Project: Determinants of eating behaviour in European children, adolescents and their parents

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Coordinator and partners: The I.Family study was coordinated by Prof Dr Wolfgang Ahrens, University of Bremen and Leibniz Institute for Prevention Research and Epidemiology – BIPS, Bremen, Germany (deputy coordinators: Prof Dr Alfonso Siani, Institute of Food Sciences, National Research Council, Epidemiology and Population Genetics Unit (EPIGEN), Avellino, Italy; Prof Dr Iris Pigeot, University of Bremen and Leibniz Institute for Prevention Research and Epidemiology – BIPS, Bremen, Germany)

Seventeen research groups and small/medium enterprises from twelve countries participated in the I.Family study (alphabetically):

- Copenhagen Business School (CBS): Department of Intercultural Communication and Management (ICM); Copenhagen, Denmark
- Fondazione IRCCS Istituto Nazionale Tumori (INT): Nutritional Epidemiology Unit; Milan, Italy
- Institute of Food Sciences, National Research Council (ISA-CNR): Epidemiology and Population Genetics Unit (EPIGEN); Avellino, Italy
- Leibniz Institute for Prevention Research and Epidemiology (BIPS): Department Biometry and Data Management and Department Epidemiological Methods and Etiological Research; Bremen, Germany
- Minerva PRC Ltd. (MIN): Andover, United Kingdom
- National Institute for Health Development (NIHD): Department of Chronic Diseases; Tartu, Estonia
- Research and Education Institute of Child Health (REF); Strovolos, Cyprus
- Rudolf Magnus Institute of Neuroscience (UMC): Department of Neuroscience and Pharmacology of the Rudolf Magnus Institute of Neuroscience at the University Medical Center Utrecht; Utrecht, Netherlands
- Sahlgrenska Academy at the University of Gothenburg (UGOT): Department of Public Health, Section for Epidemiology and Social Medicine; and Community Medicine within the Sahlgrenska Academy; Gothenburg, Sweden

- Universidad de Zaragoza (UNIZAR): Research group Growth, Exercise, Nutrition and Development (GENUD); Zaragoza, Spain
- University of Bremen (UNIHB): Department of Neuropsychology and Behavioural Neurobiology (DNBN), Centre for Cognitive Sciences; Centre for Computing and Communication Technologies (TZI); Bremen, Germany
- University of Bristol (UBR): Centre for Exercise, Nutrition & Health Sciences at the School for Policy Studies; Bristol, United Kingdom
- University of Ghent (UGENT): Department of Public of the Faculty of Medicine and Health Sciences, Unit Nutrition and Food Safety; Ghent, Belgium
- University of Helsinki (UHEL): Institute for Molecular Medicine Finland (FIMM); Helsinki, Finland
- University of Lancaster (ULANC): Department of Philosophy, Politics and Religion; Lancaster, United Kingdom
- University of Pécs (UPE): Department of Paediatrics; Pécs, Hungary
- University of the Baleares Islands (UIB): Laboratory of Molecular Biology, Nutrition and Biotechnology – Nutrigenomics (LBNB); Palma de Mallorca, Spain

Summary

I.Family pursued two objectives: (1) to understand the interplay between barriers and drivers towards a healthy food choice as well as physical activity and how these affect the health of children and adolescents; (2) to develop and disseminate strategies to induce changes promoting a healthy dietary behaviour in European consumers, especially children, adolescents and their parents. The study provides targeted scientific data on which to base concrete action that results in measurable effects by taking advantage of the unique opportunity to follow up the large IDEFICS children's cohort. This not only provides added value by maintaining the existing cohort but also, exceptionally, allows assessment of the dynamic nature of causal factors (biological, behavioural, social and environmental factors), dietary behaviour and health outcomes over time and during the transition into adolescence. The project's acronym indicates its focus on the individual and his or her family by investigating the family environment, i.e. the socio-behavioural and genetic factors determining familial aggregation. We re-assessed children and their parents by comparing those families who developed or maintained a healthy diet with those whose diet developed in an unfavourable direction. These so called "contrasting groups" have undergone an enhanced protocol including expression of genes related to food choice and measurement of brain activation, sensory taste perception, sleep quality and duration, sedentary time, screen time, physical activity and impact of the built environment. I.Family also determined the prognostic value of diet, physical activity and other lifestyle factors for health outcomes such as body composition and cardio-metabolic markers in youth. The overall framework of the study is illustrated in Figure 1.

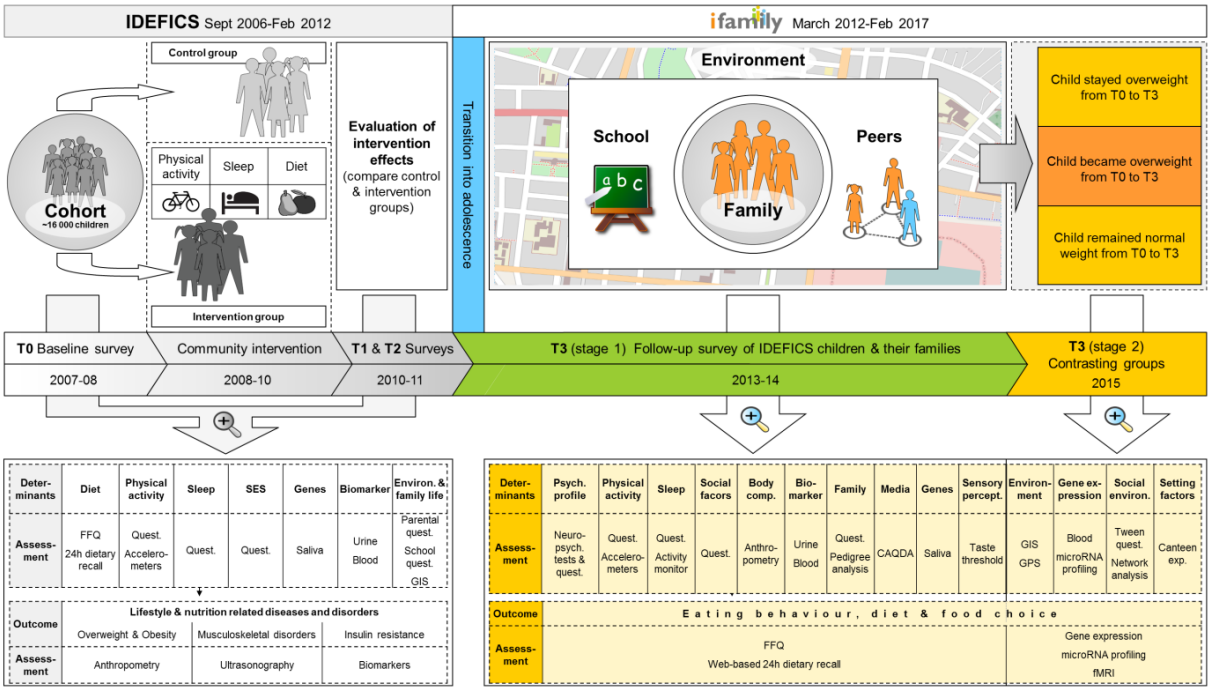

Figure 1: Framework of the I.Family study with overview of all examination modules and how it builds on the IDEFICS cohort[1]

I.Family provides methodological strengths, together with breadth of coverage and depth of investigation in the context of the ecological model. The study adds important evidence concerning the impact of environmental factors on health and health behaviours, in particular regarding exposure to food adverts and food choice, as well as the built environment and physical activity. It thus identifies leverage points for primary prevention, for empowerment of European consumers and protection of children from an overly obesogenic environment.

STUDY OBJECTIVES

I.Family pursued two strategic objectives:

- To understand the interplay between barriers and drivers towards a healthy food choice, physical activity and lifestyle factors, and their association with related health outcomes.
- To develop and disseminate strategies to induce changes promoting a healthy dietary behaviour in European consumers, especially children, adolescents and their parents.

WHO PARTICIPATED AND WHAT WAS MEASURED?

I.Family continued work that started in the previous IDEFICS study, which involved children aged 2–10 years at baseline from Belgium, Cyprus, Estonia, Germany, Hungary, Italy, Spain and Sweden. I.Family followed these children as they moved from childhood into adolescence and studied biological, behavioural, social and environmental factors that influence diet and health.

In 2007/8, the IDEFICS study recruited 16,228 children (**survey 1**). Two years later, 13,596 children were examined of whom 11,041 already participated previously (**survey 2**). Between the two surveys, about half of the children participated in a community-oriented **setting-based intervention** that was implemented in one region of each country where the other community served as control region.

I.Family then examined 9,617 children of whom 7,105 had participated before, now between the ages of 7 and 17 years, plus members of their families (**survey 3**). These children still depend on their immediate families, but are becoming more independent. Most recently, we undertook in-depth examinations of contrasting groups of children (**survey 4**) – specifically, children who had shown different weight trajectories in the previous surveys. The timeline of the baseline and follow-up examinations as well as of the intervention activities is shown in Figure 2.

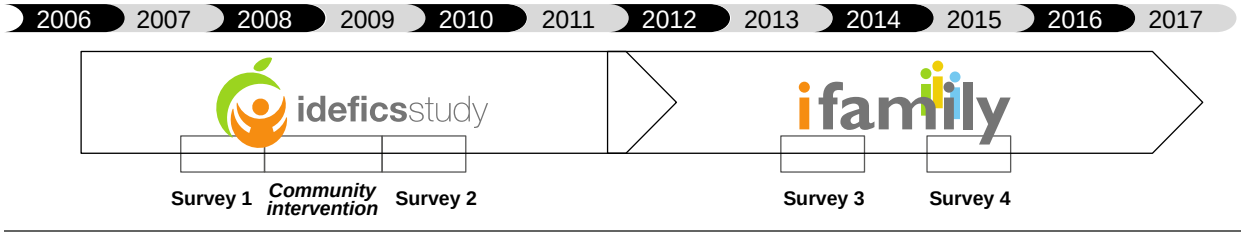

Figure 2: Timeline of the IDEFICS and I.Family studies

By tracking children's development across these transitional years and by examining the family environment in depth – including siblings as well as parents – I.Family studied how families, friends and environments influence health and behaviour.

Questionnaires

Questionnaires were filled in by parents about themselves or their children if they were younger than 12 years, and by adolescents themselves if they were at least 12 years old. The questionnaires asked for:

- General information about the participant/ the family
- Household structure and family kinship
- Family life, family rules
- Parenting style
- Socio-demographic characteristics of parents
- Pregnancy, breastfeeding & infancy for each child
- Medical history and medications
- School grades (adolescents)
- Peer networks (adolescents)
- Media consumption and attitudes towards TV advertisements
- Children's/ teens' money spending
- Dietary behaviour: meal habits, dieting and food frequency

- Food & beverage preferences
- Web-based 24-hour dietary recall
- Smoking/ alcohol consumption
- Physical activity and sleeping habits
- Well-being
- Body image
- Tanner stage
- Impulsiveness

Examinations and tests

Apart from the completion of the questionnaires, the participation in the study implicated going through an extensive set of examinations and tests. Participating in the single modules was voluntary. Children or parents could refuse their participation in any examination at any time. The examination protocol covered:

- Anthropometry (weight, height, waist circumference and skinfolds)
- Bioelectrical impedance analysis (BIA)
- Blood pressure
- Biological samples (urine, saliva, venous blood)
- Calcaneal ultrasonography (bone stiffness)
- Accelerometry (physical activity)
- Sleep duration and quality
- Location of physical activity using the global positioning system (GPS)
- Handgrip strength
- Sensory taste perception tests
- Neuropsychological tests
- Functional magnetic resonance imaging (fMRI)

In addition, we collected maternity cards and records of routine child visits and complemented the information on physical activity behaviour by data obtained from geographic information systems (GIS).

MAIN RESULTS

In the following we present some of the main results from the I.Family study as shown in the Publishable Summary of the Final Project Report from April 2017. The full report is available upon request (mail to: family@leibniz-bips.de). Some of these findings have been previously published. A list of all I.Family publications can be also found on the project website, under “Project publications”.

Impact of socio-economic status on prevalence/incidence of overweight/obesity

- In the study regions, the percentage of overweight/obese children differed between families of lower and higher socio-economic status (SES), but also between countries as shown in Figure 3 with a south-north gradient as also observed by other studies.

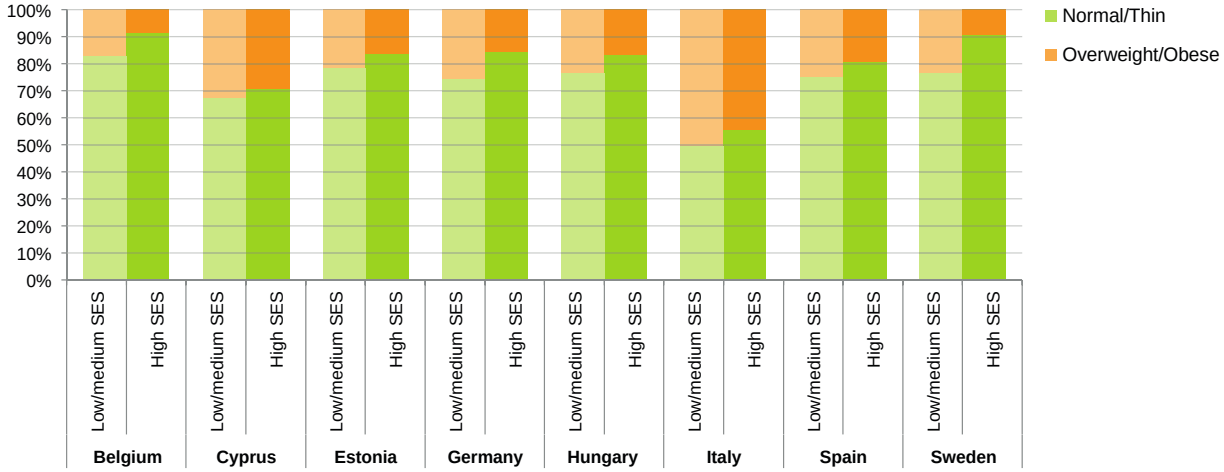

Figure 3: Prevalence of overweight and obesity by socio-economic status (SES, parental education) and by country

- As children grew up this effect got stronger. Figure 4 shows the incidence of overweight/obesity by socio-economic status (SES) over a six year period. In families of medium or low socio-economic status (SES), nearly twice as many as compared with higher SES families.

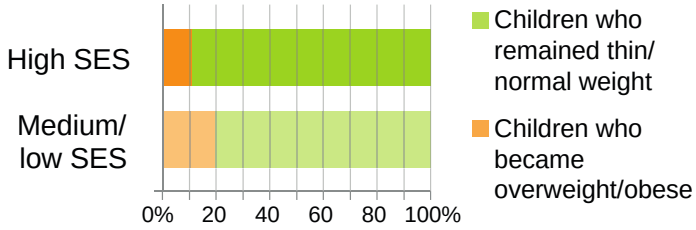

Figure 4: Percentage of normal weight children becoming overweight or obese within 6 years of follow-up by socio-economic status (SES)

Diet and children's health

- On average, the children ate too much **energy-dense food**, where the consumption of such foods increased with age. The average energy density of foods eaten by I.Family children was about 2 kcal/g^2 where an average energy density of about 1.25 kcal/g is considered as appropriate. Figures 5 and 6 show examples of popular foods among European children with relation to energy density and kilocalorie count.

3.4 kcal/g

2 kcal/g

1.4 kcal/g

Figure 5: Energy density of different ways of serving potatoes: Examples of the energy density of various potato preparations popular among European children

Chocolate	Potato chips	Bread	Spaghetti	Apples	Tomatoes
16 g	19 g	37 g	75 g	250 g	526 g

Figure 6: Six portions of foods with a kilocalorie count of 100 chosen from those most popular among children from the I.Family study

- A healthy **Mediterranean-type diet**, rich in vegetables, legumes, fruits, nuts, cereals and fish and low in other animal products, was popular in 30-40% of children. It is noteworthy that this was particularly the case in Swedish children[3].
- **Sugar intake** (all mono- and disaccharides) of children in I.Family was very high and made partly (e.g. in Germany) more than 30% of their total energy intake, irrespectively of being added or naturally occurring. The intake of total sugars as well as consumption of foods and drinks rich in added sugar were found to be higher on weekend days compared to weekdays[4].
- Children with a diet high in vegetables, wholemeal cereals, fruit and plain milk, and low in sugary products had a lower incidence of overweight/obesity[5]. After two years, the risk of becoming overweight/obese was reduced by 36% among children who adhered to this type of diet.
- **Infant breastfeeding** was associated with markers of metabolic health[6] and reduced risk of childhood overweight[7] (Table 1).

Exclusive breast-feeding duration	Risk of becoming overweight/obese compared to children who were never breastfed
1-3 months	13% decreased
4-5 months	19% decreased
6 months	29% decreased

Table 1: Effect of breastfeeding on overweight/obesity in later childhood

- Unhealthy diets were more common in children from poorer and less educated families[8] (Table 2).

	Common dietary patterns		
Family type	**Street food, fast food** French fries, hamburger, pizza, kebab, savoury pastries	**Sweet foods** Sweetened drinks, chocolate, biscuits, candies	**Healthy foods** Raw vegetables, fruits, wholemeal products
Migrants compared to non-migrants	↑ +24%		
High paternal education compared to low paternal education		↓ -30%	↑ +50%
High household income compared to low household income		↓ -30%	↑ +30%

Table 2: Dietary patterns that are more common (↑) or less common (↓) in children from families with specific characteristics

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- Parents who preferred fatty foods consumed twice as many fatty foods compared to those who did not prefer fatty foods. This could be observed for sweet foods: parents who preferred sweet foods consumed three times as many sugar-rich foods compared to those who did not prefer sugar-rich foods. However, children's food consumption seemed to be unaffected by their own **preferences** (see Figure 7).

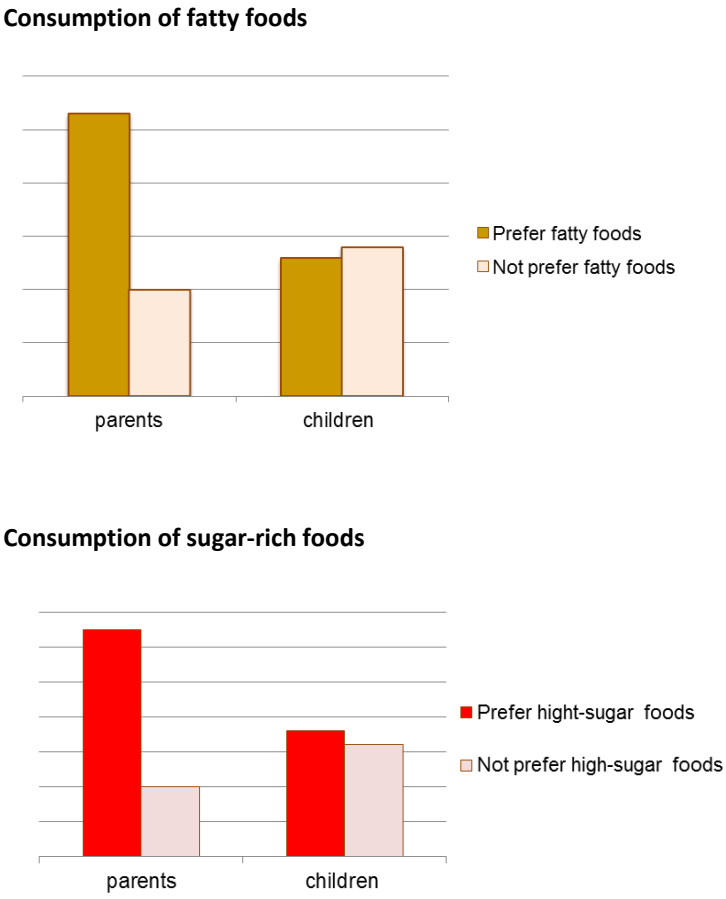

Figure 7: Sensory taste preferences and frequency of consumption of foods with high sugar and fat content

- Children were likely to adopt the same eating habits as their parents[9], an effect that got stronger as the number of shared meals increased, and even 3 times stronger if both parents shared the same or similar eating habits.

Media consumption

- A sub-study in Swedish children showed that **TV advertising** was a major factor encouraging children to eat unhealthy foods. Media influence was actually stronger than parental guidance in deciding what children eat. Children exposed to TV, especially commercial TV, consumed much more sweetened drinks (see Figure 8). This was observed regardless of whether parents discouraged such drinks or not[10].

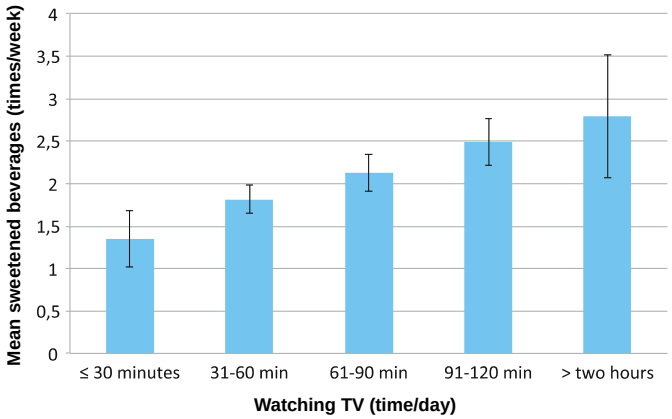

Figure 8: Consumption of sweetened drinks increased as TV time increased[10]

- Children who consumed **meals while watching TV** had a 20% greater risk of eating fatty foods and 30% greater risk of eating sugary foods compared to children who did not eat while watching TV. More surprisingly, we found that the effect of TV was the same for children who expressed high and low preferences for fats and sweets[11.]

Adherence to sleep guidelines and association with diet

- Only one third of children and adolescents met the recommended sleep guidelines issued by the National Heart, Lung, and Blood Institute[12] (Table 3). There was no difference between boys and girls.

Age	Recommended amount of sleep / 24hrs
Newborns	16–18 hours
Preschool-aged children	11–12 hours
School-aged children	At least 10 hours
Teens	9–10 hours
Adults (including the elderly)	7–8 hours

Table 3: Sleep recommendations for different age groups

- Children who met night-time sleep recommendations ate more vegetables than those not meeting the night-time sleep recommendations. Children who met the night-time sleep guidelines were also more likely to have healthy diets overall, as compared with those who did not meet the guidelines.

Sleep and well-being – what are the relationships?

- Children with poor psychosocial well-being (in particular, emotional and behavioural problems, problems with friends or peers) were at greater risk of becoming overweight[13].

- Overweight children were at greater risk of developing poor psychosocial well-being – in particular, worse emotional well-being, lower self-esteem, and problems in relationships with both family and friends[14].
- A large body of evidence suggests that short sleep duration and poor sleep quality are risk factors for childhood overweight[14]. Our data support the observation that children with short sleep duration were at increased risk of being overweight[15].
- Children whose well-being improved over time or stayed at a constant level tended to sleep longer at night as compared with children whose well-being worsened. In addition, they tended to have fewer difficulties in falling asleep and getting up in the morning.
- Furthermore, children who improved their night-time sleep duration or stayed at a constant level tended to have better well-being as compared with children whose sleep duration reduced. Children whose sleep quality remained good over time tended to have better well-being compared to those whose sleep quality worsened.

Physical activity and children's health

- Only 2% of young people in our 8 European study regions met current physical activity guidelines (Box 1) – to be at least moderately active for 60 minutes or more each day (Figure 9). The group with the highest percentage meeting the guidelines was Belgian boys – but still only 5% of them did so.

▪ Children and youth aged 5-17 should accumulate at least 60 minutes of moderate-to-vigorous intensity physical activity daily. ▪ Amounts of physical activity greater than 60 minutes provide additional health benefits. ▪ Most of the daily physical activity should be aerobic. Vigorous-intensity activities should be incorporated, including those that strengthen muscle and bone, at least 3 times per week.

Box 1: World Health Organisation´s recommendations on physical activity[16]

- Girls were less active than boys irrespective of how old they were. The daily duration of physical activity children declined at an average rate of 4.3% from the age of five to 15 years – a 4.1% per annum decrease in boys and a 4.5% per annum decrease in girls. Young people also became progressively more sedentary as they matured. At 5-7 years, they spent 40% of their time sitting, compared to 62% of their time at 14-16 years.

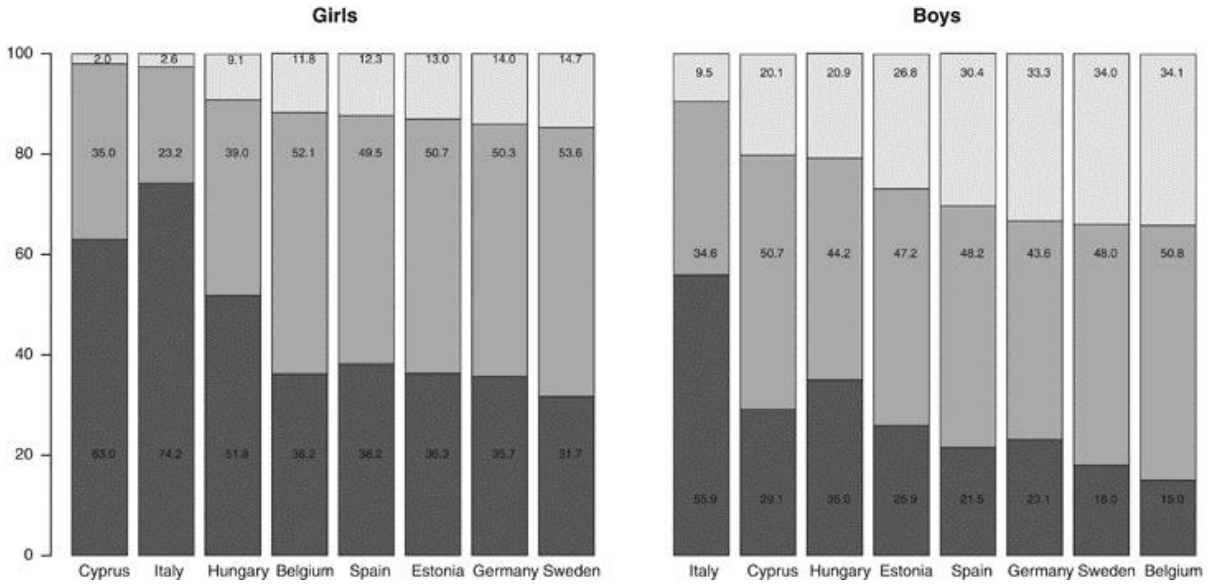

Figure 9: Percentage compliance to moderate-to-vigorous physical activity (MVPA) recommendations: lowest part: 0–30 min, middle part: 30–60 min, upper part: over 60 min[17]

- The place of residence also affected the gender gap in physical activity. There was considerable variation in physical activity levels by country. The children in our Italian cohort were the least active, and the Sweden children the most active. The difference in average daily activity duration between the least active population (Italy) and the most active (Sweden) was larger than the difference we observed between boys and girls. Indeed, girls in the two most active countries (Belgium and Sweden) were more active than boys in the two least active countries (Italy and Cyprus).
- There was a weak trend towards **increasing physical activity with increasing parental education and income** in the full sample. This trend was similar across the eight countries. There were some differences in the social gradient for particular behaviours (e.g. active transport, structured sports). However, these did not necessarily show up when we looked at overall activity levels.
- **Physical activity was clearly related in families** in a straightforward way: more active children had more active parents and siblings. This relationship was strongest between siblings; it was not quite as strong when we compared parents/ carers and children.

Local neighbourhoods – what difference do they make?

- For children, physical activity was encouraged by the availability of public open spaces within densely residential areas. However, this association was modified by safety concerns, age and sex. If parents felt that the neighbourhood was not safe for children, they tended to restrict children's outdoor activity. This is especially true if their child is female[18].
- For adolescents, good walking and cycling facilities as well as diverse destinations mattered, while public open spaces became less important. In addition, we know that physical activity declines sharply in the transition from childhood to adolescence. Our research showed that

urban moveability counteracts this decrease in physical activity, but with some differences between boys and girls. Connectivity and availability of walking and cycling facilities as well as diverse destinations seemed to promote an active lifestyle in girls. For adolescent boys, public open spaces remained an important factor to support adequate physical activity.

How family relations influence children's health

- **Family members resembled one another** in terms of height, body fat measures and cardiovascular disease risk (e.g. total cholesterol) (Figure 10). Mothers tended to resemble their children more than fathers. The resemblance was stronger for biological relatives (sibling pairs, parent-child pairs) than non-biological relatives (parental pairs), which indicates that these traits are likely under strong genetic influence. Sibling correlations for body fatness and total cholesterol were stronger than parent-child correlations, which could be related with the environment shared by siblings.

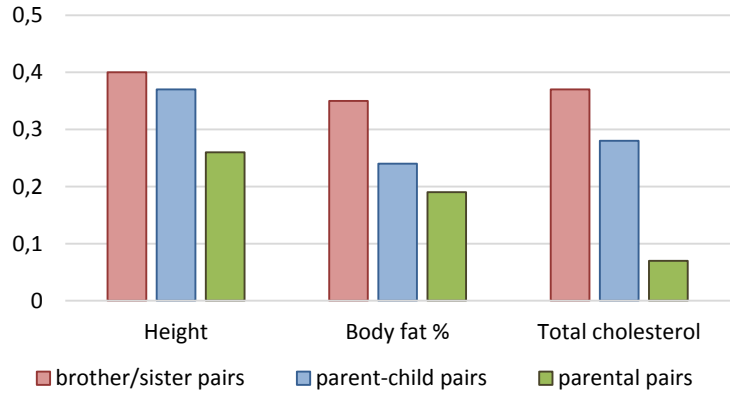

Figure 10: Correlations for height, body fat % and total cholesterol among family members

- Family members also had similar diets (Figure 11). Interestingly, the resemblance was strongest for sibling pairs and a bit less for parent-child and parental pairs. Since the correlation was similar in genetically related and non-genetically related family members, we may infer that the shared household is an important factor in dietary intake.

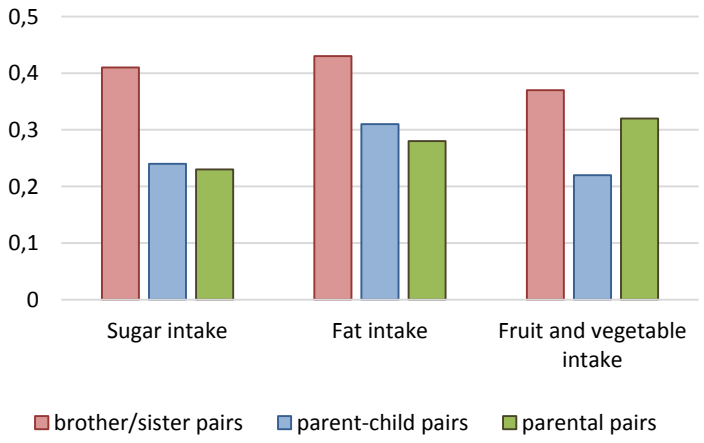

Figure 11: Correlations for sugar, fat, and fruit and vegetable intake within families

- **Parents and their children had similar food intakes** (Figure 12). This was especially true for the intake of healthy foods, but less so for the intake of unhealthy foods. One possible explanation might be that there are many external influences promoting unhealthy foods to children (e.g. supermarkets, advertising, pester power, etc.) in developed European societies but only few external influences for healthy foods.

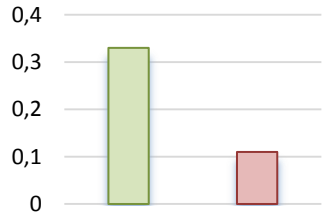

Figure 12: Parent-child correlations for healthy (green bar) and unhealthy (red bar) food intake

- The home environment is likely to be the main factor explaining intake of healthy foods, including fruit and vegetables: If such foods were not available to children at home, children were unlikely to consume them outside the home with the possible exception of meals provided at school or daycare.
- Children had a higher natural preference for sweet tastes than adults. So it was not surprising that we saw more variation between children and parents when it came to eating unhealthy foods.
- Familial factors explained 60% of the variability in the intake of healthy foods but only half as much (30%) in the intake of unhealthy foods (see Figure 13).

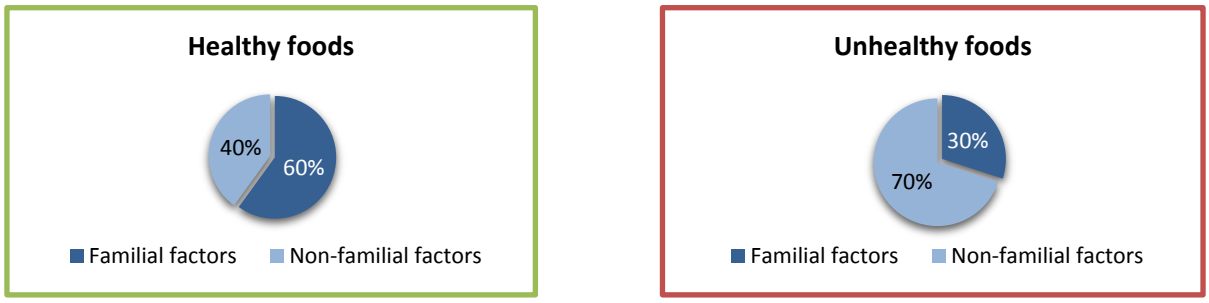

Figure 13: Proportion of variability in the intake of healthy foods and unhealthy foods explained by familial factors

- In terms of the **intake of healthy foods**, there was a greater resemblance between younger sibling pairs (< 11 years) than older sibling pairs (≥ 11 years), and parents and their younger children (< 11 years) than parents and their older children (≥ 11 years) (Figure 14). It is likely that the frequency of family meals declines and that the influence of friends becomes more important as children become older and more independent.

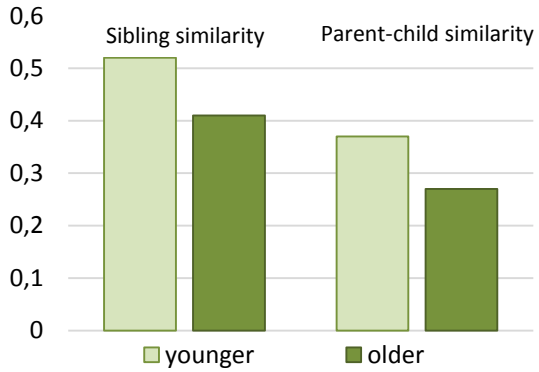

Figure 14: Sibling and parent-child correlations for healthy food groups, comparing younger and older children

How do friends affect teenagers' health behaviours?

- Parents' perception of their child's weight was influenced by how much other children weighed. Parents perceived their child to be thinner than he or she was when their peers were heavier. The opposite effect occurred when other children around were slimmer.[19]
- Teenagers' unhealthy food consumption was strongly associated with their friends' unhealthy food consumption (sugar sweetened beverages, fatty foods, food high in sugar, fast foods). However, we did not observe an association for healthy foods among peers (vegetable/fruit consumption, fibre rich foods).[20]
- Patterns of sedentary behaviour and leisure time activity also tended to be more similar between teenagers and their friends. [20]

Role of genetic and epigenetic factors

The results of a pilot study on a sub-sample of the I.Family cohort showed that a set of circulating microRNAs were differentially regulated in overweight/obese as compared with normal weight children[21]. In-depth bioinformatics analyses are currently in progress (a) to investigate differences in miRNAs expression patterns in sub-groups, and (b) to study the correlation between expression levels of selected miRNAs and anthropometric and biochemical variables.

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