA was negatively correlated with commercial baby foods and MCDs, ($r=-0.395$, $p<0.001$ and $r=0.258$ $p<0.001$, respectively). Furthermore, serum lipid levels TC, LDL-C,
and apo B were negatively correlated with intake of commercial baby products, whereas there was no correlation with intake of butter, oil, margarines, or fat from dairy products.

Between 6 mo and 12 mo the serum lipid levels showed only small changes except for a decrease in apo A. Girls had higher apo B levels than boys at both 6 mo and 12 mo, but no other differences between boy’s and girl’s lipid levels were noted (Table 4).

**TABLE 4.** Serum lipid concentrations at 6 and 12 months of age in Swedish boys and girls.

<table>
<thead>
<tr>
<th></th>
<th>Boys (n=111)</th>
<th></th>
<th>Girls (n=125)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6 mo</td>
<td>12 m</td>
<td>6 mo</td>
<td>12 mo</td>
</tr>
<tr>
<td>TC mmol/l</td>
<td>3.39 (0.66)</td>
<td>3.34 (0.62)</td>
<td>3.45 (0.8)</td>
<td>3.47 (0.70)</td>
</tr>
<tr>
<td>LDL-C mmol/l</td>
<td>1.70 (0.51)</td>
<td>1.83 (0.64)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HDL-C mmol/l</td>
<td>0.94 (0.24)</td>
<td>0.91 (0.27)</td>
<td>0.90 (0.23)</td>
<td>0.90 (0.18)</td>
</tr>
<tr>
<td>ApoA g/l</td>
<td>1.02 (0.17)*</td>
<td>0.94 (0.18)*</td>
<td>0.99 (0.16)**</td>
<td>0.95 (0.15)**</td>
</tr>
<tr>
<td>ApoB g/l</td>
<td>0.68 (0.17)***</td>
<td>0.69 (0.14)***</td>
<td>0.73 (0.22)***</td>
<td>0.73 (0.17)***</td>
</tr>
</tbody>
</table>

Abbreviations: apoA, apolipoprotein A-1; apoB, apolipoprotein B; HDL-C; High-density lipoprotein cholesterol; LDLC, low-density-lipoprotein cholesterol (calculated from Fridewald’s formula); TC, total cholesterol
Values are mean and (SD)
* P < 0.001 in boys between 6 and 12 mo, ** P < 0.001 in girls between 6 and 12 mo,
*** P < 0.05 between genders at 6 and 12 mo

**Iron intake and iron deficiency**

Associations between iron status and dietary intake at 4 years were weak (Paper II). In this study group, which had an adequate intake of iron, calcium, and ascorbic acid, there were no associations between Hb concentrations and dietary intake such as mean daily intake of iron, meat, MCDs, ascorbic acid, calcium, or dairy products at 4 years. In boys, but not girls intake of meat products was a significant contributor to S-Ft.

Similarly, MCV was associated with intake of meat products but only in boys.

Interestingly, we found tracking of iron status and a correlation between the child’s and the mother’s Hb levels. Hb as well as MCV levels tracked during infancy to childhood from 6 months to 12 and 18 months and further on to 4 years. For S-Ft levels, there was tracking during infancy, but this was not sustained to 4 years. The children’s Hb at 12 months,
Results

18 months, and 4 years were significantly associated with their mother’s but not father’s Hb (Figure 6). In the 4-year old children, no one had IDA, but two children (1.8 %) had Hb < 110 g/l and three (2.8 %) had S-Ft < 12 µg/l. There were no differences in Hb or S-Ft between boys and girls, but MVC was higher in girls.

Mean iron intake at 4 years was within recommendations although it ranged between 2.8-22.5 mg per day and in 57% the intake was below 8 mg per day. The mean iron intake at 12 months was 9.2 mg, at 18 months 9.6 mg, and decreased to 8.2 mg at 4 years. The main source of iron was formula or MCD at both 12 months and 4 years (Figure 7). Because 27% of the children did not eat these products at 4 years, we also compared children eating MCD with those who were not. Children with higher intake of MCD had a higher intake of both iron and calcium than others. In spite of the different intake of iron, iron status did not differ between those consuming MCD and those that did not. Neither milk intake nor calcium intake were associated with iron status in this study group.

![Figure 6](image_url)

**Figure 6.** Associations between the child’s Hb at 12 mo and 4 y and the mothers’ Hb. (R² 0.069 and 0.094, P= 0.001 and 0.004, respectively).
Results

There was a positive association between relative linear growth and Hb at 4 years in girls ($r = 0.397 \ p = 0.002$) but not boys and for S-Ft in boys ($r=0.33, \ p= 0.02$) but not girls. Weight gain and BMI were not associated to any measure of iron status (data not shown).

**Diet and dental health**

As reported earlier, most of the infants were consumers of sweet products at 12 months although the amounts were low with an intake of sucrose about 5 E%. The intake of sucrose increased, and at 4 years was responsible for 13 E% of total energy. In total, sweet products (such as candies, chocolate, sugar, soft drinks, ice-cream, biscuits, and fruit syrup) were responsible for 17% of total energy. In **Paper III**, the associations between diet and dental health were analyzed using data on dietary intakes, dental caries, oral hygiene including tooth brushing habits, fluoride habits, presence of plaque, and gingival inflammations, and levels of mutans streptococci and lactobacilli in salvia. Eighty-nine of the children took part in the oral examination and 69 children fulfilled both oral and dietary examinations. Of the 4-year old children, 70% were caries-free while 30% were affected by caries. A larger proportion of the boys than the girls had caries; however, in girls with caries, the caries experience [mean decayed-filled surfaces (dfs)] was greater.
Results

Cheese intake seemed to have a caries-protective effect. The children, who ate cheese daily in the 5 day period, were caries free (Figure 8) and caries correlated negatively with intake frequency of cheese ($r_s=-0.25$, $P=0.004$). One additional serving of cheese in a 5-day period reduced the risk to have one more caries-affected surface by 33%.

Black pudding seems to affect caries experience positively ($r_s=0.27$, $p=0.03$). Caries did not correlate with intake frequency or total intake of any other food group such as sweet products like biscuits, cakes, jam, marmalade, candies, and sugar. Nor did caries correlate with intake of particular nutrients as total carbohydrate or sucrose. Almost all children had a high sugar intake but were regularly exposed to fluoride in toothpaste.

**Figure 8** The frequency of cheese intake and caries prevalence in 4-year old children. Data are means with upper 95% CI. The figures in the bars refer to number of children in each group.
Results

Factors associated with Body Mass Index

In a univariate regression analyse we found significant positive associations between BMI at 4 years and nutrient intakes over time (Table 5). Correlations between the child’s BMI and father’s BMI was found at 12 and 18 months and at 4 years and with mother’s BMI at 4 years. Variables with a p value<0.05 were included in a multivariate analyse. In that linear multivariate regression, current and previous protein intake and father’s BMI remained positively associated with BMI in 4 years old Swedish children (Table 6).

The univariate regression analyse showed positive associations between BMI and nutrient intakes over time. Intake of total energy at 12 months, 17/18 months, and 4 years, protein at 17/18 months and 4 years, carbohydrate at 17/18 months and 4 years were all positively associated with BMI at 4 y. With respect to classes of fatty acids, there was a positive association between BMI at 4 years and the intake of n-6 fatty acids at 4 years, but not with intake of n-3 fatty acids. In the final multivariate liner regression analysis we found that protein intake at 17-18 months and 4 years remained positively associated with higher BMI in children at 4 years. During the analysis, we found macronutrients as well as energy to be associated with each other. Protein was highly associated with energy intake (r= 0.793, p< 0.001). There were also positive associations between n-6 fatty acids and energy intake at 4 years (r=0.556, p<0.001) as well as with total dietary fat, n-3 fatty acids, and protein intakes (r= 0.613, r= 0.508 and r= 0.369 respectively, p< 0.001). The n-3 fatty acid intake was associated with total fat and energy intake (r= 0.271 and r=0.216 respectively, p< 0.05) but not with protein intake. The more the children were eating, the higher their protein intake. There were no correlations between BMI and any specific food source.

Body Mass Index (BMI) is used to measure nutritional status and high BMI is an indicator of overweight and obesity. BMI was calculated in children over time from 6 months to 4 years and in parents when the child was 4 years (Paper IV). At 4 years, 16.4% of the children were classified as being overweight or obese with no gender differences (Figure 9).

Figure 9
Numbers of the 4-year old children classified as obese, overweight, or non-overweight with the use of Coles cut offs for iso-BMI (n=122).
Table 5. Associations between nutrient intake and BMI at 4 y in the participating children. Univariate regression analysis (n=99).

<table>
<thead>
<tr>
<th>Independed variable</th>
<th>R²</th>
<th>B (s.e)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (kcal/day) 12 m</td>
<td>0.028</td>
<td>0.001(0.001)</td>
<td>0.07</td>
</tr>
<tr>
<td>Energy 17/18 m (kcal/day)</td>
<td>0.068</td>
<td>0.002(0.001)</td>
<td>0.006</td>
</tr>
<tr>
<td>Energy 4 y (kcal/day)</td>
<td>0.056</td>
<td>0.002(0.001)</td>
<td>0.02</td>
</tr>
<tr>
<td>Protein (g/day) 12 m</td>
<td>0.023</td>
<td>0.034(0.02)</td>
<td>0.097</td>
</tr>
<tr>
<td>Protein (g/day) 17 -18 m</td>
<td>0.117</td>
<td>0.074(0.02)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Protein 4y (g/day)</td>
<td>0.087</td>
<td>0.045(0.015)</td>
<td>0.004</td>
</tr>
<tr>
<td>Fat intake 4 y (g/day)</td>
<td>0.023</td>
<td>0.023 (0.015)</td>
<td>0.14</td>
</tr>
<tr>
<td>n-6 fatty acids 4 y (g/day)</td>
<td>0.088</td>
<td>0.251(0.083)</td>
<td>0.003</td>
</tr>
<tr>
<td>n-3 fatty acids 4 y (g/day)</td>
<td>0.21</td>
<td>0.175 (0.123)</td>
<td>0.16</td>
</tr>
<tr>
<td>Carbohydrate 17-18m (g/day)</td>
<td>0.088</td>
<td>0.021(0.007)</td>
<td>0.002</td>
</tr>
<tr>
<td>Carbohydrate 4 y (g/day)</td>
<td>0.062</td>
<td>0.012 (0.005)</td>
<td>0.015</td>
</tr>
</tbody>
</table>

Macronutrients with p< 0.2 are shown.

Table 6. Final multiple stepwise linear regression model showing associations between BMI at 4 y, intake of protein at 17/18 mo and 4 y, and father’s BMI.

<table>
<thead>
<tr>
<th>Independed variable</th>
<th>R²</th>
<th>B (s.e)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein intake (g) 17/18 m</td>
<td>0.072</td>
<td>(0.025)</td>
<td>0.005</td>
</tr>
<tr>
<td>Protein intake (g) 4y</td>
<td>0.053</td>
<td>(0.017)</td>
<td>0.002</td>
</tr>
<tr>
<td>Father’s BMI</td>
<td>0.108</td>
<td>(0.054)</td>
<td>0.049</td>
</tr>
</tbody>
</table>

Independed variables entered into the analyses were variables with p< 0.05 in the univariate regression analyse, i.e. intake of protein at, 17/18 mo and 4 y, energy intake at, 17-18 mo and 4 y, carbohydrates at 17/18 mo and 4 y and n-6 fatty acids at 4 y and BMI of mothers and fathers. Adjusted for gender.
BMI was positively correlated with fat mass percent, confirming that high BMI was associated with overweight/obesity. Although we found no significant gender differences in BMI or overweight using Cole’s definition, girls’ fat mass percent was higher than boys’ fat mass percent.

In parents, mean BMI was higher in fathers than mothers [25.3 (3.1) vs. 23.8 (3.5), p<0.001]. Of the fathers, 34% and 8.6% were overweight and obese, respectively and among the mothers, 19.5% were overweight and 7% were obese.

Furthermore, BMI at 4 y tracked significantly over time from 6 mo of age.
DISCUSSION

The most interesting observations in this study were the association between the child’s and the mother’s Hb concentrations and the child’s and the father’s BMI and that there was strong tracking of both Hb concentrations and of BMI. Furthermore we found a strong association between early protein intake and later BMI, but not with total fat, carbohydrates, or energy intake. Another finding was that the quality of dietary fat affected serum lipid levels differently in girls and boys at 12 months. Finally, regular intake of cheese seemed to be protective against caries.

The longitudinally-followed children in our study group were healthy and well-nourished. Although parents and other carers often are concerned that children do not eat enough, our data clearly indicate that the quality of the diet rather than the quantity of food should be of concern.

The quality of dietary fat did not meet the recommendation of the NNR. For almost all infants, the intake of SAFA was too high and in one-third of the infants the PUFA intake was below the recommended 5-10 E%. This situation worsened at 4 years as the proportion of SAFA had increased and PUFA decreased. At 4 years, no child met the national or Nordic recommended with respect to the fat composition of the diet.

We confirm previous studies that noted that sweet products are one of the main sources of energy in 4-year old Swedish children (22, 34, 54). Already at 12 months most of the children had been introduced to sweet products that were responsible for 5-10 % of daily energy intake, partly depending on which products were classified as “sweet products”. Besides intake of dietary fat and sucrose, most nutrients were within the recommendations, but intake of vitamin D and selenium were below. Unfortunately we did not measure vitamin D status. Low vitamin D status does negatively affect health and studies in Swedish children are required (122-124).

Milk

Cultural factors and available food sources influence current feeding practise in infants and children (56). In Sweden, cow’s milk and products based on cow’s milk have long been used as an important food source during childhood (125). The present study was started before the current recommendation to introduce infants to cow’s milk not until the end of the first year [45, 46]; hence milk was introduced without restriction before the age of 12 months (57, 58). Whether milk as such, milk fat, or milk protein (126) as well as calcium from milk has only negative or only positive influence on health is a matter of continuing debate (45, 51, 58, 127-129). Moreover, the exact role of specific fatty acids present in milk fat is not clear (130, 131). Of the 255 infants at 12 months, 248 were drinking milk, and both full fat and low fat dairy products were consumed. Interestingly, those who were drinking...
Discussion

Low fat milk had a higher mean and total intake of milk. Dairy products were the main source of both energy and protein at 4 years even if MCD were as not included. As MCD contain both milk and cereal, they were analysed separately and not included in dairy products in the analysis.

**Serum lipids and diet**

An important finding from this study was that dietary fat intake affected serum lipid levels differently in girls and boys, although neither total dietary fat intake, nor serum lipid levels or duration of being breastfed differed between genders.

As breastfed infants compared to formula-fed infants have higher TC levels until breastfeeding is discontinued (84,132) we were surprised by the low TC levels in our study group compared to Finish and Icelandic infants (see below), and the small change in TC from 6 months to 12 months (Tables 4 and 7). The number of infants’ breastfed at 6 months was close to official national statistics of 76% (The National Board of Health and Welfare, 1999). A likely explanation is that the expected change in TC from 6 to 12 months of age was counterbalanced by a gradual decrease in breastfeeding rate during infancy.

Besides the apoB level that was higher in girls compared to boys, there were no significant differences in serum lipid levels between gender. ApoA has been reported to be higher in boys during the first decade of life (133), but this was not confirmed in our study.

In *Paper I*, we compared our data with similar data from Finland and Iceland and an interesting picture emerged (Figure 10, Table 7). Icelandic infants had a relative (E%) total fat intake comparable to the Swedish infants but the proportion of SAFA was higher and that of both MUFA and PUFA lower. At the time of the Icelandic study, cow milk was used rather than infant or follow-on formula, which explains the comparatively high intake of saturated fat.

In the Finnish study, infants had lower intake of total fat, SAFA and MUFA but equal intake of PUFA (all expressed as E%) compared to the Swedish infants. The Finnish infants had significantly higher levels of TC (P<0.001) and non-HDL-C, but the level of HDL-C was equal to the level in the Swedish study population. This is also supported by the comparison of the ratio apoA/apoB that was significantly higher in Swedish girls compared to Finnish girls but not boys. In total, Swedish infants showed lower TC, non-HDL-C and LDL-C levels than both the Finnish and Icelandic infants while HDL-C were higher in Icelandic infants compared with those in our study group. Thus, we could conclude that the quality of dietary fat rather than quantity is associated with what is considered favourable serum lipid levels. Despite a higher total dietary fat intake in Swedish, as compared to Finnish infants, the Swedish infants had more favourable serum lipid levels.
Figure 10 Intake of total fat, saturated fatty acids (SAFA), monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) in Swedish, Finnish(134), and Icelandic (135) infants 12-13 month of age.
TABLE 7. Serum lipid concentrations in Swedish, Finnish, and Icelandic infants.

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td></td>
<td>Boys (n=120)</td>
<td>Girls (n=128)</td>
<td>Boys (n=201)</td>
</tr>
<tr>
<td>TC† (mmol/l)</td>
<td>3.33 (0.60)§</td>
<td>3.48 (0.70)§</td>
<td>3.74 (0.60) ‡</td>
</tr>
<tr>
<td>LDL-C** (mmol/l)</td>
<td>1.70 (0.51) §</td>
<td>1.83 (0.64) §</td>
<td>-</td>
</tr>
<tr>
<td>Non-HDL-C†† (mmol/l)</td>
<td>2.41 (0.57) ‡</td>
<td>2.58 (0.65) ‡</td>
<td>2.87 (0.57) ‡</td>
</tr>
<tr>
<td>HDL-C‡‡ (mmol/l)</td>
<td>0.92 (0.27)</td>
<td>0.90 (0.18) ***</td>
<td>0.87 (0.2)</td>
</tr>
<tr>
<td>apoA§§ (g/l)</td>
<td>0.94 (0.18) ‡</td>
<td>0.95 (0.12) ‡</td>
<td>1.05 (0.16) ‡</td>
</tr>
<tr>
<td>apoB¶¶ (g/l)</td>
<td>0.69 (0.14) ‡</td>
<td>0.73 (0.17) ‡</td>
<td>0.75 (0.16) ‡</td>
</tr>
<tr>
<td>Ratio apoA/apoB</td>
<td>1.44 (0.39)</td>
<td>1.36 (0.32) †††</td>
<td>1.47 (0.47)</td>
</tr>
</tbody>
</table>

1Data collected from the SINUS study and published comparable data from studies in *Finland (Lagström H. 1997) and †Iceland (Thorsdottir I. 2003). Values are presented as mean and SD. ‡Corrected SD after communication with the authors. §Total cholesterol, **Low-density-lipoprotein cholesterol calculated from Friedewalds formula in Swedish and Icelandic infants, ††Non-high-density lipoprotein cholesterol, re-calculated in Swedish and Icelandic infants from numbers in the table, ‡‡High-density lipoprotein cholesterol, 
§§Apolipoprotein A, ¶¶Apolipoprotein B, †p <0.001 between Sweden and Iceland, ***p <0.05 between Swedish and Icelandic girls, ††† <0.05 between Swedish and Finnish girls.
Discussion

We found no correlations between intakes of total milk or of milk fat and serum lipid levels. Surprisingly, we could not see any impact of SAFA intake on serum lipid values, although there is a general agreement that high SAFA intakes are positively linked to high TC and LDL-C levels in children (24,25). A possible explanation for the lack of associations could be the relatively high SAFA intake in all studied infants. Another possibility is that serum cholesterol levels are not affected by total SAFA intake but specifically by palmitic and myristic acids (129).

To enable a decrease of SAFA intake below the recommended upper level of 10 E%, it seems necessary to reduce the contribution of fat from dairy products in infants and children. In older children, other main sources of total dietary fat and SAFA were snacks and sweet products (22, 34). In line with recent studies from Finland (62), sucrose intake was positively correlated with SAFA. In addition, to increase the intake of PUFA in accord with the recommendations for infants and children, the intake of fish, soft margarines, and oils needs to be increased. Even if the intake of SAFA from milk products needs to decrease in children, milk and milk products are valuable constituents of the diet with high nutritional density. The nutrient intake of most children would improve if full fat milk is exchanged with low-fat milk and the fat replaced by soft spreads and oils. Another possibility could be to change the fatty acid composition in cow’s milk (130, 136, 137). Studies have shown that the fat composition of cows’ milk in the Nordic countries differs due to differences in cows’ fodder.

As a result of these comparisons, we concluded that it seems appropriate to focus on quality of fat rather than quantity, although overfeeding should be avoided. The Finnish study group is still followed, but the goal for the ratio of unsaturated to saturated fatty acids has not been reached as current intake of SAFA accounts for more than 10 E% in spite of the individualized dietary counselling (138, 139). This implicates a difficulty of changing the fatty acid composition of the diet mainly by lowering total fat intake in ordinary diets.

In addition, we need more data to clarify the optimal intake of dietary fat during infancy and early childhood.

Iron status and diet

The main findings from the study on iron status (Paper II) were the tracking of Hb from infancy to 4 years of age, and the correlation between the mother’s and her child’s Hb concentrations.

As mentioned, the children studied at 4 years were followed-up from a baseline double-blind intervention study from 6-12 months of age on effect of the phytate content in complementary food on iron status dur-
Discussion

ing infancy. Irrespective to phytate content in the diet, the prevalence of IDA was low, 1.2% and 0.4 % at 12 and 18 months respectively (47). Although the infants were not iron deficient, total iron intake correlated positively with the Hb concentration between 6-12 months but with s-Ft between 12 months and 18 months. This was interpreted as an ongoing development of iron metabolism during that age period (48).

At 4 years no child was classified as having IDA. The Hb concentrations tracked from 6 mo to 4 y. Tracking of Hb from infancy to childhood has been reported by others (91, 95, 140) as well as an association between the child’s and the mother’s Hb(91, 93).

For 4-year old children there were no associations between Hb and dietary intake such as the mean daily intake of iron, meat, MCD, vitamin C, calcium, or dairy products. As reported earlier, mean iron intake at 4 years met the recommendations although the intake varied considerably between 2.8 and 22.5 mg per day.

Children consuming MCD had a higher intake of both iron and calcium than those who did not, but iron status did not differ. This might be due to the high bioavailability in meat, which also is as an enhancer of iron absorption and was consumed by all children and an average high intake of vitamin C which is another enhancer. In boys, but not girls, intake of meat products was associated with higher S-Ft and MCV concentrations.

Although other studies (96, 141-144) have reported negative associations between intake of cow’s milk and iron status, we found no such relation, including associations between s-Ft or Hb concentrations and intake of all dairy products or calcium. Globally, in areas with low total iron intake and high prevalence of ID, milk intake is inversely associated with iron status (145).

Iron-fortified infant formula during the complementary feeding period and later MCDs as well as meat products and high intake of vitamin C are likely reasons for lack of ID in this study group. The prevalence of IDA in infants and pre-school children varies even in well-nourished populations (51, 91, 94, 96, 143, 144, 146). In a British group of 18 month old children, mean iron intake was 4.9 mg in girls and 5.2 mg in boys and 1.7% had IDA (144). Concurring with Lind et al. (48), they reported a positive association between total iron intake and S-Ft levels but not with Hb.

In contrast, the positive associations between vitamin C and Hb concentrations found by Cowin et al. (144) were not confirmed in the present study, probably due to the high overall intake and low prevalence of ID and anaemia. In Cowin’s study group the prevalence of low Hb levels was higher in children who consumed no meat (144). Thus the prevalence of ID
is possible to reduce (147) and even prevent by iron fortification of infant products and by introducing meat early during the weaning period in healthy infants (41, 145). Oral iron drops given to iron replete infants are suggested to negatively affect growth and highlight a possible risk with too high iron consumption (148). Such negative effects have not been seen when iron is given in fortified infant products.

The reason behind the association between the child’s and the mother’s Hb is unclear. Only one previous study suggests that hereditary factors affect Hb concentrations in populations with low prevalence of ID (93). However, the lack of association between the child’s dietary intake and Hb concentration suggests that family factors besides shared diet are important for the children’s Hb. One such factor is heredity which would be compatible with the tracking of Hb from infancy.

Dental health and diet

Dental caries experience in the present study group (Paper III) was similar to County Council data, but not quite meeting the WHO goal of 80% caries free-children at 6 years. The study indicated that cheese consumption is protective against caries. Daily intake of cheese during a five-day period reduced the risk to have one more caries-affected surface by 33% in pre-school children compared to no cheese. This effect agrees with previous studies in children, adult dry-mouth patients, and elderly subjects (149-151). The frequency of black pudding consumption was associated with increased caries experience. However, only 19% of the children were consumers and of them, two had black pudding twice during the five days record. Swedish black pudding is cariogenic since it contains about 8% sucrose and almost always eaten with jam. Because black pudding clings to the teeth, it is important to brush the teeth after the meal. Sugar is well known as a risk factor of dental caries (152). However, although sugar consumption was high among the children, no association with caries could be found. This might be due to the generous use of fluoridated toothpaste as well as from the small differences in sugar consumption between the children. In non-fluoridated areas, with declining caries prevalence, higher daily consumption of sugars and higher between meals consumption is still a risk factor for caries (153, 154). Reducing the sugar intake should promote dental health as well.
as other health aspects. In many industrial countries, dental health has improved but without a concomitant decrease in sugar consumption. In a recent longitudinal study from Finland, persistently high sucrose intake increased the risk of dental caries in children at 10 years (62). A conclusion from that study was that the habit of consuming excessive amount of sucrose daily starts early in childhood. Thus early childhood oral health needs to be protected. In Sweden, dental care for children is free of charge and preventive strategies have been used for more than 30 years. In spite of that, dental caries is still a public health problem, affecting more than 20% of young children.

In addition to caries, there are other reasons to reduce the intake of sucrose and sweet products. One such reason is the increasing prevalence of overweight and obesity.

**BMI and diet**

In the present study, we found higher protein intake over time to be associated with higher BMI at 4 years. BMI also tracked over time from 6 months and BMI in infancy was in fact a predictor of BMI at 4 years. There was also an association between the child and the parental BMI; in particular, that of the father.

We were surprised to find a stronger association between the child’s BMI and the father’s BMI than the mother’s BMI. Associations between maternal BMI, or obesity, and her child’s BMI have been described although most studies were conducted before the “obesity epidemic” started (155). Regarding the associations with the father’s BMI, few studies have compared the maternal-offspring and paternal-offspring associations of BMI separately. Obesity in both parents increases the risk of obesity 10-fold for obesity in the child (142), compared to two-fold if only the mother is obese (156). Our data is supported by a previous Swedish study where the impact of obesity in fathers was higher than that in mothers on the prevalence of childhood overweight (157). BMI of normal weight girls was found to be associated to that BMI of both parents (158). And paternal BMI, independently of maternal, was reported to be associated with the child’s birth weight (159). Our findings seem to agree with at least some previous observations (160). One possible explanation of the positive association between the child’s BMI and the father’s BMI is suggested to be mother’s dieting behaviour (161). Dieting is more common in young women than men as is fruit and vegetable consumption (162, 163). On the other hand, young men are eating more meat and drinking more milk, products linked to protein intake (164, 165). In our group, we have no data on parents’ diet and can only speculate. Swedish fathers are perhaps more involved in the care of their children than fathers in many other countries due to the social security system ensuring paid parental leave to both parents. Of the 480
Discussion

days parental benefit, 60 days can only be used by the father and 60 only by the mother. The remaining 360 days can be used as the parents see fit. It is also of note that in our study group, mean BMI and both overweight and obesity rates were higher in fathers as compared to mothers, which may have increased the power in the analysis.

Although we found higher intake of protein to be associated with higher BMI at 4 years, we could not confirm the suggested association between higher milk intake and higher BMI (126). Higher milk intake at 9-12 months and 12-18 months was positively associated with height and weight at 4 years. Similar results were reported from Denmark where protein intake at 9 months correlated with body size but not body fat at 10 years (166). High early protein intake enhances weight gain in infancy and is suggested to be a risk for obesity later in life (167). BMI increases more in tall children than in short and the authors suggest that this probably is mediated via appetite (168). Protein stimulates secretion of insulin like growth-factor (IGF-1), which might explain the associations between growth and protein intake (169). Often milk protein is suggested to be the stimulating factor, but this remains to be proven. Moreover it seems that the quantity and quality of protein intake matters (170-172). In our study group, dairy products were the main source of protein and because of that probably involved in the positive associations between protein intake and BMI.

Intake of carbohydrate and protein, as well as of total energy, but not total fat was associated with BMI in the univariate analysis. A major source of energy is dietary fat, but in the present study we found no relationship between BMI and dietary fat intake expressed as total fat, saturated fatty acids, monounsaturated fatty acids, polyunsaturated fatty acids, or as n-3 fatty acid intake. The only significant univariate association between BMI and fat intake in our study was with n-6 fatty acids, but this association did not remain significant in the final multivariate regression analysis, where only the protein intake and the father’s BMI remained associated with the child’s BMI.

In a previously well-described study, energy-dense, low-fibre, and high fat diet was associated with increased fatness in childhood (173). Energy density is increased by fat and it has been demonstrated that high-fat diets may lead to an accidental overconsumption of energy and thereby overweight (20, 21). BMI seems to increase more in the tallest children than in the shortest (168), and in infants with high growth rate a consistently high fat intake during the second year is positively associated with higher body fat percent between 2 and 5 years of age (174).

Disregarding that reduced intake of dietary fat, particularly of saturated
Discussion

fat, is generally recommended in healthy diets to reduce the risk for overweight and cardiovascular disease. These recommendations were disputed in a recent study on 4-year olds where a low fat intake seemed to be associated with an increased risk of overweight (35). The reason for these different results is confusing, but may be due to differences in the statistical analyses. We used BMI as a continuous variable that may increase the statistical power compared to group analyses when evaluating data sets with small sample sizes (175). Other possible reasons could be differences in how the intake of macronutrients is described and which quantifying measure—gram per kilo body weight (g/kg b.w.), as percent of total energy (E%), or as total intake (g)—is used in the analysis. When calculations on intakes are expressed as g/kg b.w., the intake becomes relatively lower with increasing body weight, making it difficult to use in comparisons of groups with different body composition. Using E%, the intake of fat E% depends on the intakes of protein and carbohydrate; e.g., increased carbohydrate intake reduces the fat E% even if the total intake of fat in gram is constant. Thus collinearity is an important factor to consider in nutritional studies (176, 177). For that reason, we used total intake (g) of macronutrients in the final analyses in the present study, as compared to Garemo who used E% of fat.

Surprisingly, we could not confirm any associations between intake of sucrose and high BMI. This is probably explained by the relatively high average intake of sucrose and small differences within the study group. As mentioned, there was an interaction between the intakes of various nutrients. However, contrary to others (31, 32), we found that the children with higher dietary fat intake also had a higher sucrose intake. In these analyses, we used nutrients and some foods as single variables. In further analysis, it will be interesting to build clusters or models of dietary patterns and to consider correlations between various nutrients and foods.

In the present study, a large proportion of foods and nutrients came from the commercial baby foods, not only in infancy but also at 4 years. Moreover many children are eating several daily meals at day care centres during weekdays and these are therefore important for the preschool children’s dietary intake. For children spending full time at a day care centre, about 75% of recommended energy and nutrient intake are provided. Both in the day care centre and at home, meals are often based on convenience food. There is an increasing trend to use more of convenience food products. In German children and adolescents, such foods were high in fat content and high in number of food additives (178). This highlights the importance of food industry to produce high quality foods. Furthermore, many people (parents, chefs, teachers, and other staff) contribute to a child’s
Discussion

Food habits. Information for parents at well-baby clinics is mostly provided by nurses with paediatric education (179-181). A possibility to improve nutrition knowledge at well-baby clinics is to involve more paediatric dieticians. This now happens in Sweden. Another possibility is of course to enhance nutrition education of the nurses, cooks, chefs, teachers, and other staff of important to maintain high standards in children’s nutrition care.

Strengths and weakness of the study

The strength in this study is the longitudinally design with children followed from 6 months to 4 years and the careful collection of dietary data, anthropometrics, and blood samples. During the study, there was a close and regular contact between the research team and parents, records were continuously checked, and questions asked. During the study, the parents became experienced recorders. Another important factor is that data of parents were included in the follow-up at 4 years.

To validate reported dietary intakes, different methods can be used (13, 131). We calculated the ratio of energy intake (EI) to basal metabolic rate (BMR); EI:BMR at 12 months, 17-18 months, and 4 years and at all ages it was >1.55, which supports the validity of our data (182). In studies on small children, a cut-off ≤ 1.55 might be considered as miss-reporting. However, in small children underreporting is considered to be less common than in adults (183). We also believe we have high validity of our data because the families who volunteered in this study had a positive attitude to diet and health research in infants and children. In infants and small children, fewer recording days are needed compared with adults to assess acceptable degree of energy and nutrients (184). Reported energy intake in our study is comparable with other studies at 12 months (14, 95, 185) as well as at 18 months (185). In addition, our food intake data at 4 years are similar to previous Swedish studies (22, 34).

The weakness is that the study is not population based and the high number of children and parents who did not participate in the follow up at 4 years. The baseline study was planned to continue from 6 to 18 months and the follow-up was planned at a later stage. The parents were asked to participate in the follow-up when the child was >3 years. Reported reasons for not participating in the follow-up were lack of time and willingness to do the dietary records. This could be a selection bias. However, children with complete data at 4 years were not different from the not participating children with respect to data at 12 months on dietary intake body weight and length and serum lipid levels. Education level i.e. parents university studies were more frequent among children in the follow-up study com-
pared with the non-participants (32.6% vs. 25.4% p < 0.001).

**Future aspects**

This thesis shows important associations between dietary intake and health in Swedish infants and young children. The findings raise new questions such as the impact of dietary fat quality in infancy on health later in life. Furthermore, another unsolved question is if and how diet, from a practical perspective, will fit recommendations.

A better understanding of the reasons behind the associations found between the child’s and the parent’s BMI at 4 years is important because it might be used to improve preventive strategies.

Iron intake in young Swedish children is adequate and increased intake is not supposed to affect iron status. As we found the child’s Hb to be associated with that of its mother’s, it seems possible to use information of mother’s Hb as a predictor of the child’s Hb. This could be useful for detection of children at risk and early intervention.

Another question based on our findings is if there is any health implication of the low intake of vitamin D in young children and if there is any need of further interventions.

The Nordic (NNR) and national (SNR), nutrition recommendation are valid for healthy groups. Improving nutrition and health for individuals, we need more knowledge of interactions between diet and genetics, gender and age groups.
CONCLUSIONS

In this healthy and well-nourished group of infants and children, we found the quality of food and nutrient composition to be important indicators for the child’s health.

- Higher PUFA and lower SAFA intakes may reduce total cholesterol and low-density lipoprotein cholesterol early in life, particularly in girls. In respect of lowering serum lipid levels in early childhood, it seems appropriate to set focus on the quality rather than quantity of dietary fat intake although overfeeding should be avoided and energy balance kept. The long term consequences are largely unknown.

- The strongest predictors of Hb concentrations at 4 years were Hb concentration in infancy and the mother’s Hb. Milk-based fortified cereals and meat products are important sources of iron in infancy and early childhood. Meat was positively associated with S-Ft and MCV in boys but not in girls.

- Intake of sugar and sweet products were high and many of the sweet products consumed by children also contain dietary fat with high levels of saturated fatty acids.

- Higher protein intake over time was associated with higher BMI at 4 years. BMI tracked from 6 months to 4 years and BMI at 6 months was in fact a predictor of BMI at 4 years. There was also an association between child and parental BMI, in particular that of the father.
POPULÄRVETENSKAPLIG SAMMANFATTNING

Historiskt och globalt har målet inom barnnutrition varit att ge barn tillräckligt med mat av god kvalitet för att säkerställa adekvat tillväxt och undvika näringsbrister. Rätt mat är en förutsättning för god hälsa både i barndomen och senare i livet. Från att ha varit ett land där näringsbrister var vanliga så har vi idag andra folkhälsoproblem. Det finns flera folkhälsosjukdomar som kan påverkas av kostintaget redan under barndomen. Dit hör övervikt, för höga blodfetter, högt blodtryck, diabetes typ 2 och karies.


Barnens järnstatus var bra och det fanns ett samband med Hb-värdet över tid; från 6 månader upp till 4 år. Dessutom fanns ett starkt samband mellan mammonas Hb och deras barns Hb.

Vid 4 års ålder var 70 % av barnen kariesfria. Att äta ost minskade risken att få karies.

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Vi såg att BMI vid 6 månaders ålder hade ett samband med BMI vid 4 år. Ett intressant fynd var sambanden mellan pappornas BMI och barnens BMI. Den starkaste kopplingen till kostintaget var att barn med högre proteinintag hade ett högre BMI vid 4 år. Däremot kunde vi inte styrka påståendet att ett lågt fettsyntag eller lågt intag av omgea-3 fettsyror skulle öka risken för övervikt hos barn.
ACKNOWLEDGMENTS

This project is a team work with many people involved in which I had the benefit of being a part and learn a lot. During this wonderful journey I have met many inspiring people and new windows are opened in my mind. First of all I would like to thank all the parents and children for your contribution to this project. Without your participation by leaving blood samples, writing food records and measurements of weight, height and skin folds; all this would not have happened to me.

In particular I will extend my thanks to all my supervisors who have spent so much time in this project guiding me into and through this scientific area of paediatric research.

Agneta Hörnell, my main supervisor for your calm patience and everlasting support in scientific questions and writing and for sharing your excellent experience in infant feeding with me. Besides that, your memory is clear and bright, like a sunny winter day.

Olle Hernell, my co-supervisor, for bringing me into this area of nutrition research. Your great experience and knowledge seems to be a without end and your ability to see beyond details, focus on the entirety and draw clear conclusions are outstanding. Besides all that, your gentle and careful methods have kept me in direction.

Torbjörn Lind, my co-supervisor, for always sharing your vast knowledge. Your characteristic way of pointing in the right direction has helped me keep focus. You know like nobody else how to turn a short question into result. When-
ever there was a problem you gave an answer, mostly followed by some philosophical words of wisdom.

Ingegerd Johansson, for cooperating, introducing and supporting me in the new world of dental caries aspects. You made me feel like a kid in a candy store.

Hans Stenlund, for sharing your statistical knowledge and experience and for your invaluable statistical advices.

Catharina Tennefors who invited me into the project by offering me to work in the baseline study and contributing in the planning of the study.

Margareta Henriksson and Margareta Beckman, the research nurses who collected data and worked close together with me. Your professional and organization skills are priceless.

Phil Lyon, professor at the department of food and nutrition, for your gently manners and support for my English writing skills.

My colleges and friends, Lisbeth Nordström, Lena Hansson and Ann-Kristin Sandström, who were working hard at the clinic during my absences. You have such a supporting manner and are always quick to lend a helping hand.

Ingalill Sandström, a former college, for being such an exemplary pediatric dietician and a dear friend.

The dieticians, Maria Sehlsted, Maj-Britt Nyberg, Agneta Frängsmyr, Anna Karlsson for your work with preparing the food records and database.

Ulla Cederholm, my former college, for all your happy, supporting and stimulating questions and messages and for being such a friend.

All friends and colleges at the pediatric clinic and the department of pediatrics.
Acknowledgements

All my colleges at the department of food and nutrition, for sharing my interest in pediatric nutrition and supporting the field of science.

Anders, my husband for all support words and your positive attitude, full of never-ending optimism.

Anton, Karin and Sara, our children, you are making life fun and bringing me happiness. Besides all that, you also have added me some experiences in English.

All supporting friends for being friends during my travel in the scientific area.
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