Dietary Intakes of Swedish Children and Adolescents

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Popular scientific summary

What do Swedish children and adolescents eat? How can we very simply describe their overall diet? What should they eat less or more of? If their diet is unhealthy, are they more likely to have other unhealthy habits? And if they eat a certain way when they are young, will they still eat that way when they are older? These are the questions I have attempted to answer in this doctoral thesis.

The data comes from the European Youth Heart Study, which studies cardiovascular (heart and blood vessel) disease risk factors, of which diet is a very important one. In 1998-9, 1120 Swedish children (aged 9) and adolescents (aged 15) participated in the study. We asked them i) to describe what they had eaten on the previous day, ii) to wear a motion detector to measure their physical activity for a week, and iii) to complete a questionnaire about their lifestyle. In 2004-5, 452 of them returned to a follow-up study and provided the same type of information.

We can describe someone’s diet in terms of foods, or nutrients, or dietary requirements, but it is hard to assess all of these simultaneously. I tried to find a simple indicator that could be used to describe the overall dietary quality, and I found that energy density (energy per gram of food) can be useful as such an indicator (Study I).

As saturated fat and sugar intakes were quite high, I simulated some changes, based on current food-based dietary guidelines. I found that to lower saturated fat and sugar to recommended levels, intakes of soft drinks, confectionary and baked goods need to be reduced considerably, and lower fat alternatives of milk and cheese should be chosen (Study II).

Besides poor diet, being physically inactive, and using tobacco and alcohol are other risk factors for bad health. I looked at whether these risk factors “cluster” together in children and adolescents. Unhealthy dietary habits cluster together, but not with other risk factors in a very clear pattern (Study III).

It is often assumed that children’s dietary habits become established when they are young. I examined whether children and adolescents who ate a certain way at ages 9 and 15 had a similar diet six years later. It seems that diets between 9 and 15, and between 15 and 21, show some stability, but it is generally slight (Study IV).

I hope that the results of this thesis can contribute to improving the way we assess diet; to highlighting aspects of child and adolescent diets that should be improved; to understanding how diet and other behaviours occur together and how dietary behaviour changes with time, in children and adolescents.
List of Publications

This thesis is based on work presented in the following articles:

I. Dietary energy density as a marker of dietary quality in Swedish children and adolescents: the European Youth Heart Study.
   Patterson E, Wärnberg J, Poortvliet E, Kearney J, Sjöström M.

II. Sources of saturated fat and sucrose in the diets of Swedish children and adolescents in the European Youth Heart Study: strategies for improving intakes.
   Patterson E, Wärnberg J, Kearney J, Sjöström M.
   Submitted

III. Clustering of lifestyle risk factors in Swedish children and adolescents: the European Youth Heart Study.
   Patterson E, Kwak L, Wärnberg J, Kearney J, Sjöström M.
   Submitted

IV. Tracking of dietary intakes over six years: the European Youth Heart Study.
   Patterson E, Wärnberg J, Kearney J, Sjöström M.

The articles will be referred to in the text as Study I - IV, and are reproduced in full as appendices.
Abstract

Background Knowing what children and adolescents eat, how stable their diets are, and how diet relates to other chronic disease risk factors are important issues for public health nutrition.

Setting and design In 1998-9, 1120 children (grade 3) and adolescents (grade 9) took part in the European Youth Heart Study in Sweden. In 2004-5, 452 adolescents (grade 9) and young adults (aged 21) returned to a follow-up study.

Methods At both time points, diet was assessed by a single, interviewer-mediated 24-hr recall. Height, weight and physical activity were objectively measured. Smoking, alcohol use and other dietary behaviours were assessed by computer-administered questionnaire. The energy density of the diet (kJ/g) was assessed as an index of dietary quality (Study I). Major sources of energy, (saturated) fat and sucrose were described, together with the simulated impact of adherence to current food-based dietary guidelines (Study II). The clustering of risk factors (unhealthy dietary habits, physical inactivity, TV viewing, smoking and alcohol use) were explored (Study III). The stability of diets from childhood to adolescence, and from adolescence to young adulthood was calculated (Study IV).

Results Low dietary energy density was significantly associated positively with recommended foods, and negatively with energy-dense foods and soft drinks. Intakes of saturated fat and sucrose were higher than recommended, and strict adherence to current food-based dietary guidelines appears necessary in order to lower intakes substantially. Apart from a clustering of dietary behaviours, no clear pattern was seen between the risk factors. Tracking of foods was generally slight, in both the younger and older cohort; tracking of nutrients was somewhat stronger.

Conclusions This thesis presents an alternative dietary quality index, identifies some problem areas in the diets of children and adolescents, describes the clustering of unhealthy behaviours, and suggests that diets are slightly stable over time. Strengths and limitations discussed in this thesis could be taken into account in the design of future research and development of guidelines. It is hoped that the methods and results presented here furthers our understanding of some of the nutritional issues affecting children and adolescents.

Keywords 24-hr recall, nutritional epidemiology, dietary patterns, cardiovascular disease, food-based dietary guidelines, risk factor clustering, tracking
Glossary of terms and selected definitions

24-hr recall  a recall of all food and drink consumed in the previous 24 hours
ANOVA   analysis of variance; statistical test for comparing groups
BMI   body mass index (kg/m$^2$); relates body weight to height and can be compared to cut-offs to indicate if the ratio is too high or low for optimal health
BMR   basal metabolic rate; used to calculate minimum energy needs to support basic life processes such as breathing, kidney function and blood circulation
CHD  coronary heart disease, a type of CVD
CVD  cardiovascular disease
DALY  disability-adjusted life year; one DALY can be thought of as one lost year of “healthy” life
EYHS  European Youth Heart Study
EYHS I  first wave of data collection in EYHS (1998-9)
EYHS II  second wave of data collection in EYHS (2004-5)
FBDG  food-based dietary guidelines
g   gram
κ   kappa; a statistical test for measuring the association between categories
kcal   kilocalorie; unit of energy most commonly used when referring to food
kg   kilogram
kJ   kilojoule; the international standard unit of energy. 1 kcal $\approx$ 4.2 kJ
macronutrient   an energy-providing nutrient; protein, fat, carbohydrate or alcohol
micronutrient   nutrients needed in very small amounts; vitamins and minerals
MJ   megajoule; 1000 kJ
mm   millimetre
n-3 a type of fatty acid (fat); also known as omega-3, found most abundantly in oily fish
P   P value; used to infer if a result is (statistically) significant, by comparing it to a predefined value, e.g. 0.05. This means the risk of erroneously detecting a significant result where none really exists (a “Type I” error) is less than e.g. 5 %
PAL   physical activity level; BMR multiplied by a PAL value can be used to estimate total energy expenditure
PEACH   Personal and Environmental Associations with Children’s Health; a questionnaire used in EYHS
soft drinks refers here to non-alcoholic, sugar-sweetened beverages
WHO   World Health Organisation (a United Nations body)
# Contents

Abstract ................................................................. iii  
Glossary of terms ......................................................... iv  

I Background & Aim ......................................................... 1  

1 Background ............................................................... 3  
1.1 Introduction ............................................................. 3  
1.2 Diet and chronic diseases ............................................. 4  
  1.2.1 Cardiovascular disease ........................................... 4  
  1.2.2 How to tackle the problem? ...................................... 7  
  1.2.3 How big a problem is it? .......................................... 9  
1.3 Children and adolescents ............................................ 9  
1.4 Dietary assessment ................................................... 11  
  1.4.1 Methods of assessment .......................................... 11  
  1.4.2 Methods of identifying misreporters ............................ 13  
1.5 Dietary patterns ...................................................... 15  
  1.5.1 Energy density and dietary patterns (Study I) ................. 17  
1.6 Dietary recommendations ........................................... 17  
  1.6.1 Food-based dietary guidelines (Study II) ....................... 18  
1.7 Diet as a behaviour .................................................. 19  
  1.7.1 Clustering of dietary and other behaviours (Study III) ....... 20  
  1.7.2 Tracking of dietary intakes over time (Study IV) ............. 20  
1.8 Conclusion ............................................................ 20  

2 Aim and objectives ...................................................... 21
II Methods

3 Methods

3.1 Setting and study design

3.2 Data collection

3.3 Data treatment and statistical analysis

3.3.1 Food groups

3.3.2 Other variables

3.3.3 Misreporting

3.3.4 Energy density (Study I)

3.3.5 Food-based dietary guideline simulations (Study II)

3.3.6 Clustering (Study III)

3.3.7 Tracking (Study IV)

III Results, Discussion & Conclusions

4 Results and discussion

4.1 The EYHS study sample

4.2 Dietary intakes

4.3 Energy density is a marker of dietary quality (Study I)

4.4 Saturated fat and sucrose intakes are too high (Study II)

4.5 Dietary and other behaviours cluster together (Study III)

4.6 Dietary intakes track slightly over time (Study IV)

4.7 Methodological considerations

4.7.1 Food groups

4.7.2 Day of the week or season effect

4.7.3 Changes in food supply
5 Concluding remarks 57
  5.1 Future research questions ........................................... 58

Bibliography 59

IV Appendices 71
  Study I ...........................................................................
  Study II ...........................................................................
  Study III ...........................................................................
  Study IV ...........................................................................
List of Tables

1.1 Global health risks .................................................. 5
1.2 Swedish food-based dietary guidelines .......................... 19

3.1 Variables studied ................................................... 27
3.2 Food groups ......................................................... 29
3.3 Behavioural risk factors ............................................ 35

4.1 Brief description of the study samples .......................... 40
4.2 Intakes and energy density of food groups ..................... 42
4.3 Macronutrient intakes .............................................. 44
4.4 Sources of energy, total fat, saturated fat and sucrose .......... 49
List of Figures

3.1 EYHS study design and sample size .................................. 25
4.1 Consumers of food groups ............................................. 43
4.2 Energy density and dietary quality .................................. 46
4.3 Simulations of food-based dietary guideline adherence ............. 51
4.4 Size and number of risk factor clusters .............................. 52
4.5 Risk factors as they occurred in the clusters ......................... 53
4.6 Tracking of food groups and nutrients ............................... 55
Part I

Background & Aim

“Food is our common ground, a universal experience.”

- James Beard
CHAPTER 1

Background

1.1 Introduction

Diet is a primary determinant of health and wellbeing. Eating is one of our very first experiences of this world, and diet and food are intrinsically associated with culture, lifestyle and pleasure. What and how we eat has the potential to affect our health right throughout our life.

At a basic level, it functions as both “fuel” and “repair material” for the body (Wood and Gowland Hopkins, 1915). Our knowledge about the effects of nutrients, foods and diets is continuously expanding, and to initially simple functions we can now add more intricate ones, such as metabolic effects and gene expression. The links between diet and health are paradoxically both increasingly clear and increasingly complex, and many questions remain to be answered. If it is important to try to understand the effect that diet has on health, it is even more important to understand this effect on the more vulnerable in society, including young people. This subpopulation deserves special attention for several reasons: they are dependent on the actions of care-givers; they are still growing and developing; they are less resistant to the forces of advertising and marketing; and they are developing habits potentially for life.

There is reason to be concerned about children’s and adolescents’ diets in Sweden, as in so many other countries. In order to improve our understanding of diet in young people, we must first be able to measure dietary intakes accurately. We must be able to describe and assess its quality in its entirety. We must also understand how it behaves, both in conjunction with other health-related behaviours, and over time. These are the themes that the work included in this thesis addresses.
1.2 Diet and chronic diseases

There can be little doubt now that the evidence from epidemiological and observational studies is comprehensively aligned enough to be convincing: the dietary factors associated with most chronic diseases are common and consistent (World Cancer Research Fund/American Institute for Cancer Research, 2007; World Health Organisation, 2003). The diets of economically developed, industrialised, “Western” countries are, on balance, not compatible with optimal health, and worse, the diets of developing countries are heading in the same direction (Popkin, 2006).

The problems persist stubbornly: fruit and vegetable intakes that are too low; salt, saturated fat and sugar intakes that are too high (World Health Organisation, 2003, 2006; World Cancer Research Fund/American Institute for Cancer Research, 2007). Other risk factors for chronic disease are obviously also important, such as low physical activity, tobacco and alcohol use. The World Health Organisation (WHO) estimates that just ten risk factors account for up to 71% of deaths and 47% of disability-adjusted life-years (DALYs) in high income countries (World Health Organisation, 2009). Of these, the risks ranked 2nd, 3rd, 5th, 6th, 7th and 9th are related, either directly or indirectly, to diet (Table 1.1).

Chronic diseases are a broad group of conditions that includes cardiovascular disease, most cancers, and metabolic diseases such as obesity, the metabolic syndrome, and diabetes mellitus, among others. While chronic diseases are something associated most with adults, and often do not manifest until middle age or later, the lifestyle and behavioural factors that can increase the risk of developing disease can be established many years earlier. The long lag-time between exposure and disease makes the identification of specific dietary or other environmental factors difficult. To a child or adolescent, it may be nigh on impossible to relate the food choices of today to his or her health in 30 years time, but the reality is that the cumulative effects of multiple behaviours almost certainly have consequences for health (Darnton-Hill et al., 2004).

1.2.1 Cardiovascular disease

The work presented in this thesis arises from the European Youth Heart Study (EYHS), the aim of which was to describe the prevalence and development of cardiovascular disease risk factors in otherwise healthy children and adolescents (Poortvliet et al., 2003). Cardiovascular disease (CVD) is a type of chronic disease, and includes the conditions high blood pressure, coronary heart disease (CHD) and cerebrovascular disease (stroke). Worldwide it accounts for nearly 30% of deaths (World Health Organisation,
1.2 Diet and chronic diseases

Table 1.1 Health risks for high-income countries

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Deaths</th>
<th>DALYS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rank</td>
<td>m</td>
</tr>
<tr>
<td>Tobacco use</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>High blood pressure</td>
<td>2</td>
<td>1.4</td>
</tr>
<tr>
<td>Overweight and obesity</td>
<td>3</td>
<td>0.7</td>
</tr>
<tr>
<td>Physical inactivity</td>
<td>4</td>
<td>0.6</td>
</tr>
<tr>
<td>High blood glucose</td>
<td>5</td>
<td>0.6</td>
</tr>
<tr>
<td>High cholesterol</td>
<td>6</td>
<td>0.5</td>
</tr>
<tr>
<td>Low fruit and vegetable intake</td>
<td>7</td>
<td>0.2</td>
</tr>
<tr>
<td>Urban outdoor air pollution</td>
<td>8</td>
<td>0.2</td>
</tr>
<tr>
<td>Alcohol use</td>
<td>9</td>
<td>0.1</td>
</tr>
<tr>
<td>Occupational risks</td>
<td>10</td>
<td>0.1</td>
</tr>
<tr>
<td>Illicit drugs</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Taken from the WHO report on Global Health Risks (World Health Organisation, 2009). High-income countries defined according to World Bank criteria

m: millions

DALYS: disability-adjusted life-years

In the EU (27 countries), CVD accounts for 42% of total deaths, and CHD is the single most common cause of death before the age of 65 (Allender et al., 2008). The economic costs are considerable, estimated at €192 billion, of which €110 billion are direct healthcare costs (accounting for 10% of all healthcare expenditure across the EU) and the remainder are due to productivity losses (unavailability for work) (Allender et al., 2008). The effect on quality of life is also severe for both sufferers and carers. Of this CVD burden, CHD accounts for the largest proportion. Because of the large impact that CVD has, it is important to understand the risk factors for the disease at all stages of life.

In addition to diet, other modifiable lifestyle factors, such as smoking, heavy alcohol use, and low physical activity have been identified as increasing the risk of developing CVD (Hu, 2009). Of the WHO global risk factors for chronic disease mortality and morbidity listed in Table 1.1, eight of them - alcohol use, tobacco use, high blood pressure, high body mass index, high cholesterol, high blood glucose, low fruit and vegetable intake, and physical inactivity - account for approximately 61% of DALYs (loss of healthy life years) from CVD and 61% of deaths from CVD (World Health Or-
ganisation, 2009). In combination with genetic susceptibility, these lifestyle factors can influence intermediate clinical risk factors, such as hypertension (high blood pressure) and dyslipidaemia (unfavourable LDL to HDL-cholesterol ratios, apo-lipoprotein size, high triglycerides), abdominal adiposity, low-grade inflammation and insulin resistance.

From epidemiological studies conducted in the 1950s, hypertension, smoking and serum cholesterol emerged early as risk factors for CVD (Oalmann et al., 1997; Skeaff and Miller, 2009). The observation of an association between diet and CVD risk is credited most often to Ancel Keys, whose seminal Seven Countries Study showed how what is known now as the “Mediterranean” dietary pattern seemed protective against the disease (Keys, 1995). In the decades that followed, numerous epidemiological, observational and clinical studies have been carried out and have been summarised in several recent meta-analyses (Jakobsen et al., 2009; Mozaffarian et al., 2009; Skeaff and Miller, 2009) and reviews (Van Horn et al., 2008; Mente et al., 2009). One comprehensive systematic review, using the Bradford Hill guidelines for causation in epidemiology, identified protective effects for vegetables, nuts, monounsaturated fats and Mediterranean, prudent and high-quality pattern diets, and harmful effects for trans-fats, high glycaemic index foods, and a “Western” dietary pattern (Mente et al., 2009). Of the few factors that had also been studied in randomised control trials (often considered the best design for studying causation in medicine), only the Mediterranean pattern was found to have an effect. Additionally, modest evidence was found for fibre, fruits, whole grains, and n-3 fats (among others), but only weak evidence for saturated fat, polyunsaturated fat and total fat (among others). One computer simulation of five changes to improve diet suggested it could reduce the burden of CVD in the Netherlands by as much as 20-30% (Engelfriet et al., 2010). The effects were particularly marked for increased fruit, vegetables and fish intake, but also for lower trans-fat and saturated fat intakes.

Fairly early on in the history of diet and CVD, the effect of saturated fat on cholesterol was established, and a low saturated- and total-fat dogma took hold. In hindsight, this reductionist approach may have led research to focus too narrowly on one group of nutrients. The health benefits of low-fat diets were not as clear-cut as hypothesised (Howard et al., 2006), and in time, the effects of saturated fats have been differentiated so that it is clear that not all saturated fats have the same effect. In particular, trans-fats are now held to be the most atherogenic, with a recent meta-analysis calculating a 24% risk in CHD death for every 2% energy from trans-fats consumed (Mozaffarian et al., 2009). But more and more, the focus is shifting to whole foods and to the study of di-
etary patterns (see Section 1.5), back in fact, to patterns similar to that which was first identified as protective.

CVD is a good example of a chronic disease which clearly begins decades before it manifests itself; at the foetal stage (Barker, 2007) and in childhood and adolescence (Holman, 1961; Berenson, 1998). The atherosclerotic process (a gradual build up of plaque deposits on the arteries) is a normal process of aging, which starts early; the first signs of fatty deposits are present by the age of three, and fatty streaks are well established by the age of 15 (Oalmann et al., 1997). At these ages, they are potentially reversible, but if the process is accelerated and the deposits become fibrous, it can lead to disease. The study of CVD risk factors in young people is therefore important.

1.2.2 How to tackle the problem?

Obesity has been described elegantly as “a normal response to an abnormal environment” (Egger and Swinburn, 1997). The same could perhaps be said for any unbalanced diet that leads to ill health, and chronic diseases in general have also been described as an “eco-nutritional problem” (Wahlqvist, 2004). The abundance of cheap, tasty but nutrient-dilute food and the proliferation of energy-saving devices and transportation in recent decades have contributed to the current public health nutrition problems. The choices made by people faced with these convenient options have been entirely rational in evolutionary terms, but unfortunately damaging to long-term health.

The concept of the “environment”, when used in the context of ecological models, is a broad one. According to one widely used model (Swinburn et al., 1999), it can refer to the physical environment as well as the sociocultural, political and economic, any of which can be inter-related, and can occur in a micro- or macro-environmental setting. Methods to effectively improve this environment include changes to laws and regulation, tax and price interventions, improving the built environment, advocacy, school- and workplace-interventions (World Health Organisation, 2005).

The physical environment, such as the proximity of fast-food restaurants and supermarkets, the “walkability” of a neighbourhood, accessibility of sports and leisure facilities etc, affects a persons options in a fairly direct way. Improvements to this built environment could include more physical activity-promoting urban planning, improving public transport and controlling urban sprawl. The sociocultural environment can affect how acceptable it is to eat food in public, whether or not obesity becomes a social “norm”, or how meal patterns are structured. The political and economic environment determines policies and regulations, which can range from school-lunch policies, to
food labelling, to advertising and marketing regulations, all the way up to taxation and subsidy structures. Road congestion charges (Bergman et al., 2010) and beverage taxes (Brownell et al., 2009) are two examples of taxation schemes currently receiving attention.

Popkin (2009) recommends global price adjustments and strong regulations similar to that used for tobacco regulation. However, the political and economic environment is in turn very much influenced by the regional, e.g. EU, and global policies. The effects of those trade and taxation policies are particularly wide-ranging, and perhaps need to be better understood by public health nutritionists (Thow, 2009). For example, EU policies are required to be supportive of “health in all policies” (Commission of the European Communities, 2007). In reality, some, such as the Common Agricultural Policy, have been failing to do this (Elinder et al., 2003; Birt, 2007; Lloyd-Williams et al., 2008). If current dietary recommendations were ever actually followed completely, Srinivasan et al. (2006) have shown that very substantial changes in agricultural systems and food supply would be needed. Advocacy is an important tool for public health nutritionists, particularly as good nutrition policy development and communication requires the involvement of stakeholders from so many diverse sectors (Trübswasser and Branca, 2009).

School- and workplace-based interventions (De Bourdeaudhuij et al., 2010; Ní Mhurchu et al., 2010) are more likely to be effective than individual-level dietary advice interventions (Chapman, 2010), although high-quality studies remain relatively scarce. At the same time, at the individual level, people must be educated about dietary choices from an early age. However it is important to remember that “individual responsibility can have its full effect only where individuals have equitable access to a healthy life, and are supported to make healthy choices” (World Health Organisation, 2005). Currently, the responsibility for making healthy dietary choices in an environment offering the opposite falls very much on the shoulders of the consumer. Tools for communication and education of consumers include “back-of-pack” nutritional information, “front-of-pack” labelling schemes (Grunert et al., 2010), and food-based dietary guidelines (see Section 1.6.1).

As more is understood about the human genome, and the science of nutrigenomics develops, “personalised nutrition” is promising. It can be argued that it is a better use of resources to try to change the diets of people who can be identified as responsive to changes rather than people who, because of their genetic make-up, are not (Rimbach and Minihane, 2009) but this is a long way off being universally accessible, and “technological fixes are not societal solutions” (Lang and Heasman, 2004).
1.3 Children and adolescents

1.2.3 How big a problem is it?

It is perhaps worth pointing out that the impact of diet on chronic disease in developed countries seems small when compared to that of developing countries who are rapidly adopting an industrialised diet, particularly in urban areas. Four out of five deaths from chronic diseases occur in low and middle income countries (World Health Organisation, 2005). These countries are undergoing a “nutrition transition” (Popkin, 2006). The rapid changes in food and nutrition supply means that in countries with a history of deficiencies and under-nutrition, diseases of “overnutrition” and “inappropriate” nutrition (adequate protein and energy, but otherwise imbalanced) are now co-occurring, even within the same household (World Health Organisation, 2003). This transition is of course not limited to diet, but includes the physical environment and culture too (Rayner et al., 2006). At the same time, it is estimated that currently more than 1 billion people in the world are hungry and malnourished, the highest figure since the 1970s (Food and Agricultural Organisation, 2009). The failure to reduce hunger and malnutrition in the 21st century has rightly been described as “scandalous” (European Food Security Group, 2006). The consequences both of too little nutrition, and inappropriate nutrition, are disastrous in both human and economic terms.

Although in developed countries, we could be considered to have a headstart in understanding how diets tend to evolve with increasing prosperity, we are still relatively ineffective at changing and preventing the process. If we can assume that developing countries will mirror the diets and disease patterns of developed countries, then perhaps some of what we know about nutritional epidemiology may be of use to developing countries in the future. The principles of dietary assessment will be similar. Methodological advances can be applied elsewhere. The formulation of food-based dietary guidelines, while culturally specific, follows similar steps. We can hope that by understanding our own situation better, it may contribute in some way to diffusing the ticking time-bomb of diet-related chronic disease that the world faces.

1.3 Children and adolescents

Children and adolescents are a special population group. Their requirements are relatively high as their diet must meet fuel, repair and also growth needs. Despite this, the dietary intakes of children and adolescents are not as well studied as adults. Many countries lack good quality national data on child and adolescent intakes (Lambert et al., 2004), and regular surveys on specific groups (e.g. infants, children, adolescents
and the elderly) are conducted only in about 12 of the 53 WHO European region countries (Trübswasser and Branca, 2009). In Sweden, the first nationally representative survey was conducted as recently as 2003 (Barbieri et al., 2006).

They are also a special group in that, at least when young, they do not make all the decisions regarding their choice of food intake. It is determined at home by parents and caregivers, and at school by school or county council personnel. Sweden is one of only two countries in the world (the other being Finland) where all school pupils in state-run schools are legally entitled to a free school lunch. There is currently no requirement on the nutritional quality of the school lunch, although this is expected to change in the near future, with a new school law due in 2011. Obviously, there is no requirement on the nutritional quality of food served at home either! They are therefore reliant on the knowledge and ability of others to provide nutritious food. This is not to suggest that children cannot make their preferences known and exert influence on their parents. Children, and to a lesser degree adolescents, are more susceptible than adults when it comes to marketing and advertising, and those younger than eight years old are practically “defenceless” against it (Committee on Communications, American Academy of Pediatrics and Strasburger, 2006). Considering that advertising spend on food groups is vastly in favour of unhealthy and processed foods, it can be assumed that any advertising is likely to promote an unhealthy diet, and may even quantifiably contribute to obesity (Goris et al., 2009).

Adolescents on the other hand may have more influence over their food choices. Independence from parents begins, and peers are likely to be more important at this age. Physical growth and development is often considerable. Experimentation is common, such as with smoking, drug or alcohol use. Meal patterns, particularly breakfast habits, change. It is not known if children and adolescents with poor dietary habits are often more likely to engage in other risky lifestyle behaviours, and this is the topic of Study III.

Children and adolescents generally have a limited ability to understand the long-term consequences of their behaviour. Although usually free from disease, this age group are not immune from the effects of their diet and lifestyle on their future health, even if the lag-time for signs of disease development might be several decades. For this reason, population dietary goals and food-based dietary guidelines (see Section 1.6) apply to them too from an early age. In Study II, adherence to some of the Swedish food-based dietary guidelines is simulated, and the effect on nutritional intake in the study population is predicted.

Biological risk factors for CVD, such as hypertension, cholesterol and obesity
1.4 Dietary assessment

Epidemiology - the study of disease and its determinants - is a core science of public health (Rothman, 2002). Nutritional epidemiology is a complex branch of this science, because the determinant of interest (diet) is so difficult to capture. Diet is a multi-faceted, multi-dimensional exposure that changes constantly and considerably, as much from one day to the next as over the life course. The question of “what do people eat?” is deceptively difficult (Blundell, 2000). Various methods to collect data on dietary intake are available, and each of them has notable strengths and weaknesses (see next section). A significant problem within nutritional epidemiology is that dietary intakes are frequently misreported (see Section 1.4.2), and this issue is considered in Study I, II and IV.

1.4.1 Methods of assessment

All nutritional epidemiology is limited by the quality of the dietary data available. Unfortunately, the assessment of dietary intake is notoriously challenging. Even assessing short-term intakes is difficult, yet it is often the habitual, long-term intakes that are of interest and assessing these is even more problematic (Thompson and Subar, 2008).

Dietary intakes can be assessed either prospectively or retrospectively. All methods of prospective recording have the effect of influencing intake to some degree, whether intentional or not. One exception is perhaps when intakes are recorded by a researcher who covertly observes the subject, but this is naturally only restricted to small-scale studies, in limited settings. This side-effect can be beneficial if the aim is to make people aware of their intakes, but when the aim is to collect data that represents their usual true intake, it is undesirable. Keeping a food record, whether the food eaten is weighed or its quantity is estimated, places a large burden on the subject, and requires motivation as well as literacy, which introduces selection bias. Dropout rates from such studies can be high, particular when multiple days are to be recorded. Subjects may alter their intakes so that simpler dishes are eaten which are easier to record, or because of social desirability and the wish to record foods that reflect well on them.
Retrospective methods of reporting dietary intake are more widely employed. These rely on recall, and so do not affect actual intakes. However, the intakes reported with any retrospective method can still differ from the true intakes for a number of reasons, including genuine difficulty in remembering the intake, lack of knowledge about the type of food eaten, recall bias, social desirability bias, or even a reluctance to cooperate (Blundell, 2000; Gibson, 2005). The two most commonly used methods are food-frequency questionnaires (FFQs), and the 24-hr recall method, which, as the method employed in EYHS, is discussed further (see next section). Briefly, FFQs are often used for specific diseases or nutrients of interest, and the cognitive burden is considerably high, as it relies on generic memory. Intake must be averaged over the period of time the FFQ enquires about (sample question: “In the last six months, how many pieces of fruit did you eat on an average day?”). As the questions must be defined in advance, it must necessarily be limited in focus. A FFQ should also be tailored to the population in which it is to be used.

24-hr recall

The 24-hr recall is commonly used to assess dietary intakes, particularly for surveillance purposes. A 24-hr recall relies on specific memory (of the previous day) and is usually open-ended (typical question: “In the last 24 hours, what did you have to eat and drink?”) so the subject can report any and all foods, even those the researcher might not have considered in advance. This allows richer detail on brand names, food preparation methods and food combinations to be captured.

A 24-hr recall can be interview-administered, either face-to-face or by telephone, or self-administered. Recalls may be single or multiple, on consecutive or non-consecutive days. The interviewer must be well trained and ask questions in a non-leading way. However, the use of specific probing questions about foods commonly forgotten or under-reported has been found to increase the accuracy of reported intakes. The 24-hr recall is considered suitable even for use in children, particularly as part of a combined method, where a food record is also included, which may overcome difficulties with memory (Thompson and Subar, 2008). The presence of an interviewer may also help to keep young subjects motivated.

Even if the types of food and the portion sizes eaten are recalled accurately, without any bias or error, in the case of a 24-hr recall this cannot tell us much about the usual intake of an individual. It may be a valid (accurate) picture of that day, but how similar is that day to all the others? Huge intra-personal variation (i.e. for the same person) exists in dietary intake. This is often bigger than inter-personal variation (i.e.
between people) and the length of assessment time needed to get a true picture of habitual intake varies from days, for energy, to weeks, for more sporadically consumed micronutrients (Nelson et al., 1989; Gibson, 2005). The effect of this measurement error (where the reported intake differs from the usual intake) is most severe when assessing the adequacy of intakes as it will inflate the number of people with seemingly insufficient intakes. The other undesirable effect of this large variation is increased “noise” in the data, and the associations with outcomes tend to be attenuated (weakened) so that real associations may be masked. It is generally held that the 24-hr recall method has known limitations for assessing at the individual level, but is considered valid for groups (Beaton et al., 1979; Volatier et al., 2002). This was also the conclusion of a recent EU-funded study tasked specifically with reviewing dietary assessment methods (IDAMES, 2009).

Hope for improving the data that can be obtained from 24-hr recalls rests mainly on the use of technology to capture better data in the first place (Ngo et al., 2009; Thompson et al., 2010) and on enhanced statistical methods to overcome some of the limitations inherent in the method (Hoffmann et al., 2002; Dodd et al., 2006; Illner et al., 2010).

Self-administered 24-hr recalls are increasingly computerised, either web-based or on local computers. Tools that can be reliably self-administered can reduce personnel costs for studies, allow more subjects to be recruited and enhance comparability between studies or countries (Slimani et al., 2002; Vereecken et al., 2005). Real-time recording methods with image capturing have potential, however the feasibility of use in large-scale studies is probably limited for now. The advantages include reduced participant burden, plus the removal of the issue of recall error, but it limits participation to subjects who have or can be given access to the technology and who are comfortable using it (Thompson et al., 2010).

A number of statistical methods have been developed that adjust for the intra-personal variation, but also account for foods that are only eaten sporadically (Tooze et al., 2006). These “episodically consumed foods” can be difficult to capture by 24-hr recall (they will only be eaten by a small percentage of the population on any one day) but they can contribute importantly to intakes of some nutrients. It is likely that these statistical methods will be increasingly employed where traditional means of dietary assessment must be used.

1.4.2 Methods of identifying misreporters

Dietary assessment methods are prone to measurement error, and misreporting of intakes is a significant problem (Maurer et al., 2006). How then to judge if the reported
intake is valid (i.e. is close to the truth)? Reported intakes can be compared to an objective biomarker, or can be compared to an expected intake, based on predictions of requirements.

For overall validity of a reported diet, the judgement is most often based on reported energy intake (Livingstone and Black, 2003). (For nutrients, more specific biomarkers are available.) Theoretically, for the energy intake reported to be realistic, it must support life, and meet, at a minimum, basal metabolic requirements. If energy intake is below these requirements, then we can make an assumption about that energy reported. However, the body stores energy very efficiently in the form of glycogen and adipose (fat) tissue, which means that energy does not have to be consumed every day and that it is therefore biologically plausible that someone consumes far below their energy requirements on a given day. It is also just as likely that another person consumes well above their requirements on the same day. It is for this reason that a 24-hr recall is deemed to have good validity at a group level. This calculation of predicted energy intakes must therefore include a range of plausible values, depending on the uncertainty involved in the assessment of both energy intake and energy requirements.

Doubly-labelled water is an example of a recovery biomarker, and is considered the "gold standard" of determining energy expenditure requirements in free-living subjects, as it allows a person to go about their usual daily activities. A dose of deuterium-labelled water is given and by monitoring the rate of deterioration (through recovery of deuterium in urine concentrations), total energy expenditure (TEE) can be calculated. Doubly-labelled water remains prohibitively expensive for large studies, and requires specialist equipment and analysis. It is also burdensome as subjects are required to collect their urine.

Energy requirements can also be predicted from basal metabolic requirements (BMR), plus an allowance for physical activity level (PAL). BMR is determined by age, sex and body mass (weight) (Schofield, 1985). It is assumed that weight is constant during the period of dietary assessment. PAL can be “measured” if TEE and BMR are measured, as PAL = TEE / BMR. A PAL can also be estimated based on physical activity that has been assessed. A feasible way of assessing activity is the use of accelerometry - the measurement of a subject’s vertical movement with an accelerometer (motion detector). TEE, and therefore PAL, can theoretically be calculated from accelerometer data. However, although this is promising, the equations to do so have not yet been widely validated, and not in children, adolescents and adults simultaneously, and are unlikely to be accurate at the individual level (Plasqui and Westerterp,
1.5 Dietary patterns

2007; Nilsson et al., 2008). In the absence of measured or estimated PAL values, values can be assigned either from self-reported data on physical activity or from other published studies (Black, 2000a).

Once an energy requirement is established, the range of values must be calculated which takes into account the imprecision of both intake and requirement estimations, the duration of dietary assessment, and the number of subjects. Goldberg et al. (1991) developed the most widely used formula for this prediction of plausible intake ranges, against which reported intakes can be compared. A confidence interval around the predicted intake is calculated. Subjects with intakes below the lower end of the confidence interval are considered under-reporters, and above the upper cut-off as over-reporters.

This method identifies only the most extreme misreporters, and is not considered very specific at the individual level, particularly when few days of data are available (Black, 2000b). For this reason, the treatment of identified misreporters is not straightforward. Should they be excluded, reducing sample size and power? Should they be adjusted somehow? Or just ignored? As a minimum, Goldberg and Black (1998) recommend that they are described, and that the effect of excluding them on the results of the main analysis is examined carefully. Nonetheless, this method is useful for describing the existence and magnitude of inadequate reporting (Gibson, 2005). Although under-reporting is more common, and has received more attention, the concept of over-reporting should not be neglected. Defining the characteristics of both types of misreporters, currently poorly understood (Blundell, 2000; Maurer et al., 2006), may help in refining dietary assessment methods or study design.

1.5 Dietary patterns

A dietary pattern can be described as “multiple dietary components operationalised as a single exposure” (Edefonti et al., 2009). As diet is such a multi-dimensional exposure, it is often not clear which aspect is of most relevance to a chronic disease and should be prioritised (nutrients, foods, meals, meal patterns or overall dietary pattern?), although this depends very much on the research question. Dietary intakes of nutrients can be compared to requirements, and foods can be compared to food-based dietary guidelines. Relatively little attention is usually given to meals, with the exception of breakfast, which is probably the best-studied meal. It has been linked to better weight control, academic performance and better overall dietary quality (Rampersaud et al., 2005), and breakfast skipping behaviour is included as one of several lifestyle-related risk factors in Study III.
However, it is the overall (habitual) diet that is of interest when it comes to health and the prevention of chronic disease, and a reductionist approach focusing on constituents of the diet risks missing the total picture. Therefore methods of assessing overall diet and dietary patterns have been developed and used widely in recent years (Hu, 2002; Kant, 2004; Newby and Tucker, 2004; Schwenke, 2009).

Methods of dietary pattern analysis can be grouped into two categories: \textit{a priori} and \textit{a posteriori} methods. The former are derived before data is collected, based on established associations between foods/nutrients and health. Examples include scores and indices such as the Dietary Diversity Score, the Mediterranean Food Score, and the Healthy Eating Index (HEI). It is not unusual in the literature to see that these are modified for different study populations (e.g. the Alternative HEI, the Youth HEI). An advantage of these scores and indices is that they allow the same comparison to be made across studies, provided the data required for the scores to be calculated is available. Variations in nutritional databases, food groupings, or in the time period of data collection (and thus food consumption frequency) may make this difficult, and some modification of the original score may be unavoidable. However, care should be taken that the score is not modified too much or it essentially becomes a new, unvalidated tool (Maynard \textit{et al.}, 2005).

The other commonly employed methods are data-driven, where patterns are derived from the dietary data using statistical methods such as factor analysis, cluster analysis or reduced rank regression. These make no prior assumptions about associations between diet and health outcomes (except for reduced rank regression where an intermediate biological variable is chosen) and are interpreted afterwards. Several decisions must be made in the process, such as the optimal number of factors or clusters, which ones to keep, and even how to name the patterns, and these are often subjective judgements. The patterns are also specific to that particular study population, although it does seem that patterns termed “prudent” (healthy) and “Western” (less healthy) have emerged in a number of independent studies (Mente \textit{et al.}, 2009; Schwenke, 2009).

Both of these methods have strengths and limitations. As EYHS was essentially a study on cardiovascular disease risk factors, a logical aim from the beginning of this work was ultimately to be able to relate the overall diet to other factors such as physical activity, and biological risk factors such as overweight or metabolic risks. The idea of identifying dietary patterns was thus intuitive. Unfortunately, no validated score was available for this study population, and the dataset was deemed neither robust enough (consisting of only one day of intake) nor large enough for the data-driven methods to
be reliable (K. Tucker, personal communication). The concept of dietary energy density was therefore explored. Energy density had been associated with dietary quality in other studies, and it was possible with the data available.

### 1.5.1 Energy density and dietary patterns (Study I)

Energy density is a measure of energy per unit weight, i.e. kJ per g. Water has an energy density of 0 kJ/g, protein and carbohydrate have 17 kJ/g ($\approx$4 kcal/g), and fat has 39 kJ/g ($\approx$9 kcal/g). The energy density of a food is determined mainly by its fat and/or water content. Foods such as fruits and vegetables have a low energy density, while foods such as spreads and oils, cakes and biscuits are energy dense (see Table 4.2, p.42). The energy density of a diet is in turn determined mainly by foods that are rich in fat and/or water.

Interest in energy density was initially focused on its role in determining energy intake and affecting satiety, and explored primarily in laboratory settings (Rolls, 2009). Energy density has been identified as a factor with “convincing” evidence of a promoting role in weight gain and obesity development (World Health Organisation, 2003). It has been promoted as a guiding principle for food choice (Dietary Guidelines Advisory Committee, 2005; World Cancer Research Fund / American Institute for Cancer Research, 2007). It has been associated with dietary quality in adults (Kant and Graubard, 2005; Ledikwe et al., 2006; Schröder et al., 2008), and obesity in children and adults (Mendoza et al., 2006; Johnson et al., 2008; Du et al., 2009). It has also been used to explain the difference in the cost of different types of food (Monsivais and Drewnowski, 2007; Maillot et al., 2007). The association between energy density and dietary quality had not been explored in detail in children and adolescents. It was hypothesised that energy density would discriminate diets of differing quality, and possibly have an application as a simple dietary pattern marker. If this were the case, it could be included in subsequent studies.

### 1.6 Dietary recommendations

Recommendations for nutrients and foods are set with the aim of preventing deficiencies, providing for optimal health, and/or preventing chronic disease. Nutrients are by definition compounds essential for health and not synthesised by the body, therefore specific recommendations of minimum daily intakes, estimated average requirements and upper limits are set.
Recommendations for macronutrients are usually set in terms of population goals, where the optimal average intake for the entire population is determined (World Health Organisation, 2003; Alexander et al., 2004). Unfortunately, it is not always obvious which aims have been used as criteria for setting the goals, particularly with regard to fat (Smit et al., 2009). Population goals are often used for the planning of group diets. Because the population intake is an average of all the individual intakes, some individuals will naturally have higher and lower intakes than this goal. Fruit and vegetable intakes are one of the few food groups that are often recommended in terms of a definite amount, which can highlight a discrepancy between individual goals and population goals. For example, the population goal for fruit and vegetable intake for cancer prevention is 600 g, yet the individual goal is set as a target of 400 g (World Cancer Research Fund/American Institute for Cancer Research, 2007). While recommendations and reference values are set for nutrients, most people think of diet in terms of foods, not nutrients. Complex nutrient recommendations are therefore often translated into something more acceptable to the general population, such as food-based dietary guidelines.

### 1.6.1 Food-based dietary guidelines (Study II)

As the name suggests, these focus on foods, rather than nutrients. Food-based dietary guidelines (FBDG) have been described as a mix of “common sense and science” (Smitasiri and Uauy, 2007). They should address dietary patterns, be practical, be comprehensive, and be culturally acceptable (World Health Organisation, 1998; Sandström, 2001).

The recommended starting premise for FBDG formulation is that a public health concern, and the nutrients associated with that concern, should be identified (World Health Organisation, 1998). Then, several steps are followed: 1) the identification of major food sources of the nutrient of interest, 2) the identification of foods contributing substantially to population intakes, 3) the identification of foods or food patterns compatible with desirable nutrient intakes, 4) the formulation of FBDG based on foods, portion sizes, intake frequency or meal composition (Sandström, 2001).

As of June 2007, all 27 countries of the EU, and 40 countries (of 53) in the WHO European region had FBDG in place (Trübswasser and Branca, 2009), and they are becoming more common worldwide. FBDG are an important part of, and implementation tool for, national nutrition policies, although the monitoring of their implementation is often not well-documented (Keller and Lang, 2008). In keeping with their aim of better communication with the general public, the majority of countries with FBDG
have also developed a graphical representation of their FBDG. The most common form in Europe is a nutrition pyramid, followed by a circle, and a food plate (World Health Organisation, 2006).

One of the keys to the success of FBDG is how understandable and acceptable they are to the target population. In Sweden, FBDG in their current incarnation have been in place since 2005. They are known as “Fem kostråd” (“Five pieces of dietary advice”) and are listed in Table 1.2.

<table>
<thead>
<tr>
<th>Table 1.2 Swedish food-based dietary guidelines “Fem kostråd”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eat lots of fruit and vegetables, preferably 500 g a day</td>
</tr>
<tr>
<td>Choose wholegrain when you eat bread, cereal, pasta and rice*</td>
</tr>
<tr>
<td>Choose Keyhole-marked products†</td>
</tr>
<tr>
<td>Eat fish often, preferably three times a week</td>
</tr>
<tr>
<td>Use liquid margarine or oil when preparing food</td>
</tr>
</tbody>
</table>

* Updated in 2009  
† The Keyhole is a Swedish front-of-pack labelling system

On the basis of the results from the most recent national survey of children, conducted in 2003 on children aged between four and 11, it was concluded that young people should double their fruit and vegetable intake, choose skimmed milk instead of standard and reduced fat milk, choose lower fat cheeses instead of high fat, choose leaner meats over high-fat meat products, replace a meat dish with a fish dish once a week, choose fluid fats in food preparation instead of hard fats, and should also halve the amount of confectionary, baked goods and snacks eaten. Water should also replace some of the soft drinks consumed. In general, they should follow the same guidelines as adults (Barbieri et al., 2006).

1.7 Diet as a behaviour

Diet is considered a lifestyle-related, or behavioural, risk factor for CVD, similar to smoking, physical activity or alcohol consumption. These behaviours are (theoretically, at least) easily modifiable. In contrast, hypertension and high cholesterol, for example, are considered biological risk factors.
1.7.1 Clustering of dietary and other behaviours (Study III)

It is possible that multiple risk factors can act synergistically and be more damaging than when occurring in isolation, although this is not certain. Certain behaviours, such as smoking and alcohol drinking, are well known to co-occur (Room, 2004). However previous research has often been focused on a limited number of risks. Some behavioural researchers also suggest that targeting multiple behaviours for change may be more effective than targeting single ones (Prochaska et al., 2008). Therefore understanding which behaviours tend to occur together (“cluster”) can be useful to both identify at-risk populations, and to guide interventions.

1.7.2 Tracking of dietary intakes over time (Study IV)

Chronic disease risk is affected by the cumulative effect of behavioural risk factors over time. It is therefore important to understand how these behaviours behave with age. Tracking is often defined as the “stability over time” or “ranking relevant to one’s peers”. What is established is that biological risk factors, such as overweight, high cholesterol and hypertension tend to track well (Ovesen, 2006; Singh et al., 2008), underscoring the importance of a life-course approach to understanding disease risk. On the other hand, not very much is known about the stability of dietary behaviours.

In EYHS II, the intakes of subjects aged approximately 15 could be compared to their intakes in EYHS I when aged 9, and those of subjects aged 21 could be compared to those when they were 15. This allowed us to investigate, in the same people, the effect of time. If children have a healthy diet at age 9, are they more likely to have a healthy diet at age 15? Can a high intake of a food at one time point predict a high intake at a later time point? This is important to understand because it could identify windows of particular stability and/or change in young people, and this in turn could suggest periods when dietary change interventions could be more or less effective.

1.8 Conclusion

Although the four studies presented in this thesis are relatively diverse in methodology and focus, it is the intention that, when taken as a whole, they will illustrate some current issues in nutritional methodology and some areas of concern in child and adolescent diets. In addition, they address two important aspects of diet in a broader context: how it relates to other chronic disease risk factors, and how it behaves over time.
Chapter 2

Aim and objectives

The aim of the work presented in this thesis is to describe various aspects of the dietary intakes of children and adolescents in Sweden.

The more specific objectives are:

- to develop a method of describing overall diet quality suitable for use in further studies (Study I)

- to identify macronutrient intakes of concern and to test the effect of FBDG strategies on improving these intakes (Study II)

- to explore whether poor dietary intakes and habits are associated with other unhealthy lifestyle factors in these ages (Study III)

- to investigate if dietary intakes (both foods and nutrients) are stable over time (Study IV).
Part II

Methods

“He may be mad, but there’s method in his madness. There nearly always is method in madness. It’s what drives men mad, being methodical.”

- GK Chesterton
CHAPTER 3

Methods

3.1 Setting and study design

The European Youth Heart Study (EYHS) is a study which aims to examine the “nature, strength and interactions” of cardiovascular disease risk factors in otherwise healthy children (Poortvliet et al., 2003). Although originally an international multi-centre study, the data in this thesis comes from Sweden only. The study was an observational, closed cohort study with two periods of data collection six years apart (Figure 3.1).

In Sweden, a convenience selection of Stockholm and Örebro was made. From these two cities, the sampling frame of all children in grade 3 (children aged 9-10) and grade 9 (adolescents aged 15-16), in all state schools in Örebro and the southern region of Stockholm (the municipalities of Botkyrka, Haninge, Huddinge, Nynäshamn, Salem, Södertälje and Tyresö) was defined. Schools with less than 20 students in the target grades were excluded. Schools were stratified by mean income level in their

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**Figure 3.1** EYHS study design and sample size

<table>
<thead>
<tr>
<th>Sampled</th>
<th>EYHS I (1998-9)</th>
<th>EYHS II (2004-5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2313 (100 %)</td>
<td>Participants 1137 (49 %)</td>
<td>Participants 459 (40 %)</td>
</tr>
<tr>
<td></td>
<td>Non-participants 1176 (51 %)</td>
<td>Non-participants 678 (60 %)</td>
</tr>
</tbody>
</table>
catchment areas and schools were randomly sampled from each stratum. Within the schools that accepted to collaborate, groups of students were randomly selected. Further details have been published by Hurtig-Wennlöf et al. (2003). Data collection for EYHS I was conducted during the school year 1998-9. The second wave of EYHS took place six years later, in 2004-5, when the participants of EYHS I, aged approximately 15 and 21, were contacted by mail and invited to participate in a follow-up study (EYHS II).

3.1.1 Ethical permission and consent

The ethical boards at Huddinge University Hospital (permit no. 474/98) and Örebro city council (no. 690/98) granted ethical permission. The parents or guardians of the participants in grades 3 and 9 provided written consent; the participants provided verbal consent. In EYHS II, the older participants themselves provided the written consent.

3.2 Data collection

Data collection took place at schools in EYHS I, and at Örebro University and Karolinska Institutet (Huddinge, south of Stockholm) in EYHS II. Research staff underwent EYHS training courses to develop their techniques for measuring anthropometry, blood pressure, taking blood samples, and performing the test for physical fitness (bike test). Dietary recall interviewers, who were qualified nutritionists, also underwent training in the EYHS 24-hr recall methodology. The variables used in this thesis are summarised in Table 3.1.

3.2.1 Dietary data

In EYHS I, a food record was kept for the day before the recall and subjects filled this in with the help of their parents. This was to serve as a prompt in case of difficulties with the recall, and particularly in case of discrepancy or uncertainty surrounding the type of fat used on bread and in food preparation. To help the subject estimate portion sizes, a food atlas with photographs of varying amounts of commonly eaten foods, and sample household units, e.g. glasses, bowls, plates, with markings at the quarter-full, half-full points etc, were used. Specific probing questions were asked about types of spreads used, milk and sugar consumed in drinks, snacks, and food supplements. The amount of food discarded was also asked about. The intakes were entered into
### Table 3.1 Variables studied

<table>
<thead>
<tr>
<th>Dietary intake</th>
<th>Method</th>
<th>Inclusion criteria for Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>nutrients</td>
<td>24-hr recall</td>
<td>I, II, III, IV *</td>
</tr>
<tr>
<td>food groups</td>
<td>24-hr recall</td>
<td>I, II, III, IV *</td>
</tr>
<tr>
<td>frequency</td>
<td>FFQ</td>
<td>III</td>
</tr>
<tr>
<td>Physical activity</td>
<td>Accelerometry</td>
<td>III</td>
</tr>
<tr>
<td>Body composition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>height</td>
<td>Anthropometry</td>
<td></td>
</tr>
<tr>
<td>weight</td>
<td>Anthropometry</td>
<td></td>
</tr>
<tr>
<td>weight status</td>
<td>Anthropometry</td>
<td></td>
</tr>
<tr>
<td>Lifestyle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>smoking</td>
<td>Questionnaire</td>
<td>III</td>
</tr>
<tr>
<td>alcohol consumption</td>
<td>Questionnaire</td>
<td>III</td>
</tr>
<tr>
<td>television viewing</td>
<td>Questionnaire</td>
<td>III</td>
</tr>
</tbody>
</table>

FFQ: food frequency questionnaire

* Recall data at both EYHS I and EYHS II required for Study IV

StorMats dietary analysis software (Rudans Lättdata, Västerås, Sweden; version 4.02) and analysed using the National Food Administration’s nutritional database, version 99.1. The results of this analysis were transferred to a database program (Microsoft Access, Windows Inc., USA). From there, the data was imported into a statistical program (SPSS, PASW Inc., USA).

In EYHS II, data collection was performed on-site at the universities. The interviewers were different, but the trainers of the interviewers, the 24-hr recall interview method, the food atlas and units were the same. The dietary analysis software version used was 4.06, with nutritional database version 02.1.

### 3.2.2 Physical activity

To estimate usual physical activity, the subjects were requested to wear an accelerometer. An accelerometer is a small motion detector, worn on an elastic band around the waist and positioned at the lower back/hip. It records movement in one or more planes several times per second, and is averaged over a user-defined time period. In EYHS, a uni-axial accelerometer (MTI Actigraph Inc., USA) was used which measures
movement in the vertical plane only, and movement was averaged over 60 seconds. For a subject’s accelerometer data to be considered valid, the accelerometer had to be worn for at least three days, one of which had to be a weekend day, and to have been worn for at least 10 hours on each day. Consecutive periods of time (≥10 mins) with zero counts (indicating no movement) were considered to be time when the device was not worn, and this was excluded from the calculation of total time worn.

### 3.2.3 Body composition

Weight and height were measured (by a researcher of the same sex as the subject), with the subject wearing light clothing (underwear and t-shirt; no shoes). A calibrated electronic scales and a portable Leicester stadiometer (both from Seca Inc., USA) were used to measure weight to the nearest 0.1 kg and height to the nearest 5 mm, respectively. Body mass index (BMI) was calculated (kg/m²) and weight status was determined by comparing BMI to international age- and sex-specific cut-offs for children and adolescents (Cole et al., 2000). In EYHS II, the 21-year-olds were compared to adult WHO cut-offs (World Health Organisation, 2000). BMR was estimated based on sex, age and weight (Schofield, 1985).

### 3.2.4 Questionnaires

Both the participants and their parents/guardians were required to complete a questionnaire. A paper questionnaire was sent home with the participants and parents/guardians were requested to answer questions on their health, occupation, education and income, and on their children’s health. For the children, a questionnaire entitled Personal and Environmental Associations with Children’s Health (PEACH) was used. It was computer-based and self-administered. Smoking and alcohol drinking habits were asked about, as well as selected dietary and physical activity behaviours and socio-cognitive variables.

### 3.3 Data treatment and statistical analysis

The statistical package SPSS (versions 15-17 for Windows; PASW Inc., USA) was used for all analyses, and a P of 0.05 was set as the level of significance. The statistical analyses are described here in brief, and only for the analysis that is presented (see the Appendices for more detailed analyses and results).
3.3.1 Food groups

Each food was originally considered to belong to one of the National Food Administration’s 38 food groups (which included 140 subgroups). For various reasons, this food classification was felt to be inappropriate for the analyses planned in this series of studies, and so each food was re-allocated to a new food group. These were groups with nutritional or dietary similarities, based on the original ones from the Administration, but modified to allow more specific classification in some cases and less in others. A more manageable 22 food groups, with 57 subgroups, was thus created. In Study I and IV, the intakes of most of the 22 food groups are presented, along with just six subgroups which were felt to illustrate an important aspect of the food group, e.g. high fibre bread, full-fat cheese, etc. Both the old and new groups are listed in Table 3.2).

<table>
<thead>
<tr>
<th>New food groups</th>
<th>New subgroups</th>
<th>Original food groups$^\S$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Spreads and oils</td>
<td>High fat</td>
<td>Cooking oil, fatty sauces</td>
</tr>
<tr>
<td></td>
<td>Low fat</td>
<td>Sauces</td>
</tr>
<tr>
<td></td>
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</tr>
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<tr>
<td></td>
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<td>Milk, fil, yoghurt</td>
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<td>Semi-skimmed</td>
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<td>Low fibre</td>
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<td>Reduced fat</td>
<td>Cooking oil, fatty sauces</td>
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<td>Pasta</td>
<td>Pasta, pasta dishes</td>
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<td></td>
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<tr>
<td>7 Vegetables</td>
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<td>Other vegetables</td>
<td>Vegetables, vegetable dishes</td>
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<td>Vegetable dishes</td>
<td></td>
</tr>
<tr>
<td>8 Fruit</td>
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<td>Fruit and berries</td>
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<td>9 Juice</td>
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## Chapter 3: Methods

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<th>Porridge, gruel</th>
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<td>Pulses, dried and dishes</td>
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<td></td>
<td>Legumes</td>
<td>Nuts, seeds, potato chips, popcorn*</td>
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<td></td>
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<td>Red meat</td>
<td>Meat, poultry and dishes*</td>
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<td>Burgers**</td>
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<td></td>
<td></td>
<td>Sausages**</td>
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<td>Poultry</td>
<td>Meat, poultry and dishes*</td>
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<td>White fish</td>
<td>Fish, seafood and dishes</td>
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<td>Seafood, caviar</td>
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<td>Fish dishes</td>
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<td>16</td>
<td>Chips, crisps</td>
<td>Snack foods</td>
<td>Nuts, seeds, potato chips, popcorn*</td>
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<tr>
<td></td>
<td></td>
<td>Potatoes cooked with oil</td>
<td></td>
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<td>17</td>
<td>Cakes, biscuits</td>
<td>Buns, biscuits, cakes</td>
<td></td>
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<tr>
<td>18</td>
<td>Soft drinks (sweetened)</td>
<td>Light/diet drinks</td>
<td>Cordial, soft drinks, ices, sorbet*</td>
</tr>
<tr>
<td>19</td>
<td>Beverages (other)</td>
<td>Alcoholic drinks</td>
<td>Beverages, non-energy containing</td>
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<td></td>
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<td>Coffee, tea</td>
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<td></td>
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<td>Water</td>
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<td>20</td>
<td>Sweets, chocolate</td>
<td>Sweet foods</td>
<td></td>
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<tr>
<td>21</td>
<td>Other sweet foods</td>
<td>Desserts</td>
<td>Pancakes, waffles, crêpes*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sweet soups, sauces</td>
<td>Icecream</td>
</tr>
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<td></td>
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<td>Icecream</td>
<td>Sweet soups, crème, desserts</td>
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<td>Sugar, honey</td>
<td>Marmelade, jam, stewed fruit</td>
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<td></td>
<td>Jams</td>
<td>Sugar, syrup, honey</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cordial, soft drinks, ices, sorbet*</td>
</tr>
<tr>
<td>22</td>
<td>Miscellaneous</td>
<td>Miscellaneous</td>
<td>Spices, salt, vinegar</td>
</tr>
</tbody>
</table>

*continued*
3.3 Data treatment and statistical analysis

<table>
<thead>
<tr>
<th>Ketchup</th>
<th>Alcoholic drinks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sports foods†</td>
<td>Flour, thickeners</td>
</tr>
<tr>
<td>Food supplements</td>
<td></td>
</tr>
</tbody>
</table>

§ Original (National Food Administration) groups also had subgroups, but too many to list
* Foods in this group assigned to two or more new groups
† EYHS II only
“Burgers and sausages were joined as one subgroup

The food groups are mostly self-explanatory, but the following should be noted: the “milk, fil, yoghurt” group includes fil, a soured-milk product similar to yoghurt, common in Nordic countries; “soft drinks” refers to sugar-sweetened or cordial-based non-alcoholic drinks; “juices” are concentrated or fresh juices. The “other sweet foods” group includes desserts, ice-cream, sweet soups, jams and sugar. “Burgers, sausages” are processed/higher fat meat products and are a subsection of the “meat, meat dishes” group. “Cereals” refer to breakfast cereals (both sweetened and unsweetened). Potatoes fried in oil are included in the “chips, crisps” group. Mixed dishes, e.g. vegetable dishes, were included in the parent groups i.e. “vegetables”. This was done after determining that the mixed dishes made a very small contribution to the group and did not warrant a separate group of “mixed dishes”. The alternative of deconstructing the mixed dishes to their component parts was not chosen. Food supplements were rarely reported, and were not considered in the calculation of micronutrient intakes. The focus in this series of studies is mainly on food group intake and macronutrients, rather than micronutrient intakes. A “consumer” of a food group was defined as someone who reported eating any amount of that food group (used in Study I and IV).

3.3.2 Other variables

As a marker of socioeconomic status, maternal education as reported in the parental questionnaire was used, dichotomised into greater than or less than nine years of education. For Study III, information on the lifestyle risk factors “current smoking” and “current alcohol use” were constructed from responses to questions in PEACH. Eating breakfast on less than seven days per week was termed “breakfast skipping”. Television viewing before and after school was combined and a variable that indicated more or less than two hours of viewing was made.
3.3.3 Misreporting

Possible misreporting of energy intake was identified by comparing intakes to a range of plausible intakes based on estimated requirements, according to the method proposed by Goldberg et al. (1991) and Black (2000a) (see Section 1.4.2).

At the individual level, the sensitivity to correctly identify misreporters is low (Black, 2000b). Therefore, in the studies in this thesis, potential misreporters are identified but not excluded from further analyses. Instead the analysis has been repeated with misreporters excluded to see if the main results changed, which could indicate serious reporting bias and differences between mis- and adequate-reporters.

To subjectively rate the quality of the dietary information provided in EYHS I, the interview was immediately scored by the interviewer, based on the subject’s perceived interest and motivation and the level of detail provided. Interviews with a score of less than three (out of five) were suspected to be of low quality.

The effect of excluding lower-quality interviews was examined in Study I, potential under-reporters in Study I and II and both under- and over-reporters in Study IV.

3.3.4 Energy density (Study I)

The aim with Study I was to test if diets grouped by dietary energy density would differ in “quality” (i.e. in food group, macronutrient and micronutrient intakes). Dietary energy density was calculated as kJ/g of all consumed food on the day recalled. The definition of food extended to liquids consumed as food (i.e. soups and yoghurt), but excluded all other liquids, including milk, soft drinks, fruit juices, other energy-containing beverages and non-energy-containing beverages such as water, “diet” drinks, coffee or tea. For each age group and sex, diets based on the lowest, middle and highest tertiles of kJ/g were identified (to give low-, mid- and high-energy density diets, respectively).

Statistical analysis

To detect significant differences in food group and nutrient intakes across these three dietary patterns, a one-way analysis of variance (ANOVA) was performed. Food groups and nutrients were first regressed on total energy intakes (Willett et al., 1997), and the resulting residuals were used as the dependant variables. These residuals are by definition uncorrelated with energy, and represent the differences between the observed and predicted intakes, i.e. the difference between an individual’s actual food or nutrient intake and what it would be expected to be, given their energy intake. This was
done because energy was a component of the independent variable (energy density), and also significantly correlated with food groups and nutrients.

A confirmatory procedure, namely discriminant function analysis, was also performed. In this, all the food group intake data was used to predict three groups of diets that differed in energy density, a procedure that resembles the reverse of the preceding one. The agreement between the classification of subjects to groups based on energy density tertiles and to the groups predicted by the discriminant analysis was calculated.

### 3.3.5 FBDG simulations (Study II)

In Study II, the aim was to describe the intakes of macronutrients at group level and to identify those that deviated from the population goals. The food groups that were the biggest sources of these macronutrients were then described. A further aim was to investigate how suitable some of the current FBDG, originally aimed at adults, could be for improving intakes in children and adolescents. Because of the structure of the data, it was not possible to model all FBDG. Adherence to five guidelines relevant to saturated fat and sucrose intakes, based partly on the official ones for adults and the unofficial ones for children (see Section 1.6.1), was simulated. We modelled the effect that full adherence to these would have on population level intakes by simulating the substitution or reduction in the reported intakes of some foods, and predicting the effect it would have on mean nutrient intake. The five scenarios were:

1. All high-fat cheese is replaced with low-fat cheese (≤ 17 % fat).
2. Milk
   (a) All full-fat milk is replaced by reduced-fat milk (≤ 1.5 % fat).
   (b) All full-fat milk and reduced-fat milk is replaced by skimmed milk (≤ 0.5 % fat).
3. The intake of sweets and chocolate, cakes and biscuits, chips and crisps, and other sweet foods is halved.
4. The intake of soft drinks is halved.
5. The ratio of high-fat meat products (burgers and sausages) to other meat products is reversed (from the original 67:33 to 33:67).

For these simulations, it was necessary to make certain assumptions. It was assumed that all subjects adhered to the guidelines in full; that any reduction in energy intake that might result was not compensated for; the mix of foods in a food group
remained constant; and that neither the number of consumers nor the sizes of portions changed.

**Statistical analysis**

To determine the contribution of food groups to macronutrient intake, the population proportion method for calculating ratios was used. This is the sum of the numerator for the population, divided by the sum of the denominator for the population. This is considered a better approximation of a group mean for a ratio when just one day of intake is available (Krebs-Smith et al., 1989; Freedman et al., 2010). The percentage of the sample that complied (“compliers”) with the population goals were identified by selecting from the sample the biggest possible group of subjects that had a mean intake which did not exceed the goal.

For the simulation of the FBDG adherence, adjustments were mainly made to food subgroups (e.g. high-fat cheese) so that they were consumed at a predefined target proportion (e.g. 0 %). First, the proportions in which the subgroups were originally consumed were calculated. Then the amount of the macronutrient in question (saturated fat or sucrose) provided by that subgroup at its original proportion was used to estimate the amount that would be provided by the new target proportion. Finally, the difference between the macronutrient intake based on the target intakes of the food group and the original intakes was calculated and the percent energy from the macronutrient adjusted accordingly.

The results of the simulations are presented for each scenario separately, and in various combinations.

### 3.3.6 Clustering (Study III)

For Study III, the relationships in EYHS I between different lifestyle risk factors for chronic disease, both dietary and non-dietary, were examined. These risk factors were fruit and vegetable intake, “junk food” intake, soft drink intake, the energy density of the diet, smoking behaviour, alcohol use, breakfast habits, low physical activity and television viewing (Table 3.3).

**Statistical analysis**

To analyse the associations between the nine risk factors, an observed to expected ratio was used, where the number of observed occurrences of a particular combination of risks is compared to the expected number of occurrences of that combination, had all the
3.3 Data treatment and statistical analysis

Table 3.3 Behavioural risk factors

<table>
<thead>
<tr>
<th>Risk</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>FV</td>
<td>Low fruit and vegetable intake</td>
</tr>
<tr>
<td>JF</td>
<td>High “junk food” intake†</td>
</tr>
<tr>
<td>ED</td>
<td>Energy dense diet</td>
</tr>
<tr>
<td>SD</td>
<td>High soft drink intake</td>
</tr>
<tr>
<td>BS</td>
<td>Breakfast skipping ≥ 1 d per week</td>
</tr>
<tr>
<td>Sm</td>
<td>Smoking</td>
</tr>
<tr>
<td>Al</td>
<td>Alcohol consumption</td>
</tr>
<tr>
<td>PA</td>
<td>Low physical activity</td>
</tr>
<tr>
<td>TV</td>
<td>High television viewing ≥ 2 h per day</td>
</tr>
</tbody>
</table>

All tertiles are age- and sex-specific

† Junk food refers here to cakes and biscuits, sweets and chocolate, other sweet foods, and chips and crisps combined

factors been independent. For example, if the prevalence in the population of smoking is 10 %, and alcohol use is 20 %, the expected occurrence of both smoking and alcohol use in the population is 0.1 X 0.2 = 0.02, or 2 %. If the observed occurrence is then actually 8 %, it is occurring 8 / 2 = 4 times as often as expected.

The observed and expected frequency of each of the 502 combinations that are possible from nine risk factors was calculated, and their ratio (observed:expected) was calculated. A ratio greater than 1.0 suggests that it is more common than would be expected if the factors were independent. Confidence intervals were generated around these ratios by a resampling procedure, namely bootstrapping. All risks were blinded before the analysis, which meant that they were identified only by a number and we could not be influenced by prior assumptions about which risks might cluster together when beginning to interpret the results. To refine the results, we chose ratios that had a positive (and significant) confidence interval, and where the number of expected subjects was greater than one.

3.3.7 Tracking (Study IV)

The aim with Study IV was to see if intakes of food groups and nutrients remained relatively stable, or “tracked” over time from EYHS I to EYHS II. Tracking can be thought of as the position a person holds relative to his or her peers at one time point, to that
Chapter 3: Methods

held at another time point. For this study, only subjects who completed a dietary recall in both EYHS I and II were included (see Table 3.1, p.27). At each time point, categories of low, mid and high intakes of food groups, nutrients and energy density were created, based, as before, on age- and sex-specific tertiles.

Statistical analysis

Several parameters of tracking were calculated, each aimed at addressing a specific aspect:

1. Stability: the percentage of subjects in any tertile (low, middle or high) at EYHS I who remained in the same tertile at EYHS II. Values greater than that expected by chance (33 %) indicate stability.

2. Tracking: the strength of association between tertile membership at EYHS I and tertile membership at EYHS II, measured by Cohen’s weighted $\kappa$. Perfect agreement (the same tertile at both times) was weighted most heavily, partial agreement (moving by one tertile) weighted a little, and non-agreement (moving by two tertiles) was not weighted. Cohen’s weighted $\kappa$ returns a value between zero and one, where one is perfect agreement. Intermediate values can be interpreted using a scale, such as that of Landis and Koch (1977), where values of 0.01 to 0.20 indicate “slight” agreement, values of 0.21 to 0.40 indicate “fair” agreement, etc.

3. Predictive value: the likelihood of remaining in the highest tertile, calculated as the number in the highest tertile at EYHS I who were also in the highest tertile at EYHS II, divided by those in the highest tertile at EYHS I who moved to the middle or lowest tertile at EYHS II. Values greater than 1.0 suggest some predictive value.
Part III

Results, Discussion & Conclusions

“Eat food. Not too much. Mostly plants.”

- Michael Pollan
CHAPTER 4

Results and discussion

4.1 The EYHS study sample

The inclusion criteria for each paper (see Table 3.1, p. 27) resulted in study samples of 1120 for Study I and II, 670 for Study III and 452 for Study IV. A brief overview of the study samples is provided in Table 4.1.

4.1.1 Participation (EYHS I)

The participation rate of EYHS I was 49%. Of the 2313 contacted, a total of 1154 students agreed to participate, representing about 0.5% of the national population in these age groups. Of these, 1137 kept their appointment to attend the data collection part (Figure 3.1, p.25). This rate was lower than expected, and a non-participation study looked carefully at the choice of regions, the selection of schools, the parents of the participants, and the participants themselves for evidence of selection bias (Hurtig-Wennlöf et al., 2003). The results indicated no substantial differences between the regions and the national population in terms of income, occupation and education; and no difference in income level of school catchment area between collaborating and non-collaborating schools. In both regions, manual workers and those with a low educational level were under-represented in the parents of participants compared to the entire region. At individual level, participants reported more interest in physical activity than non-participants, and in the older students who were being graded at school, they had higher school marks (including in the subject of physical education). Overall, apart from the commonly observed phenomenon of higher socioeconomic status, no major bias in participation was observed that should affect the outcomes in EYHS.
Table 4.1 A brief description of the sample in each study

<table>
<thead>
<tr>
<th></th>
<th>Study I, II</th>
<th>Study III</th>
<th>Study IV</th>
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<td>46.6</td>
<td>42.7</td>
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<td>51.5</td>
<td>60.4</td>
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<td>12.2</td>
<td>13.4</td>
<td>12.2*</td>
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<td>obese</td>
<td>1.9</td>
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<td>Energy-reporting</td>
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<tr>
<td>over-reporter</td>
<td>0.7</td>
<td>0.7</td>
<td>1.5*</td>
</tr>
<tr>
<td>under-reporter</td>
<td>7.5</td>
<td>7.5</td>
<td>19.5*</td>
</tr>
<tr>
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<td></td>
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</tr>
<tr>
<td>high</td>
<td>32.6</td>
<td>34.3</td>
<td>38.7</td>
</tr>
</tbody>
</table>

n: number
SES: socioeconomic status
* At EYHS II

4.1.2 Follow-up (EYHS II)

Of the 1137 EYHS I participants, 459 (40 %) took part in EYHS II (Figure 3.1, p.25). A “dropout” analysis (Gribbins et al., 2006) showed that more of the younger EYHS I participants returned than the older. Females, and participants with mothers who had high education were more likely to return. Female participants had higher school grades (available at both time-points for the older group only) than dropouts, but physical activity, physical fitness and anthropometry did not differ between participants and dropouts. A separate dropout analysis focusing on diet (Patterson et al., 2009) found that dropouts were more likely to report skipping breakfast, less likely to be consumers of milk, fil, yoghurt, and reported less frequent consumption of salad than participants. They were no more likely to under-report energy intakes (although in contrast to Studies I to IV, this was defined as EI:EE > 1.2), and reported similar amounts of energy, energy from macronutrients (except carbohydrate), percent consumers of all food groups (except for one of the 19 tested), and energy density. Overall,
no major discrepancies between the diets of participants and dropouts were found.

### 4.1.3 External validity of EYHS

The generalisability of results must take the characteristics of the study sample into account. The sample is not, and was not intended to be, nationally representative. The sample is from an urban population only. Losing the students that were less interested in physical activity means we could have an excessively homogeneous sample, and those most at risk of low physical activity might have been missed. Similarly, an over-representation of higher socioeconomic status could result in sample that has a more favourable cardiovascular risk profile than the general population.

For Study II, where intakes are compared to national population goals, a bias in reported intakes would affect the generalisability of the results, but if anything, a bias probably means that the dietary intakes reported here are likely to be better than that of the general population. Although this is far from certain as a systematic review of socioeconomic status and health in children and adolescents in Sweden (of studies conducted between 1975 and 2001) found that while mortality, not being breastfed, alcohol consumption and smoking were all higher in disadvantaged socioeconomic groups, the few studies that included dietary variables had mixed results: meal skipping was more frequent (two studies), but vegetable or nutritional intake (one study each) did not differ (Bremberg, 2002). The national children’s survey, with a representative sample, reported no differences in diet by socioeconomic status (Barbieri et al., 2006).

For Study III, which considers clusters of cardiovascular risk factors, including but not limited to diet, a higher socioeconomic bias may have led to a bias in the prevalence of risk factors, but again, the results we present are therefore, if anything, an “optimistic” version of reality in the general population. Study I and IV deal with methodology and stability of behaviour, respectively, and should not suffer as much from problems with generalisibility.

### 4.2 Dietary intakes

Aspects of dietary intakes are presented in Figure 4.1 and Table 4.2 for the sample used in Study I and II.
## Table 4.2 Intakes (median (IQR)) and energy density of each food group in EYHS I

<table>
<thead>
<tr>
<th>Food Group</th>
<th>Girls (9y)</th>
<th>Boys (9y)</th>
<th>Girls (15y)</th>
<th>Boys (15y)</th>
<th>Energy Density (ED) (kJ/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spreads and oils</td>
<td>15 (8-25)</td>
<td>15 (10-26)</td>
<td>12 (9-20)</td>
<td>20 (10-30)</td>
<td>21.8</td>
</tr>
<tr>
<td>high fat</td>
<td>10 (6-20)</td>
<td>14 (9-20)</td>
<td>10 (6-16)</td>
<td>15 (9-25)</td>
<td>28.8</td>
</tr>
<tr>
<td>Cheese</td>
<td>40 (20-60)</td>
<td>45 (20-80)</td>
<td>35 (20-60)</td>
<td>60 (38-100)</td>
<td>14.6</td>
</tr>
<tr>
<td>high fat</td>
<td>42 (20-60)</td>
<td>50 (30-80)</td>
<td>30 (20-60)</td>
<td>60 (36-100)</td>
<td>15.4</td>
</tr>
<tr>
<td>Milk, fil, yoghurt</td>
<td>516 (315-747)</td>
<td>619 (412-876)</td>
<td>490 (252-726)</td>
<td>769 (506-1124)</td>
<td>2.2</td>
</tr>
<tr>
<td>full fat</td>
<td>320 (176-497)</td>
<td>320 (206-527)</td>
<td>252 (166-412)</td>
<td>435 (288-808)</td>
<td>2.7</td>
</tr>
<tr>
<td>Bread</td>
<td>80 (50-133)</td>
<td>102 (60-157)</td>
<td>95 (56-148)</td>
<td>153 (94-237)</td>
<td>11.0</td>
</tr>
<tr>
<td>low fibre</td>
<td>80 (47-124)</td>
<td>94 (51-150)</td>
<td>81 (47-135)</td>
<td>141 (80-225)</td>
<td>11.0</td>
</tr>
<tr>
<td>Sauces</td>
<td>50 (19-100)</td>
<td>50 (25-100)</td>
<td>50 (15-75)</td>
<td>80 (45-145)</td>
<td>6.1</td>
</tr>
<tr>
<td>full fat</td>
<td>30 (15-60)</td>
<td>48 (15-89)</td>
<td>30 (16-75)</td>
<td>90 (34-108)</td>
<td>11.6</td>
</tr>
<tr>
<td>Pasta, rice, potatoes</td>
<td>213 (125-300)</td>
<td>225 (150-325)</td>
<td>180 (150-255)</td>
<td>284 (185-415)</td>
<td>4.2</td>
</tr>
<tr>
<td>Vegetables</td>
<td>52 (25-95)</td>
<td>55 (30-100)</td>
<td>100 (50-190)</td>
<td>96 (50-146)</td>
<td>1.6</td>
</tr>
<tr>
<td>Fruit</td>
<td>190 (120-265)</td>
<td>150 (105-225)</td>
<td>198 (105-311)</td>
<td>200 (105-248)</td>
<td>2.4</td>
</tr>
<tr>
<td>Juice</td>
<td>206 (150-350)</td>
<td>206 (150-410)</td>
<td>252 (206-412)</td>
<td>378 (206-504)</td>
<td>1.8</td>
</tr>
<tr>
<td>Cereals</td>
<td>26 (19-174)</td>
<td>45 (26-200)</td>
<td>40 (20-101)</td>
<td>57 (26-145)</td>
<td>7.1</td>
</tr>
<tr>
<td>Pizza, pies, pancakes</td>
<td>200 (140-255)</td>
<td>210 (140-273)</td>
<td>175 (103-241)</td>
<td>250 (133-345)</td>
<td>9.0</td>
</tr>
<tr>
<td>Eggs, nuts, legumes</td>
<td>60 (30-143)</td>
<td>60 (30-180)</td>
<td>60 (30-121)</td>
<td>60 (35-106)</td>
<td>7.6</td>
</tr>
<tr>
<td>Meat</td>
<td>135 (70-206)</td>
<td>159 (89-246)</td>
<td>145 (88-208)</td>
<td>210 (150-370)</td>
<td>7.5</td>
</tr>
<tr>
<td>burgers, sausages</td>
<td>115 (60-185)</td>
<td>130 (60-210)</td>
<td>120 (84-185)</td>
<td>187 (120-300)</td>
<td>8.0</td>
</tr>
<tr>
<td>Poultry</td>
<td>85 (59-119)</td>
<td>103 (83-148)</td>
<td>103 (71-155)</td>
<td>150 (62-200)</td>
<td>6.0</td>
</tr>
<tr>
<td>Fish</td>
<td>60 (38-125)</td>
<td>69 (30-111)</td>
<td>75 (50-125)</td>
<td>100 (30-175)</td>
<td>6.4</td>
</tr>
<tr>
<td>Chips, crisps</td>
<td>100 (18-155)</td>
<td>75 (24-150)</td>
<td>85 (25-150)</td>
<td>168 (98-225)</td>
<td>9.6</td>
</tr>
<tr>
<td>Cakes, biscuits</td>
<td>50 (24-90)</td>
<td>49 (25-90)</td>
<td>55 (25-92)</td>
<td>56 (30-105)</td>
<td>16.1</td>
</tr>
<tr>
<td>Soft drinks</td>
<td>252 (176-503)</td>
<td>297 (206-500)</td>
<td>330 (206-504)</td>
<td>471 (330-800)</td>
<td>1.7</td>
</tr>
<tr>
<td>Beverages (other)</td>
<td>273 (176-500)</td>
<td>320 (181-574)</td>
<td>561 (261-1028)</td>
<td>618 (324-1019)</td>
<td>0.3</td>
</tr>
<tr>
<td>Sweets, chocolate</td>
<td>16 (6-33)</td>
<td>12 (6-33)</td>
<td>36 (14-75)</td>
<td>30 (12-84)</td>
<td>18.0</td>
</tr>
<tr>
<td>Other sweet foods</td>
<td>61 (20-129)</td>
<td>70 (30-175)</td>
<td>64 (16-142)</td>
<td>59 (23-163)</td>
<td>7.3</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>12 (6-18)</td>
<td>18 (10-36)</td>
<td>17 (7-24)</td>
<td>18 (15-34)</td>
<td>4.5</td>
</tr>
</tbody>
</table>

| Total energy (MJ)          | 8.11 (6.79-9.60) | 8.91 (7.45-10.46) | 8.37 (6.75-10.30) | 12.08 (9.75-14.87) |
| Total energy (kcal)        | 1939 (1622-2294) | 2130 (1780-2500) | 2000 (1613-2463) | 2887 (2330-3553) |
| ED (kJ/g)                  | 6.62 (5.63-7.74) | 6.53 (5.55-7.82) | 6.55 (5.50-8.18) | 7.39 (6.13-8.66) |

IQR: inter-quartile range, 25<sup>th</sup>-75<sup>th</sup> percentile
Figure 4.1 Consumers of food groups. Percentage of consumers of each food group and subgroup. Food groups and subgroups are in the same order when read clockwise from the top of the diagram as in Table 4.2.

Figure 4.1 illustrates the percentage of consumers for each food group, by age and sex. This provides a point prevalence of consumption on a given day. Table 4.2 presents the median intakes for consumers only. In most of the studies, results are presented for 9- and 15-year-olds and for girls and boys separately. This is due to large differences in food and energy intakes between these different life-stages, and between the sexes at similar life-stages, particularly in adolescence. The energy density of each food group is also given, discussed more in Section 4.3.

An association with macronutrient intakes and socioeconomic status was seen only in 15-year-old girls, where those with mothers with a high level of education had significantly lower fat intakes than those without, however the differences were very small (29.1 % vs. 30.1 %, \( P = 0.017 \))

Crude differences in intakes between EYHS I and II are not discussed further, but the stability of intakes is the focus of Study IV (see Section 4.6).

Macronutrient intakes for EYHS I and II are presented in Table 4.3. Compliance with the goals for macronutrient intakes as percentage of energy was generally poor,
particularly for saturated fat and sucrose, and this is examined in more detail in Study II (see Section 4.4).

![Table 4.3](image)

<table>
<thead>
<tr>
<th></th>
<th>NNR</th>
<th>EYHS I</th>
<th>EYHS II</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All</td>
<td>9y</td>
<td>15y</td>
</tr>
<tr>
<td>Protein</td>
<td>15</td>
<td>15.1</td>
<td>15.3</td>
</tr>
<tr>
<td>Fat</td>
<td>30</td>
<td>32.6</td>
<td>32.2</td>
</tr>
<tr>
<td>saturated fat*</td>
<td>&lt;10</td>
<td>14.8</td>
<td>14.8</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>55</td>
<td>51.9</td>
<td>52.4</td>
</tr>
<tr>
<td>sucrose</td>
<td>&lt;10</td>
<td>11.5</td>
<td>11.6</td>
</tr>
</tbody>
</table>

NNR: Nordic Nutrition Recommendations’ population goals (Alexander et al., 2004)
* Saturated fat limit includes trans-fats

### 4.2.1 Energy reporting

The range of suspected energy misreporting can be seen in Table 4.1. The proportion of energy under-reporting in this sample was not excessive and is in line with other reported prevalences, however it should be noted that wide variation exists (Maurer et al., 2006). In this study, 9-year-olds were considered adequate reporters if they had a reported energy to predicted energy ratio of between 0.97 and 2.91 (girls) or between 0.98 and 3.08 (boys); 15-year-olds if the ratio was between 0.98 and 2.98 (girls), and 1.03 and 3.06 (boys); 21-year-olds needed a ratio of between 0.93 and 3.05 (girls) and 1.00 and 3.41 (boys) to be considered adequate reporters. Energy over-reporting was lower, as expected, but this has not traditionally been given as much attention as under-reporting.

In EYHS I, energy misreporting occurred significantly more in the older age group, but no difference between sexes was seen. In EYHS II, no association with either age or gender was seen.

In Study I, II and IV, the subjects identified as possible under/mis-reporters were removed from the sample, and the main analysis was repeated on the remainder. Removing under/mis-reporters had almost no effect in any of the studies.
4.3 Energy density is a marker of dietary quality (Study I)

The method employed here, and widely elsewhere, can only flag the most extreme under-reporters when just one day of dietary data is available (Black, 2000b). The Goldberg method is perhaps more suited to detecting misreporting at the group level, but while this is informative, this offers no means of dealing with the actual misreporters as they are not identified. To calculate the predicted energy requirements and thus the cut-offs, we predicted BMR from equations (Schofield, 1985), and used PAL values that were published. The more days of intake, the larger the sample, and the more precisely measured BMR and PAL are, the narrower the range, and the more accurate the results, would be. As accelerometry is proving a good method for objectively measuring activity in field studies, the potential for improving energy expenditure estimation cheaply in free-living subjects is huge. As accelerometry data was also available, it was theoretically possible to calculate energy expenditure from this. However, as the equations have not been fully validated, it was felt that they were too preliminary to be used reliably in this study. It should be acknowledged that an inaccurate PAL value will result in an over or under-estimation of inadequate energy reporters. Improved methods for assessing energy expenditure would help increase the sensitivity of this method to detect misreporters.

4.3 Energy density is a marker of dietary quality (Study I)

Subjects with low energy density diets had significantly higher intakes of micronutrients and of food groups that are recommended in both national and Nordic FBDG. They also had significantly lower intakes of total fat, saturated fat and sucrose, and these diets were the only ones that met the population goals for these nutrients. Higher energy density diets were associated with an increased intake of food groups that should be limited in the diet, such as foods high in energy and low in nutrients (i.e. cakes, biscuits, sweets, chocolate, other sweet foods and soft drinks). The picture both in terms of amounts consumed and of the proportion of the sample consuming the food groups was quite consistent in all age and sex groups.

The discriminant analysis was able to classify subjects to the same groups as energy density alone did 65% of the time, increasing to 89% if just the extreme tertiles were considered. This means that 89% of the time, using dietary energy density to classify most subjects into groups with two very different kinds of diets (the upper and the lower tertile) [a relatively simple calculation] resulted in subjects being classified into
the same groups as when subjects were classified into groups based on the information on all food groups [a more complex calculation].

In addition, the discriminant analysis also indicated that the food groups that discriminated the most between people with the low and high energy-density diets were also the same food groups as those that differed most across the energy density tertiles based on the results of the ANOVA. These food groups and macronutrients are shown in Figure 4.2 for diets of low-, mid- and high-energy density.

Figure 4.2 Energy density and dietary quality. Diets of low, mid and high dietary energy density (based on tertiles) and i) percent energy from macronutrients, and ii) grams of selected food groups. Food groups selected were those associated most with energy density in both the ANOVA and discriminant analysis. All nutrients and food groups were significantly associated with energy density, $P < 0.001$. 

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46
4.3.1 Use of energy density

These results suggest that grouping people based on the energy density of their diet can function as a way of identifying people with more- and less-healthy diets, at least in nutritional studies, if not clinically. While it is not yet possible to calculate the energy density of a diet and say that is “healthy” or not, it is plausible that ranges could be developed in the future that could serve as a guide. The WCRF, for example, recommends an energy density for the population of 525 kJ (125 kcal) per 100 g (World Cancer Research Fund/American Institute for Cancer Research, 2007). One methodological problem is that while fats and oils naturally have the highest density, they are very different in terms of their health effects, something that energy density obviously cannot differentiate. While more complex means of dietary patterning are also useful, and may provide richer information, it could be beneficial if some common standard, such as energy density could also be reported to help with the comparability between studies. Currently this is a problem as data-driven patterns are specific to each study.

The definition and calculation of energy density is something that should be agreed on, which is another methodological issue. It is variously calculated in the literature as the density of food with beverages, without beverages, with milk but not soft drinks, etc. Because of the huge effect that beverages, being naturally energy dilute, can have, and the fact that they can be influenced by temperature, activity etc (Rolls, 2009), a consensus is gradually emerging that it should, as a bare minimum, be based on solid food only (Ledikwe et al., 2005; Johnson et al., 2009).

4.4 Saturated fat and sucrose intakes are too high
(Study II)

As seen in Table 4.3, p.44, group means in EYHS I and EYHS II of several macronutrients did not meet the population goals. This was most extreme for saturated fat and sucrose, both of which are distinct in that the population goals for these nutrients are set as an upper limit only (i.e. <10 % of energy) (World Health Organisation, 2003; Alexander et al., 2004). The goals are formulated so that the mean of 100 % of the population should be at the stated level. Naturally, members of the population will have higher and lower intakes than the goal. When the largest possible group of compliers with the goals was calculated - by starting with subjects with the lowest intakes first and adding more and more subjects and recalculating the mean - it was found that more children than adolescents complied with the goal for sucrose, while more adoles-
cents than children complied with the total fat and saturated fat goals. By the time the mean saturated fat intakes of 8% of the 9-year-old boys was calculated (again, starting with the lowest), the mean was above the goal. Overall, just one fifth of all subjects complied with the goal for saturated fat.

The food groups identified as the largest sources of energy, total fat, saturated fat and sucrose in Study II are presented in Table 4.4. They reflect the traditional Swedish diet, where milk products, potatoes, bread and meat feature heavily. They also illustrate the large contribution that energy-dense, nutrient-dilute food groups such as soft drinks; cakes and biscuits; sweets and chocolate; other sweet foods; and crisps and chips are making in the diets of children and adolescents. In all, these foods contributed approximately 20% of energy, fat and saturated fat, and almost three-quarters of sucrose intakes.

Intakes of saturated fat remain stubbornly above dietary recommendations across Europe (World Health Organisation, 2006). Sweden is not unique in this sense, although a recent pan-European comparison of intakes did find that Swedish adults had the highest percent energy from saturated fat of the countries examined (Linseisen et al., 2009).

### 4.4.1 Setting recommendations for fat and sugar

Any comparison of intakes to population goals takes for granted that the goals and recommendations are sound. The setting of such recommendations is not easy, and it should be recognised that although based in science, these are rounded figures chosen partly for convenience and are not set in stone (Taubes, 2001; Smit et al., 2009). Fat and sugar increase the palatability and hence the enjoyment of food. Humans have an innate preference for sweet, energy-dense foods. They are important and valuable components of the diet. Fat enhances absorption of fat-soluble vitamins, and some fatty acids are essential (i.e. cannot be synthesised by the body). A diet low in total fat will often be higher in carbohydrates (a phenomenon termed the “fat-sugar see-saw” (McColl, 1988) and this also has consequences for energy balance, satiety and insulin sensitivity.

Dietary guidelines have been in place for decades now, but recommendations alone are ineffective at changing the food supply, as evidence from the US suggests (Krebs-Smith et al., 2010). In the rush to recommend reduced intakes of fat and in particular saturated fat, the importance of the replacement for saturated fat was not fully appreciated. It seems that in terms of CHD, PUFAs are the optimal replacement (Jakobsen et al., 2009), while trans-fats are probably the worst (Mozaffarian et al., 2009). On the
### Table 4.4 Food group sources of energy, total fat, saturated fat and sucrose in EYHS I. The ten biggest contributors to each are shown.

<table>
<thead>
<tr>
<th>Energy Rank</th>
<th>Total fat Rank</th>
<th>Saturated fat Rank</th>
<th>Sucrose Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Milk, fil, yoghurt full fat</td>
<td>1 13.9</td>
<td>2 13.7</td>
<td>1 19.7</td>
</tr>
<tr>
<td>Bread low fibre</td>
<td>2 13.5</td>
<td>10 3.8</td>
<td>-</td>
</tr>
<tr>
<td>Meat, dishes burgers, sausages</td>
<td>3 12.1</td>
<td>1 21.5</td>
<td>2 19.5</td>
</tr>
<tr>
<td>Pasta, rice, potatoes</td>
<td>4 8.7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sweets, chocolate</td>
<td>5 5.8</td>
<td>8 4.7</td>
<td>5 5.6</td>
</tr>
<tr>
<td>Other sweet foods</td>
<td>6 5.6</td>
<td>7 4.8</td>
<td>6 5.0</td>
</tr>
<tr>
<td>Cheese high fat</td>
<td>7 4.8</td>
<td>4 9.8</td>
<td>3 13.9</td>
</tr>
<tr>
<td>Cakes, biscuits</td>
<td>8 4.1</td>
<td>6 5.0</td>
<td>7 4.9</td>
</tr>
<tr>
<td>Soft drinks</td>
<td>9 4.0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pizza, pies, pancakes</td>
<td>10 3.9</td>
<td>5 5.2</td>
<td>8 4.5</td>
</tr>
<tr>
<td>Spreads, oils high fat</td>
<td>- 3</td>
<td>11.7</td>
<td>4 11.5</td>
</tr>
<tr>
<td>Sauces</td>
<td>-</td>
<td>9 4.6</td>
<td>-</td>
</tr>
<tr>
<td>Chips, crisps</td>
<td>-</td>
<td>-</td>
<td>10 2.3</td>
</tr>
<tr>
<td>Fruit</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Juice</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cereals</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Other food groups</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
other hand, the total amount of fat in the diet is probably of less importance than originally assumed (Smit et al., 2009). However, this should not distract from the fact that a diet that is higher in fruits and vegetables, wholegrains, fish and lower in salt and saturated fats, particularly trans-fats, is health-promoting. In other words, it may be “time to simplify the message until we can clarify the specifics” (Schwenke, 2009).

As trans-fats are of such concern, it would have been interesting to examine the food sources of these, but detailed information was not available in the nutritional database at the time of EYHS I. In the national survey (Barbieri et al., 2006), half of the trans-fat intake was found to come from processed foods; cakes, biscuits, sweets and chocolates, chips and crisps and fatty sauces. Therefore, the sources of saturated fat identified here probably mirror the sources of trans-fats to some degree, and advice to decrease intakes would still require a much lower consumption of processed foods.

### 4.4.2 Food-based dietary guidelines (FBDGs)

FBDG aim to translate nutritional advice into more practical advice. One of the keys to the success of FBDG is how understandable and acceptable they are to the target population. Although they are aimed at everyone, the reality is that not everyone will follow them. What then is the effect on the population (the level at which these goals are set) if they are only partially followed?

The results of Study II suggest that to lower sucrose intakes to the recommended level, a reduction in the foods termed “junk foods” here (sweets and chocolate, cakes and biscuits, chips and crisps, and other sweet foods), or in soft drink consumption, would be sufficient for children. For adolescents, reducing “junk foods” would be effective, but soft drink intakes are so high that a halving of consumption would still leave sucrose intakes above 10 % of energy. For saturated fat intakes, it seems that unless all of the guidelines proposed here are adhered to in full, and by all children and adolescents, the goal for saturated fat is unlikely to be met. No individual scenario was sufficient to lower intakes to less than 10 % of energy. Multiple changes were required for both children and adolescents to bring intakes close to 10 % of energy, but for children, even a combination of scenarios was not enough to bring intakes in line with the goal.

The current FBDG were not designed specifically for children, and therefore how they are interpreted by children and adolescents (and/or their caregivers) should probably be evaluated specifically. Currently adherence to the FBDG is studied in adults.
One of the aims of Study II was to see if an additional food group could be identified as a target for a FBDG, but we found that the ones identified by Barbieri et al. (2006) were the most relevant and should form the basis for children’s FBDG. However, the feasibility of such changes is questionable. For example, soft drink consumption (in available kg/p/y) has increased four-fold between 1960 and 2005 (Jordbruksverket, 2009). Adherence to FBDG would require substantial changes in behaviour, and the acceptability to consumers of such guidelines must be considered.

The only food for which a guideline is expressed in terms of grams per day is for fruit and vegetables, of which an average of 500 g per day should be consumed, or 400 g between the ages of four and nine. Given that far less than 100 percent of all age and sex subgroups ate either fruit or vegetables, despite the generous definition of a consumer (someone who ate ≥1 g), and the median intakes of those who did consume fruit and vegetables, this guideline is a long way from reality. Considering the benefits of high fruit and vegetable intake for CVD, cancer and chronic disease protection, this is a worrying finding.
The difficulty with comparing intakes from the studies to recommendations is that the recommendations that were in place at the time of data collection were different to those in place now. However, the basic principles have not changed, and even according to a graphical model that was also in place then (the plate model), fruit and vegetables should have comprised more than one-third of every meal.

4.5 Dietary and other behaviours cluster together
(Study III)

The results of Study III suggest that, already at young ages, unhealthy behaviours cluster together. Clusters differed in both number and size between the different ages and sexes, and adolescent girls had more and bigger clusters than any other group (Figure 4.4).

![Bubble chart showing the mean number of risk factors per cluster (y-axis) in each age- and gender-subgroup. The size of the bubble is proportional to the number of significant clusters (given below bubble).](image)

Figure 4.4 Size and number of risk factor clusters. Bubble chart showing the mean number of risk factors per cluster (y-axis) in each age- and gender-subgroup. The size of the bubble is proportional to the number of significant clusters (given below bubble).

Figure 4.5 illustrates the risk factors that occurred most frequently within the clusters. The risks that clustered together most were dietary factors, and although some were correlated, not all were. The finding of more and bigger risk clusters in 15-year-old girls is worthy of further study.
4.6 Dietary intakes track slightly over time (Study IV)

The findings regarding the tracking of diets between childhood and adolescence, and between adolescence and young adulthood were similar (Figure 4.6). Fair tracking (a $\kappa$ value of between 0.21 to 0.40) was found for one food group in each of the two age
groups, and several more had slight tracking. All nutrients exhibited at least slight tracking in both age groups.

While these results seem modest, it must be borne in mind that a 24-hr recall is considered a poor measure of habitual diet. Therefore the associations between EYHS I and EYHS II would be expected to be weak, because of the statistical “noise” caused by uncertainty in the measurements. Another point is that six years is quite a long time at these stages of life, and much may have changed in terms of home situation, school environment, personal development and physical requirements. In view of this, low (but detectable) tracking values hint that some stability is present. However, while the results are perhaps too premature to base interventions on, they add to an emerging picture of this relevant area. For longitudinal studies, regular dietary assessments are needed.

4.7 Methodological considerations

Beyond the methodological issues mentioned in the preceding sections, such as the nature of the study design and the limitations of the dietary assessment method, the following are also worthy of consideration.

4.7.1 Food groups

New food groups were created. This is problematic as it limits the comparisons that can be made with other Swedish studies that might otherwise have used the same food composition database as us. On the other hand, the definition of food groups is important and it was felt that the creation of modified groups was justified to enable examination of particular subsections of the food group that were of interest (e.g. high and low fibre bread).

4.7.2 Day of the week or season effect

The dietary recalls were conducted throughout the school year, from September 1998 to May 1999. The aim was to minimise the effect of seasonal variation. Although a large portion of the year was covered, 70 % of recalls were collected in the months October, November, February, March and April. The summer months were not represented, and December and January were under-represented.
### 4.7 Methodological considerations

#### Figure 4.6 Tracking values for food groups and nutrients, from childhood to adolescence, and from adolescence to young adulthood. Within the food groups (top) or nutrients (bottom), and for each tracking parameter, cells are shaded relative to the values for each parameter. Darker colours indicate higher values and thus greater tracking. Cells are blank where a tracking value could not be calculated.

<table>
<thead>
<tr>
<th></th>
<th>9y to 15y</th>
<th></th>
<th></th>
<th>15y to 21y</th>
<th></th>
<th></th>
</tr>
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<td>κ</td>
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<td>0.55</td>
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<tr>
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<td>0.06</td>
<td>0.55</td>
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<td>0.14</td>
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<tr>
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<td>0.15</td>
<td>0.77</td>
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<td>0.11</td>
</tr>
<tr>
<td>Pizza, pies, pancakes</td>
<td>0.66</td>
<td></td>
<td>0.22</td>
<td></td>
<td>0.77</td>
<td></td>
</tr>
<tr>
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<td>0.00</td>
<td>0.47</td>
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<tr>
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<td>Spreads, oils</td>
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<td>Other sweet foods</td>
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<td>0.06</td>
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<td>Soft drinks</td>
<td>0.44</td>
<td>0.07</td>
<td>0.63</td>
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<td>0.48</td>
<td>0.17</td>
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<tr>
<td>Chips, crisps</td>
<td>0.67</td>
<td></td>
<td>0.22</td>
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<td>Energy</td>
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<td>Protein (%E)</td>
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<td>0.05</td>
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<tr>
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<td>0.06</td>
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<td>saturated fat (%E)</td>
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<td>0.07</td>
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<td>0.54</td>
<td></td>
<td>0.35</td>
<td>0.03</td>
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<tr>
<td>sucrose (%E)</td>
<td>0.39</td>
<td>0.11</td>
<td>0.57</td>
<td></td>
<td>0.38</td>
<td>0.07</td>
</tr>
<tr>
<td>Fibre</td>
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<td>0.09</td>
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<tr>
<td>Vitamin C</td>
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<td>0.04</td>
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<td>0.19</td>
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<tr>
<td>Folic acid</td>
<td>0.35</td>
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<td>Iron</td>
<td>0.35</td>
<td>0.04</td>
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<td></td>
<td>0.34</td>
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<tr>
<td>Calcium</td>
<td>0.43</td>
<td>0.18</td>
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<td>0.06</td>
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<tr>
<td>Energy density</td>
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<td></td>
<td>0.40</td>
<td>0.16</td>
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S: stability; K: Cohen’s κ; P: predictive value for staying in the highest tertile. See p.36 for further details. %E: percentage of energy.
Variation over a week was not as completely captured either, as the recall interviews were carried out on Mondays to Fridays in EYHS I, and on Mondays to Saturdays in EYHS II. This means that no Fridays or Saturdays were captured in EYHS I, while some Fridays were described in EYHS II. If food intake varies systematically between the weekend and weekdays, this would mean that weekend intakes are under-represented, and evidence suggests that these foods are more likely to be higher in fat and sugar. A weekday effect on energy from sucrose (but no other macronutrient) was detected in both EYHS I and II. In EYHS I, percent energy from sucrose significantly ($P < 0.01$) higher on Sundays (13.5 %) compared to every other day of the week (10.7-11.1 %). In EYHS II, percent energy from sucrose was significantly higher ($P < 0.05$) on Friday (13.8 %) than other days. Sunday had the next highest level (12.1 %), but this was not significantly more than other days (range 9.5 to 10.2 %).

While this is an unfortunate bias, and a result of practical considerations, it is most likely that the bias would underestimate the unhealthy foods, and that therefore the intakes we have are “healthier” than in reality. This is something that should be incorporated into future study designs as much as possible.

### 4.7.3 Changes in food supply

The data presented here are from 1998-9. It is reasonable to wonder if the picture today would look very different. A more recent nationally representative study carried out by the National Food Administration in 2003 (Barbieri et al., 2006) suggests that at least by then, no major improvement was seen. The most recent food availability statistics for Sweden show no dramatic increase in fruit and vegetables availability (per capita) in the years to 2005, the most recent year for which data is available (Jordbruksverket, 2009). It is therefore likely that the data presented here is a fair indication of the current situation and that the issues illustrated here remain relevant.
CHAPTER 5

Concluding remarks

Dietary energy density can discriminate diets of differing dietary quality within a population. Diets with the lowest energy density are more likely to meet population goals for nutrients, and to include more fruits and vegetables and other recommended foods. They also included less energy-dense, nutrient-dilute foods such as confectionary, baked goods and soft drinks. Dietary energy density may therefore have potential as a simple indicator of overall dietary quality. This could be of use in nutritional epidemiology, as well as perhaps in the formulation of dietary guidance for the population.

Intakes of saturated fat and sucrose exceed the population goals set for optimal health, particularly in children. The sources of these macronutrients indicate that energy-dense, nutrient-dilute food groups were substantial contributors. The simulations performed here showed that changes which would result in a healthier macronutrient profile were possible. However, the goals are unlikely to be met without considerable alterations in dietary habits, and/or food supply.

Already at these young ages, multiple risk factors for chronic disease are present. Examining the clustering of unhealthy lifestyle behaviours suggests that very different clustering occurs in children and adolescents, and in boys and girls. These should be considered as disparate groups when studying these multiple behaviours, or in targeting behaviours for change.

The stability of dietary intakes from childhood to adolescence and from adolescence to young adulthood is slight. Methodological limitations could be particularly important to acknowledge here. Certain food groups tracked better than others, and the tracking for nutrients was generally stronger. Encouragement and support to consume a healthier diet needs to be constant and consistent from a young age.
5.1 Future research questions

Based on these conclusions, the following research questions appear worthy of further attention:

Given the focus on dietary pattern analysis, can energy density be used as a complement to more advanced methods of analysis, to enhance comparability? Can the results of Study I be replicated using data from a study using different assessment methodology and in a different population? How important is the method used to calculate energy density? Can an energy-density/nutrient-density profile system be an effective tool to facilitate change at the individual level?

The intakes of saturated fat and sucrose remain high in children and adolescents, but are adult population goals suitable for these ages? Should dietary guidelines be developed specifically for this population? How will caregivers accept such guidelines? How can the intakes of fruits and vegetables be increased, and is it even realistic given that there is not currently enough available?

Why do unhealthy lifestyle risk factors appear to cluster so much more in adolescent girls? How do healthy lifestyle behaviours cluster in these ages? Do a mixture of healthy and unhealthy behaviours cluster together in a way that might suggest compensation between them?

Do dietary intakes track well over time, and in whom does it track best? Were the low values seen here a result of weak dietary assessment methodology, or a reflection that circumstances and diet naturally change over time, and with age?

The answers to these questions could help to improve the diets of current and future generations of Swedish children and adolescents.
Bibliography


European Food Security Group (2006). 10 years on... hunger still prevails.


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Several years ago someone advised me not to leave the writing of the acknowledgments section until the very end of the thesis writing, when one is invariably exhausted and emotional. The same person also advised me not to do a PhD. I am happy to say that, as usual, I only followed half of the advice…

Michael Sjöström, main supervisor: thank you for taking me on as a PhD student and for guiding me through the process, teaching me about the world of science and research, and always giving me the freedom to try new things.

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