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Grant Agreement No. 266044

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

Funding Scheme: Large Integrating Project

# FINAL PROJECT REPORT

(Due date: month 60)

**Grant agreement number:** 266044

**Project acronym:** I.Family

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

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**Date of latest version of Annex I against which the assessment will be made:** 14th December 2015

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

## Final Project Report

I.Family Consortium at the last meeting of the General Assembly in Ghent, February 2017

Funding scheme: Large Integrating Project
Project No. 266044
Start date of project: 01/03/2012
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# Final publishable summary

## 1. Executive 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 measurement of brain activation, expression of genes related to food choice, biological and genetic basis for taste thresholds, role of sleep, sedentary time, screen time, physical activity and impact of the built environment. I.Family also determines 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.

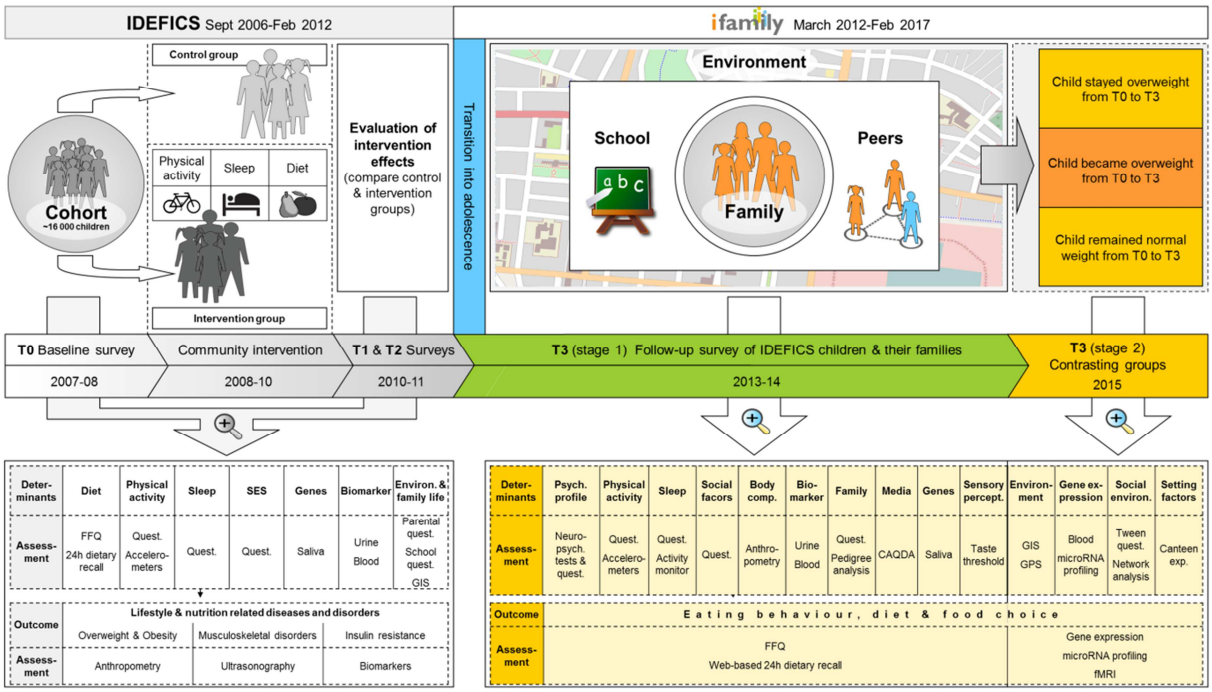


**Figure 1:** Framework of the I.Family study with overview of all examination modules and how it builds on the IDEFICS cohort[1]

[1] Ahrens W, Siani A, Adan R, De Henauw S, Eiben G, Gwozdz W et al. Cohort Profile: The transition from childhood to adolescence in European children–how I.Family extends the IDEFICS cohort. Int J Epidemiol. 2016;dyw317. Available at: http://ije.oxfordjournals.org/content/early/2016/12/31/ije.dyw317.full.

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 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.

# 2. Summary description of the project context and the main objectives

## 2.1 PROJECT CONTEXT

Over the last decades, it has become evident that differences in nutrition explain an important part of the variations in health in Europe and that poor nutrition is a major contributor to the overall burden of disease. Worldwide, nutrition-related diseases have become a major health concern, reportedly causing a loss of over 56 million years of healthy life of European citizens in the year 2000[2]. The World Health Organisation (WHO) has estimated that diseases caused by diet-related risk factors and physical inactivity account for 19% of global deaths and 7% of global DALYs (disability-adjusted life years)[3]. As a consequence, in March 2005 the European Commission established the High Level Group on Nutrition and Physical Activity[4] as well as the European Platform on Diet, Physical Activity and Health[5] to improve overall nutrition and to tackle nutrition-related diseases like obesity. The need for action to tackle the obesity epidemic has also been acknowledged by European policy makers at several conferences, resulting in the European Charter on Counteracting Obesity, adopted in Istanbul by the WHO European Ministerial Conference on Counteracting Obesity (2006)[6], the Vienna Declaration on Nutrition and Non-communicable Diseases in the Context of Health 2020 (2013)[7] and the Minsk Declaration The Life-course Approach in the Context of Health 2020 (2015)[8]. Recently, the WHO Report of the Commission on Ending the Childhood Obesity Epidemic (2017)[9] gave recommendations for future research and policy measures. It is vital that policy-makers and healthcare professionals target their resources as effectively and fairly as possible to help families achieve healthier lives.

## 2.2 GENERAL PROJECT 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.

[2] World Health Organization (WHO). Food and health in Europe: a new basis for action. World Health Organization Regional Publications: European Series 96, 2004:7

[3] World Health Organization (WHO). Global health risks: mortality and burden of disease attributable to selected major risks. World Health Organization, Geneva, Switzerland, 2009

[4] https://ec.europa.eu/health/nutrition_physical_activity/high_level_group_en

[5] https://ec.europa.eu/health/nutrition_physical_activity/platform_en

[6] WHO European Ministerial Conference on Counteracting Obesity, 15–17 November 2006, Istanbul, Turkey. Conference report available at http://www.euro.who.int/__data/assets/pdf_file/0006/96459/E90143.pdf

[7] http://www.euro.who.int/en/media-centre/events/events/2013/07/vienna-conference-on-nutrition-and-noncommunicable-diseases/documentation/vienna-declaration-on-nutrition-and-noncommunicable-diseases-in-the-context-of-health-2020

[8] http://www.euro.who.int/en/media-centre/events/events/2015/10/WHO-European-Ministerial-Conference-on-the-Life-course-Approach-in-the-Context-of-Health-2020/documentation/the-minsk-declaration

[9] World Health Organization (WHO). Report of the Commission on Ending Childhood Obesity: implementation plan, 2017 [13 Jan 2017] EB140/30. Report available from http://apps.who.int/gb/ebwha/pdf_files/EB140/B140_30-en.pdf.

## 2.3 SPECIFIC PROJECT OBJECTIVES

The I.Family project was funded in response to a European Commission research call with six key objectives.

**Objective 1. Identification of the main driving factors for food choice and eating habits to understand consumer behaviour and consumer preferences**

The call's first main objective to identify the main driving factors for food choice/ eating habits. I.Family addressed this by investigating consumer behaviour and consumer preferences with particular focus on the family and its environment.

To achieve this aim, I.Family investigated the mechanisms by which key factors influence behaviour and how they interact with each other. It studied how genetic factors relate to sensory perception of taste, to neuropsychological profiles, to pathways of neurotransmitter signalling, and to familial aggregation in food related behaviours. It examined differences in brain activation during (un)healthy food choice and it analysed relationships between gene expression profiles and actual food choice. The assessment of these biological mechanisms was complemented by studying how physical activity, sedentary behaviours, screen time and sleep patterns interact with dietary behaviour. I.Family investigated how the built environment impacts on physical activity and how access to food in community and school settings impacts on food choices. These aspects were studied in conjunction with consumer preferences, perceptions and attitudes to develop an ecological model of consumer behaviour. Most of the above mentioned factors were considered in a longitudinal perspective in order to allow assessment of causality.

**Objective 2. Understanding of discrepancies between actual versus optimal dietary behaviour to identify targets for intervention**

The objective to understand discrepancies between actual versus optimal dietary behaviour was pursued by I.Family by looking at cross-cultural and gender differences as well as societal and cultural trends.

To achieve this aim I.Family first derived a definition of optimal dietary behaviour from existing recommendations. In the next step, I.Family identified subpopulations that differ in terms of their socio-cultural environment (e.g. area level deprivation) as well as their lifestyle. I.Family compared nutrition behaviour and the use of traditional food across European countries and social groups. In particular, I.Family has built on longitudinal data in order to further examine contrasting groups in terms of the development of dietary behaviour (healthy/ unhealthy) and proxy indicators of energy balance (body mass index (BMI), body composition) over time. These contrasting groups included children with divergent developmental trajectories. The comparison of these subpopulations enabled the identification of factors explaining the gap between actual and optimal dietary behaviour. The cohort design of the study also allowed the observation of food choice, eating habits and other health behaviours during the critical transition from childhood to adolescence and the assessment of the role of parenting style and parental control in a longitudinal perspective. In this way, I.Family investigated the decline of parental influences and the simultaneous increase in peer and social network influences. I.Family identified the influence of key societal and cultural trends with focus on media influence (e.g. mobile Internet), broader cultural patterns, social norms and values and compared these factors across Europe.

**Objective 3. Study of the interaction between determinants and lifestyle factors and their influence on food choice to understand the impact of food on health/ well-being**

I.Family exploited the results achieved under objectives 1 and 2 in order to study the interaction between determinants and lifestyle factors in their influence on food choice and to understand the impact of food on the health and well-being of the European citizens.

To achieve these aims I.Family analysed the effects of the main driving factors identified under the first objective and of the confounding factors and mediators identified under the second objective. I.Family captured the complexity of the resulting model in structural equation models, directed acyclic graphs as well as in multilevel regression models. I.Family generated longitudinal data on dietary behaviour, its determinants and related health-outcomes in children, adolescents and their parents to study the temporal relationship between determinants and outcomes. This enabled the appraisal of causal relationships (which is hardly possible in cross-sectional studies) and the evaluation of the relative impact of diet on health-related outcomes.

**Objective 4. Development of strategies to induce behavioural changes and facilitate consumers' choice for a healthy diet**

Objectives 1-3 identify the most powerful intervention targets. This enabled I.Family to develop strategies to induce behavioural changes and facilitate consumers' choice for a healthy diet.

To achieve this aim I.Family used the human ecological model to guide intervention efforts related to eating behaviour. The model integrates multilevel linkages of the relationships among the many determinants which impact health and nutrition and the connections between people and their environments. I.Family assessed which of the factors studied under objectives 1 and 2 are amenable to intervention and prioritised them according to the output reached under objective 3. It compiled strategies to alter consumer behaviour in a healthier direction, based on the analysis of best practices in existing intervention programmes. Here it made explicit use of the unique opportunity to assess the sustainability of intervention measures implemented in the IDEFICS study. The strategies were tailored to subpopulation groups regarding gender, socio-economic status and cross-cultural differences. Moreover, I.Family investigated in how far these strategies can be translated to measures taken by public bodies, companies or other stakeholders to facilitate the consumers´ healthy choice.

**Objective 5. Setup of methods for communication and dissemination to reach children, adolescents and their parents to induce favourable changes of health behaviour**

The last main objective of the topic, i.e. to set up methods for communication and dissemination to reach children, adolescents and their parents was a particular focus of I.Family that built on the general strategies developed under objective 4.

I.Family used communication tools to reach families most effectively accounting for the Transtheoretical Model of Behavioural Change. The developed communication strategies consider ethical issues in relation to families' attitudes towards behaviour changes, in order to overcome so-called 'resistance to interventions'. I.Family provided tailored recommendations on healthy diet and action knowledge that support and enhance healthy lifestyles in a sustainable way. The project developed web-based tools to meet the youth's interest in electronic media and provided personalised feedback and guidance on

healthy food choices. I.Family related all developed communication/ intervention tools to broader public policy strategies, particularly to voluntary agreements and platforms that form an important plank of current EU policy (e.g., the European Platform on Diet, Physical Activity and Health). Eventually, these tools are being made available to study participants, the general public, stakeholders and the scientific community through the study website, newsletters, press releases, scientific publications and other communication fora such as workshops and scientific symposia. The developed electronic tools offer opportunity for exploitation and wider dissemination via public-private partnerships.

**Objective 6. Development of databases to serve food and nutrition research**

Databases and assessment tools for food and nutrition research were developed as an immediate output of I.Family.

The follow-up data generated to reach objectives 1 to 3 are itself a valuable asset for this and future studies. These data not only include questionnaire data, food composition tables (including children's diets) and the physical examination results but also a bio-repository that allows study of the temporal sequence of physiological characteristics and health outcomes later in life. These databases were complemented by the provision of novel and easy-to-use instruments to assess dietary behaviour like a web-based instrument for 24-hour dietary recall and personalised dietary advice. The data collected using these tools will both enrich existing data on nutrition and promote healthy food choice.

# 3. Description of the main scientific & technological results/ foregrounds

## 3.1 THE I.FAMILY STUDY – OVERVIEW AND KEY FINDINGS

The I.Family study is a major international research project on health, food and lifestyles among European families. Over the past decade, we have examined children's development, looking for ways to improve young people's health and tackle problems such as obesity. The project has involved 17 consortium partners in 12 different countries and a unique cohort of children in eight countries – the largest pan-European cohort of children ever studied[1]. All applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during this research. Approval by the appropriate ethics committees was obtained by each of the centres doing the fieldwork.

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

In 2007-8, the IDEFICS Study examined some 16,228 children (**survey 1**). It then examined 13,596 children two years later of whom 11,041 already participated previously (**survey 2**). Between the two surveys we undertook a **community-based intervention** in each country – half of the children were involved in this – to test the interventions' effects.

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.

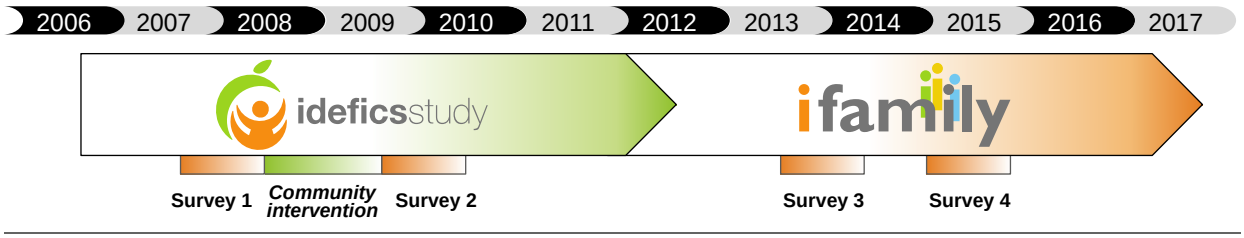


**Figure 2:** Timeline of the IDEFICS and I.Family studies

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 has studied how families, friends and environments influence health and behaviour.

### The I.Family study's key findings

In the following the key findings are summarised. A more detailed description of the main study results is given in sections 3.2 to 3.10.

*General*

- Rates of overweight/obesity vary widely between European regions – from around 40% of children aged between two and ten in southern Italy to less than 10% in Belgium.
- Girls are more likely to be overweight/obese compared with boys.
- Children from disadvantaged families, i.e. those with a lower social position or a migrant background, are more often overweight or obese than children from more advantaged groups. This social divide increases as children get older.
- The energy-density of European children's diet is too high and increases with age.
- Unhealthy diets are far more common in children from poorer and less-educated families.
- Findings suggest there is a link between shorter sleep duration and higher weight, particularly in primary school children.

*Physical activity and the built environment*

- Less than a third of children meet physical activity guidelines of 60 minutes of physical activity per day. The proportion varies from as low as 2% in Cyprus to 34% of boys in Belgium.
- Well-designed public open spaces and safe and well-connected facilities are key to increasing physical activity. Open spaces are more important to younger children, while walking/cycling routes matter more for adolescents.

*Media consumption*

- Children are much more likely to eat energy-dense foods, i.e. foods high in fat and sugar, and to consume sugar sweetened beverages after being exposed to advertising promoting them.
- Children exposed to commercial TV are more likely to consume soft drinks, regardless of their parents' norms or the daily duration of TV-viewing.
- Frequently asking for products advertised on TV by children increases their preference for fatty foods and their likelihood of being overweight**.**
- Greater time spent watching TV and using a computer is negatively associated with children's well-being.
- Watching TV during meals, having a TV in the children's bedroom and watching TV for more than 1 hour per day are all associated with being overweight/obese.

*Influence of family and friends*

- Family members resemble each other in their weight status and body composition, risk factors for disease and dietary patterns. Mothers tend to resemble their children more than fathers. Both genetic and shared family environment contribute to this resemblance.
- Parents' perception of their child's weight is influenced by how much other children around them weigh.
- The body weights of children and teenagers are related to those of their peers. Teenagers are particularly likely to eat more unhealthy foods if their friends do and are more likely to be active if their friends are.

**Socio-economic status has a major effect on rates of overweight and obesity**

Figure 3 compares children in our European study regions. It shows how the percentage of overweight/obese children differs between families of lower and higher socio-economic status (SES). (Here, we use parents' education level to gauge this.)

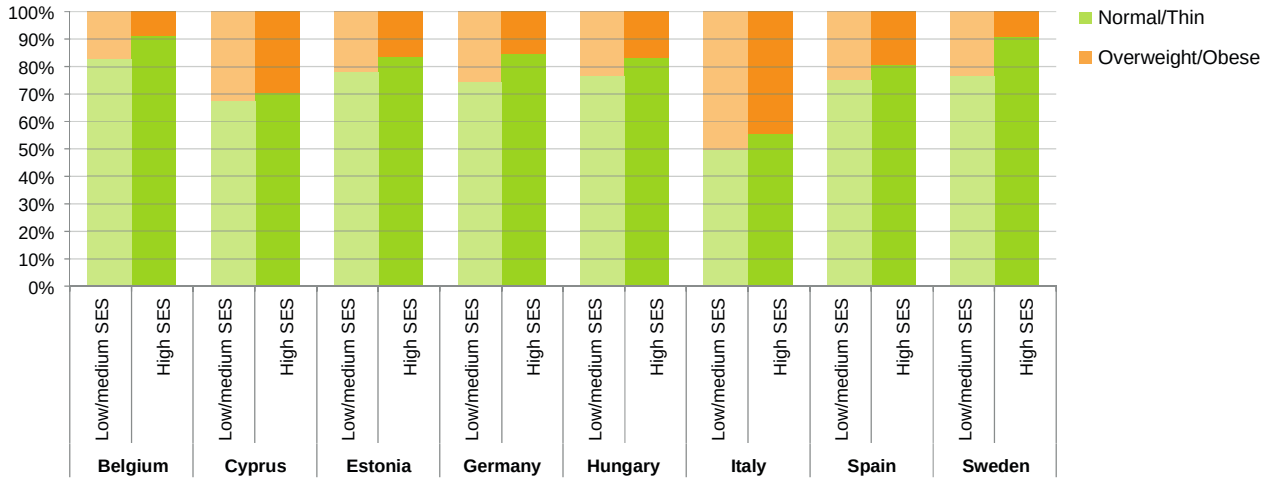


**Figure 3:** Prevalence of overweight and obesity by socioeconomic status (parental education) and by country

Tracking children as they grow up shows that this effect gets stronger. Figure 4 shows what happens to children who were thin or normal weight at baseline. Six years later we see a major difference in how many children have become overweight or obese (orange bars): In families of medium or low socio-economic status (SES), nearly twice as many have, as compared with higher SES families.

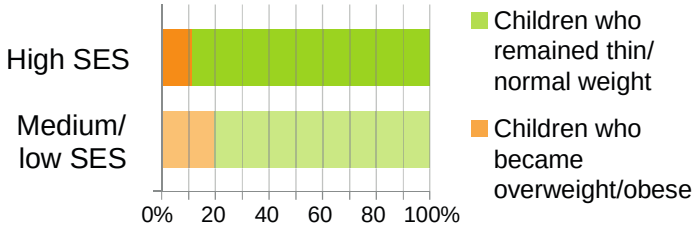


**Figure 4:** Percentage of normal weight children becoming overweight or obese within 6 years of follow-up by SES

## 3.2 Diet and children's health

### Too much energy-dense food

Our findings bear out the worldwide problem of unhealthy eating and excessive food consumption by children. The children we studied eat too much and tend to eat too much energy-dense food. The average energy density of foods eaten by I.Family children was similar to that of high energy density foods like oven-baked French fries (about 2 kcal/g)[10]. An energy density of about 1.25 kcal/g is recommended. Still, dietary energy-density was not associated with BMI z-score in I.Family children, but with energy intake[10]. And energy intake and daily food intake were positively associated with BMI z-score in our cohort[11, 12]. Figure 5 gives examples of the energy density of various potato preparations that are popular among European children.

[10] Hebestreit A, Börnhorst C, Pala V, Barba G, Eiben G, Veidebaum T, et al. Dietary energy density in young children across Europe. Int J Obes. 2014;38 Suppl 2: 124-134.
[11] Hebestreit A, Börnhorst C, Barba G, Siani A, Huybrechts I, Tognon G, et al. Associations between energy intake, daily food intake and energy density of foods and BMI z-score in 2-9-year-old European children. Eur J Nutr. 2014;53(2):673-681.
[12] Hebestreit A, Barba G, De Henauw S, Eiben G, Hadjigeorgiou C, Kovács É, et al. Cross-sectional and longitudinal associations between energy intake and BMI z-score in European children. Int J Behav Nutr Phys Act. 2016;13:23.

**3.4 kcal/g** **2 kcal/g** **1.4 kcal/g**

**Figure 5:** Energy density of different ways of serving potatoes

The energy density of a food depends on its composition and portion size. Water contributes weight but no calories, thus it lowers the energy density of foods as it contains no calories. Dietary fibre increases the portion size while adding few calories and helps to lower energy density. High fat content increases energy density, even more than proteins and carbohydrates. Figure 6 shows six portions of foods with a kilocalorie count of 100, chosen from those most popular with children from the I.Family study.

| 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

### Mediterranean-type diet

A healthy Mediterranean-type diet is rich in vegetables, legumes, fruits, nuts, cereals and fish and low in other animal products. This type of diet was popular in 30-40% of children, even in northern European countries[13].

### Sugar intake

Sugar intake (all mono- and disaccharides) of children in I.Family is very high and made 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[14].

### Consequences of unhealthy eating

Adverse consequences of unhealthy eating are evident in young children. There is also evidence that healthy diets can improve children's health. We found that 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[15]. After two years, children with a high adherence to this type of diet had 36% less probability of becoming overweight/ obese. High intake of sugar and heavily processed foods combined with a low

[13] Tognon G, Hebestreit A, Lanfer A, Moreno LA, Pala V, Siani A, et al. Mediterranean diet, overweight and body composition in children from eight European countries: Cross-sectional and prospective results from the IDEFICS Study. Nutr Metab Cardiovasc Dis. 2014;24(2): 205-513.

[14] Svensson A, Larsson C, Eiben G, Lanfer A, Pala V, Hebestreit A, et al. European children's sugar intake on weekdays versus weekends: the IDEFICS study. Eur J Clin Nutr. 2014;68(7):822-828.

[15] Pala V, Lissner L, Hebestreit A, Lanfer A, Sieri S, Siani A, et al. Dietary patterns and longitudinal change in body mass in European children: A follow-up study on the IDEFICS multicenter cohort. Eur J Clin Nutr. 2013;67(10): 1042-1049.

intake of vegetables and fruits was associated with increased levels of high sensitivity C-reactive protein, a marker of inflammation related to the risk of cardiovascular disease[16]. Infant breast-feeding is associated with markers of metabolic health [17] and reduced risk of childhood overweight[18]. The beneficial effects of exclusive breastfeeding on weight status are summarised in Table 1.

| *Exclusive breast-feeding duration* | |
|---|---|
| *1-3 months* | -13% decreased probability of becoming overweight/ obese |
| *4-5 months* | -19% decreased probability of becoming overweight/ obese |
| *6 months* | -29% decreased probability of becoming overweight/ obese |

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

### Unhealthy diets in children from poorer families

Unhealthy diets are more common in children from poorer and less well-educated families[19] (see Table 2).

| | ***Common dietary patterns*** | | |
|---|---|---|---|
| ***Family type*** | **Street food, fast food**<br>French fries, hamburger, pizza, kebab, savoury pastries | **Sweet foods**<br>Sweetened drinks, choco-late, biscuits and candies | **Healthy foods**<br>Raw vegetables, fruits, wholemeal products |
| *Migrants* | **↑ +25%** | | |
| *High parental education* | | **↓ -30%** | **↑ +50%** |
| *High household income* | | **↓ -30%** | **↑ +30%** |

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

### Taste preference and food consumption

Parents who like fatty foods consumed twice as many fatty foods compared to those who do not like fatty foods. On the one hand, parents who like sweet foods consumed three times as many sugar-rich foods compared to those who do not like sugar-rich foods. On the other hand, children's food consumption seems unaffected by their own preferences (see Figure 7).

[16] González-Gil EM, Santabárbara J, Russo P, Ahrens W, Claessens M, Lissner L, et al. Food intake and inflammation in European children: The IDEFICS study. Eur J Nutr. 2016;55(8): 2459-2468.
[17] Priego T, Sánchez J, Picó C, Ahrens W, Bammann K, De Henauw S, et al. Influence of breastfeeding on blood-cell transcript-based biomarkers of health in children. Pediatr Obes. 2014;9(6): 463-470.
[18] Hunsberger M, Lanfer A, Reeske A, Veidebaum T, Russo P, Hadjigeorgiou C, et al. Infant feeding practices and prevalence of obesity in eight European countries – the IDEFICS Study. Public Health Nutr. 2013;16(2): 219-227.
[19] Fernández-Alvira JM, Börnhorst C, Bammann K, Gwozdz W, Krogh V, Hebestreit A, et al. Prospective associations between socio-economic status and dietary patterns in European children: the IDEFICS study. Br J Nutr. 2015;113(3): 517-525.

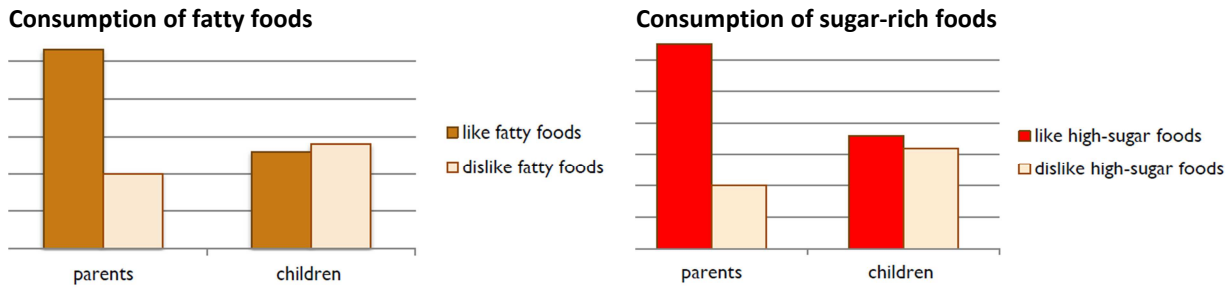


**Figure 7:** Sensory taste preferences and actual frequency of consumption of foods with high sugar and fat content

### The family food environment shapes children's food choices

Children are likely to adopt the same eating habits as their parents[20]. If the mother or father eats a sugar-rich diet, the child is twice as likely to do the same. This effect gets stronger as the number of shared meals increases. If both parents eat a sugar-rich diet, and sugary drinks are available on the table during the meal, it is three times more likely that a child will also eat a sugar-rich diet.

### Long-term effects of media exposure

Families and children need to be informed of the risks of unhealthy eating and, more importantly, the benefits of healthy eating. But this is far from enough. We found 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[20].

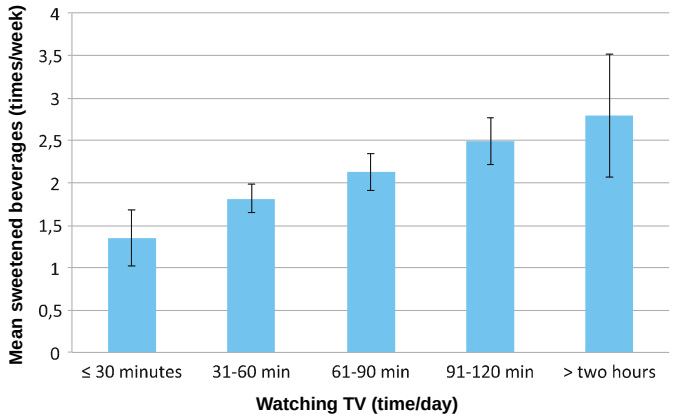


**Figure 8:** Consumption of sweetened drinks increases as TV time increases[21]

The influence of watching TV was so strong that children chose heavily-advertised sweets or snacks even when they expressed little preference for them. We also found that children who consumed meals while watching TV had a 20% greater likelihood of eating fatty foods and 30% greater likelihood of eating sugary foods. More surprisingly, we found that the effect of TV was the same on children who expressed high

[20] Hebestreit A, Intemann T, Siani A, De Henauw S, Eiben G, Kourides YA, et al. Dietary patterns of European children and their parents in association with family food environment: Results from the I.Family study. Nutrients. 2017; 9(2). pii:E126.
[21] Olafsdottir S, Eiben G, Prell H, Hense S, Lissner L, Mårild S, et al. Young children's screen habits are associated with consumption of sweetened beverages independently of parental norms. Int J Public Health. 2014;59(1): 67–75.

and low preferences for fats and sweets. In other words, marketing not only disrupts food cultures, but it also seems to disrupt individual food choices[22].

**Conclusions**

Our observations show that European children eat too much energy-dense food and that those with unhealthy dietary patterns, high energy intakes and large eating amounts are more likely to become overweight and obese. In particular parents, as role models and gatekeepers of family food consumption, influence both the quantity and quality of food that children consume. So it seems to make sense to inform families and children of the risks of unhealthy eating and the benefits of healthy eating.

However, this may not be enough to steer children towards healthy diets. Our data show that advertising is also a major factor. The massive marketing of heavily processed foods directly to children makes it difficult if not impossible even for health-conscious parents to limit their children's consumption of these products. In view of the pervasive negative influence of the media on children's eating habits, advertising, especially to children, needs to be regulated – self-regulation by the food industry has not worked.

## 3.3 CHILDREN'S FOOD CHOICES – WHAT NEUROSCIENCE CAN TELL US

In Western society, food is all around us. The sight, smell and taste of food have an immediate effect on the appetitive network in our brain. The brains of people who are overweight or obese react differently to the sight of food than those of normal weight people. Genetic data suggest that those prone to obesity may react differently already prior to becoming obese, and hence such interindividual differences need to be taken into account in relevant policies. The way that the brain reacts to the sight of food has even been shown to predict weight gain, snacking behaviour and success in a weight loss programme.

The brain's reactivity to foods is thus a relevant characteristic to determine someone's risk of gaining weight. Children are often said to be more sensitive to the sight of food than adults, and especially so for unhealthy foods. They also find it harder to make choices that go against their preferences – e.g. to choose healthier foods that they don't enjoy. However, no study has yet directly compared how children's and adults' brains react to healthy and unhealthy foods. Therefore, we examined brain reactions to healthy and unhealthy food and food choice in children and adults.

**Children's brains are more reactive to the sight of unhealthy food**

The I.Family study is the first to show that children's brains are indeed more reactive to the sight of unhealthy food than adults are. Children have a stronger reaction in an area important for physical actions – such as reaching for a cookie! – than adults do when looking at unhealthy food pictures[23] (Figure 9).

[22] Lissner L, Lanfer A, Gwozdz W, Olafsdottir S, Eiben G, Moreno LA, et al. Television habits in relation to overweight, diet and taste preferences in European children: The IDEFICS study. Eur J Epidemiol. 2012;27(9): 705–715.
[23] van Meer F, van der Laan LN, Charbonnier L, Viergever MA, Adan RA, Smeets PA. Developmental differences in the brain response to unhealthy food cues: an fMRI study of children and adults. Am J Clin Nutr. 2016;104(6): 1515–1522.

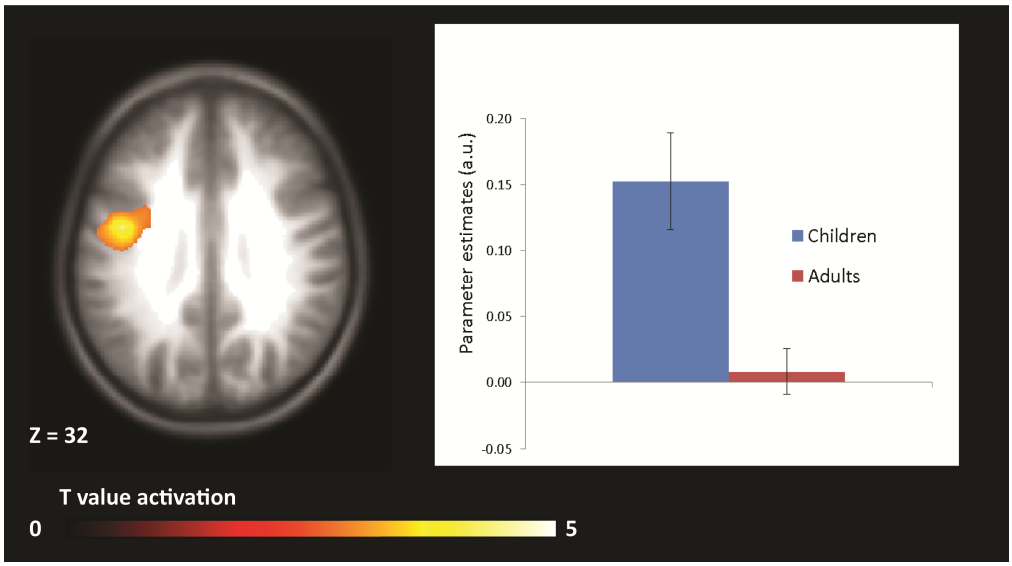


**Figure 9:** Stronger brain response in children than adults for unhealthy compared with healthy food[23]

### Children's food choice differs from that in adults

Children choose what they want to eat almost entirely based on how tasty they think foods are. When deciding, their brain reacts most strongly to tasty foods. Healthiness only comes into play when children are asked to consider this. In this case, their brain reacts more strongly to healthy foods and they make healthier choices. Nonetheless, children still make fewer healthy choices than adults, and the brain system that underlies healthy choices in adults does not respond in the same way in children.

### Children's brain reaction depends on their weight status

Children with a higher body weight for their height have less activation in an area of the brain that is important for inhibiting responses during food viewing. Furthermore, current body weight, weight change over time and pubertal stage have independent effects on brain activation during food choice. Children who have gained weight have more activation in visual areas when choosing what to eat. Older children and children with a lower body weight have more activation in an area of the brain that is important for inhibiting responses when choosing foods. These inhibition areas are among the last to fully mature. Only a longitudinal study like I.Family gives us the opportunity to look at the effects of weight change over time. Figure 10 illustrates that children with a higher body weight have less brain activation when viewing unhealthy foods in a brain area involved in inhibition.

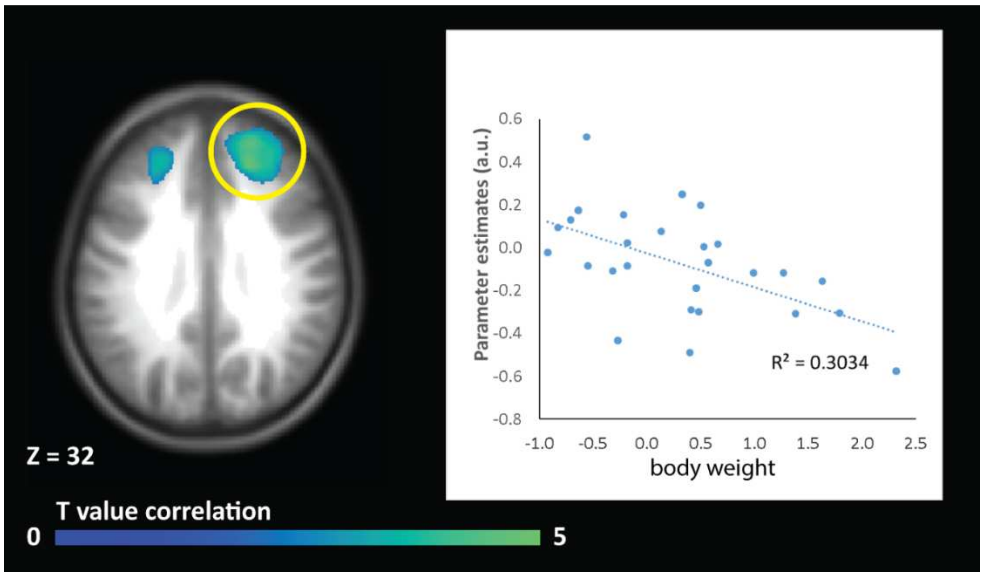


**Figure 10:** Correlation between body weight and brain responses to unhealthy compared with healthy food[23]

Figure 11 shows that body weight, body weight change and pubertal stage have independent effects on brain activation during food choice.

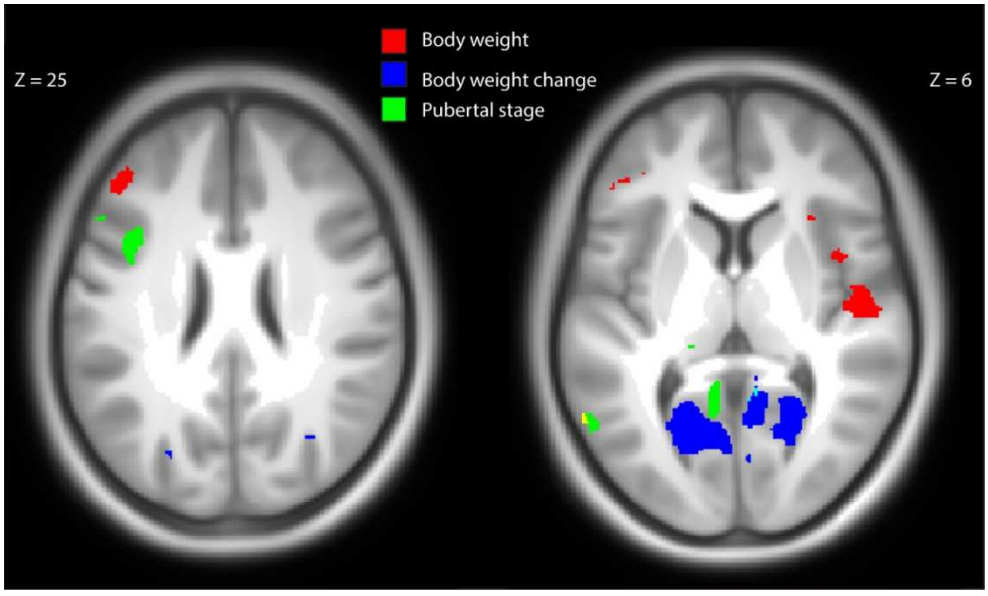


**Figure 11:** Modulation of choice brain activation by body weight, body weight change and pubertal stage

In the future we will use the genetic data and neuropsychological tests available in I.Family to unravel how hereditary factors and behavioural traits affect food-related brain activation in children.

## Conclusions

Children are more sensitive to unhealthy food cues than adults. Overweight children are especially vulnerable, since they have less inhibitory activation in response to unhealthy foods. This has important implications for the regulation of marketing since children are actively targeted by unhealthy food marketing. The results of this study send a clear message that we should protect children, especially overweight children or children prone to become overweight, because they are most susceptible to the unhealthy food temptations all around them.

Since the tastiness of food is so important for children, even more than for adults, we should also think about strategies to alter children's preferences toward healthier foods. Since we prefer foods and tastes that we are used to, letting children experience healthy foods and teaching them healthy habits early in life may help to make the healthy choice the natural choice for them.

## 3.4 SLEEP HABITS AND DIETARY INTAKE

The number of children and adolescents with overweight and obesity has increased worldwide in the past three decades. It is generally accepted that what a person eats and physical inactivity are the main proximal reasons for this increase[24].

However, it could be that other lifestyle factors are also influencing childhood overweight, such as how much time a child spends sitting or sleeping. The amount of sleep or sleep duration is believed to be related to a person's weight. In fact, sleep is thought to be essential to the development, growth and health of children and is viewed as an important contributing factor for both physical and mental health in people of all ages[25]. So it may not be surprising that getting too little sleep has been associated with problems such as feeling tired and poor immune function and other things, such as feeling irritated or performing poorly in school[26].

**What we did in the I.Family study**

We asked our participants (or in the case of young children, their parents) to report how long they slept during the working week and at the weekends/ during vacations. Answers in both cases were provided in hours and minutes per night. In addition, we analysed sleep using a small device worn on the wrist that measures movement. The participants wore the device for 5-7 nights.

In addition, dietary intake was assessed with a questionnaire. We asked how often our participants eat certain foods. We were then able to determine how many of the food choices were healthy foods, how much fatty food children ate, how much sugary food, and how many fruits and vegetables.

**Adherence to sleep guidelines and association with diet**

We observed that only one third of children and adolescents met the recommended sleep guidelines issued by the National Heart, Lung, and Blood Institute[27] (see Table 3). There was no difference between boys and girls.

[24] Branca F, Nikogosian H, Lobstein T, editors. The challenge of obesity in the WHO European region and the strategies for response. Copenhagen: WHO Regional Office for Europe. 2017; available from: http://www.euro.who.int/__data/assets/pdf_file/0010/74746/E90711.pdf.
[25] Chaput JP, Dutil C. Lack of sleep as a contributor to obesity in adolescents: impacts on eating and activity behaviors. Int J Behav Nutr Phys Act. 2016;13: 103.
[26] Khan MK, Faught EL, Chu YL, Ekwaru JP, Storey KE, Veugelers PJ. Is it nutrients, food items, diet quality or eating behaviours that are responsible for the association of children's diet with sleep? J Sleep Res. 2016. doi: 10.1111/jsr.12466.
[27] National Heart, Lung, and Blood Institute. How Much Sleep Is Enough? 2012 [Updated 2012 Feb 22; cited 2017 Apr 20]. Available from: https://www.nhlbi.nih.gov/health/health-topics/topics/sdd/howmuch.

| 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. We measured this by calculating a healthy diet score based on established dietary guidelines which call for limiting the intake of simple sugars, reducing fat intake, especially of saturated fat, choosing wholemeal grains instead of refined grains, consuming 400-500 grams of fruits and vegetables per day, and fish 2-3 times per week.

**Why this association?**

It is hypothesised that hormonal changes that occur from sleeping too little might trigger unhealthy eating. However, it may also be that the more time spent awake gives more time and opportunities for eating.

**Future research**

In our study, only one-third of children and adolescents met suggested sleep guidelines. In the future, using our data, we therefore plan to examine factors that are most important in inhibiting children from obtaining the recommended hours of sleep per night. For example, we will examine if media devices (such as computers or smart phones) are allowed in the child's bedroom and whether using these is keeping youngsters awake at night. So far, the evidence suggests that children are more likely to have a healthy weight status when there is no television in their bedrooms.

## 3.5 Sleep and well-being – what are the relationships?

As a concept closely related to health and quality of life, well-being encompasses physical, mental and social aspects. Moreover, it depends on the perspective of the person and it takes into account that health is more than just the absence of disease. In IDEFICS and I.Family, we focussed on the mental and social aspects of well-being. We therefore use the term psychosocial well-being.

**The association between psychosocial well-being and overweight**

Although research is still in the early stages, various aspects of well-being have been related to overweight in adults and children[28,29]. In our study, we found that:

[28] Cameron AJ, Magliano DJ, Dunstan DW, Zimmet PZ, Hesketh K, Peeters A, Shaw JE. A bi-directional relationship between obesity and health-related quality of life: evidence from the longitudinal AusDiab study. Int J Obes. 2012;36(2): 295-303.

1. Children with poor psychosocial well-being (in particular, emotional and behavioural problems, problems with friends or peers) were at greater risk of becoming overweight [30]
2. 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[29].

The effect of well-being on overweight might be explained by biological mechanisms (such as hormones) or behavioural factors (e.g. unhealthy diet, increased sedentary behaviour). Overweight might lead to poor well-being because of experiences of stigmatisation and teasing or higher levels of body dissatisfaction.

**Sleep in children and adolescents**

Some studies have shown that sleep duration has been decreasing over recent decades[31]. Adolescents in particular often sleep fewer hours than they need. This is partly due to biological processes during puberty which make adolescents prefer later bedtimes. This leads to shorter sleep as they nevertheless must get up early in the morning to go to school. Smart phones, social media and access to the internet may contribute, but their role requires more study.

**The association between sleep and overweight**

A large body of evidence suggests that short sleep duration and poor sleep quality are risk factors for childhood overweight[32]. Our data support the observation that children with short sleep duration were at increased risk of being overweight[33].

Various researchers have suggested that there are biological pathways linking sleep to overweight, i.e. poor sleep causes changes in the body which directly influence metabolism and affect appetite-regulating hormones. Most likely, there are also behavioural explanations. For example, less time spent sleeping means there is more time to eat. Fatigue caused by poor sleep could also increase the likelihood of being less physically active and more sedentary (watching TV etc).

**The association between well-being and sleep**

As both well-being and sleep have been linked to overweight, we should ask whether there is also an association between well-being and sleep. We found that:

1. 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.

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[29] Jansen PW, Mensah FK, Clifford S, Nicholson JM, Wake M. Bidirectional associations between overweight and health-related quality of life from 4-11 years: longitudinal study of Australian children. Int J Obes. 2013;37(1): 1307-1313.
[30] Hunsberger M, Lehtinen-Jacks S, Mehlig K, Gwozdz W, Russo P, Michels N, et al. Bidirectional associations between psychosocial well-being and body mass index in European children: longitudinal findings from the IDEFICS study. BMC Public Health. 2016; 16: 949.
[31] Matricciani L, Olds T, Petkov J. In search of lost sleep: secular trends in the sleep time of school-aged children and adolescents. Sleep Med Rev. 2012; 16(3): 203-211.
[32] Chen X, Beydoun MA, Wang Y. Is sleep duration associated with childhood obesity? A systematic review and meta-analysis. Obesity. 2008;16(2): 265-274.
[33] Hense S, Pohlabeln H, De Henauw S, Eiben G, Molnar D, Moreno LA, et al. Sleep duration and overweight in European children: is the association modified by geographic region? Sleep. 2011;34(7): 885-890.

2. 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.

**Conclusions**

Knowing more about the links between well-being and sleep helps us to disentangle the various pathways that lead to overweight and related cardio-metabolic disorders like hypertension, dyslipidaemia and insulin resistance in children and adolescents. For example, in future research with the IDEFICS and I.Family data we will examine whether poor well-being leads to poor sleep and subsequently to worse cardio-metabolic health.

Poor psychosocial well-being and poor sleep are both potential risk factors for childhood overweight – data from our study confirm findings of previous studies. Our data also show that well-being and sleep are associated in both directions. Firstly, better well-being has a positive impact on sleep and secondly, good sleep is beneficial for well-being.

Our results indicate that interventions targeting well-being could have a positive effect on sleep and, similarly, interventions targeting sleep could have a positive effect on well-being. Although the development of appropriate interventions is another research area, some interventions have already been evaluated: School-based interventions that targeted not only individual behaviours but also the social and school environment had positive effects on well-being of children[34]. Similarly, educational interventions that aim to improve knowledge about sleep and to change behaviour may also be promising ways to improve sleep[35].

## 3.6 PHYSICAL ACTIVITY AND CHILDREN'S HEALTH

The I.Family study shows that we need to address inequality in access to physical activity if we want to reduce health inequalities in young people in Europe. Physical activity provides fundamental health benefits for young people. As well as physical fitness, these include healthy development of bones[36], muscles and joints, cardiovascular health[37], and good coordination and movement control. It also builds self-confidence, social interaction and integration and contributes to a positive body image.

However, the I.Family study provides the strongest evidence to date that large numbers of young people across Europe have less chance of achieving these health benefits because of their age, gender, where they live or the household they live in.

[34] Muellmann S, Landgraf-Rauf K, Brand T, Zeeb H, Pischke CR. Effectiveness of school-based interventions for the prevention and/or reduction of psychosocial problems among children and adolescents: a review of reviews. Gesundheitswesen. 2016 [Epub ahead of print]

[35] Blunden SL, Chapman J, Rigney GA. Are sleep education programs successful? The case for improved and consistent research efforts. Sleep Med Revs. 2012;16(4): 355-370.

[36] Herrmann D, Buck C, Sioen I, Kourides Y, Marild S, Molnár D, et al. Impact of physical activity, sedentary behaviour and muscle strength on bone stiffness in 2-10 year old children. Int J Behav Nutr Phys Act. 2015;12: 112

[37] Zaqout M, Michels N, Bammann K, Ahrens W, Sprengeler O, Molnar D, et al. Influence of physical fitness on cardio-metabolic risk factors in European children. The IDEFICS study. Int J Obes. 2016; 40(7): 1119-1125.

**Specific strengths of our data**

I.Family data builds on the IDEFICS study to provide a powerful resource to answer questions about the role of physical activity in young people's lives:

- It uses the best measures of physical activity. We not only have accurate knowledge of how active young people are, but also where and when they are physically active – e.g. at home or at school, or in travelling between the two.
- It provides standardised measures of physical activity throughout the childhood and adolescent phase so we can answer questions like *'Is physical activity important for the development of obesity in young people or does being overweight or obese impact on physical activity – or both?'*
- It includes data from a wide range of countries which allows us to capture important geographical and cultural variation across Europe.
- Uniquely, it also includes measures of physical activity for the whole family in the same household – brothers and sisters, as well as parents or carers.
- It covers key transition phases in a child's life which impact on physical activity – e.g. when a child starts school or changes schools.

Because we also have detailed information about each child's family, such as parental income and education level, this means we are able to address important questions about health inequalities. These form a key focus of our research. Except where references are given, the findings presented are based on current analyses of I.Family data.

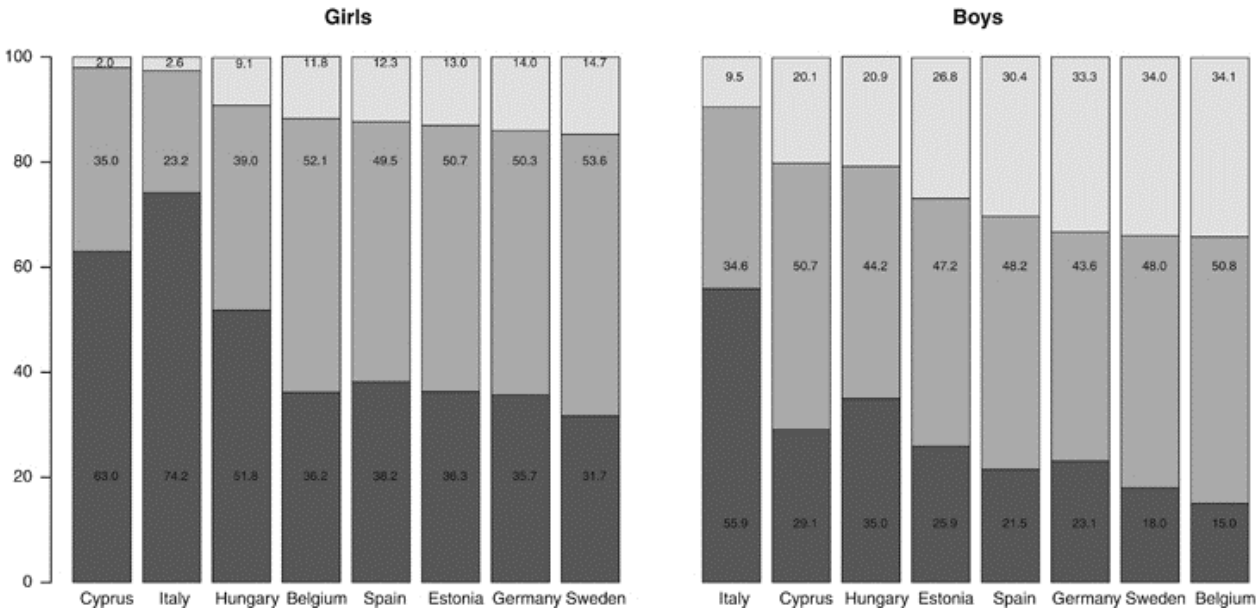



**Figure 12:** Percentage compliance to MVPA recommendations: lowest part: 0–30 min, middle part: 30–60 min, upper part: over 60 min[38]

[38] Konstabel K, Veidebaum T, Verbestel V, Moreno LA, Bammann K, Tornaritis M, et al. Objectively measured physical activity in European children: the IDEFICS study. Int J Obes. 2014;38 Suppl 2: 135–143.

**The vast majority of European young people are not physically active**

Only 2% of young people in our 8 European study regions meet current physical activity guidelines – to be at least moderately active for 60 minutes or more each day (Figure 12). The physical activity guidelines of the WHO are summarised in Box 1. The group with the highest percentage meeting the guidelines was Belgian boys – but still only 5% of them did so.

Inequality in physical activity levels is a major barrier to good health in European children. It should be systematically addressed in EU policies.

1. Children and youth aged 5-17 should accumulate at least 60 minutes of moderate- to vigorous-intensity physical activity daily.
2. Amounts of physical activity greater than 60 minutes provide additional health benefits.
3. 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 Organization recommendations on physical activity[39]

**The older children get the less active they are**

Girls are less active than boys irrespective of how old they are. The amount of physical activity children take declines 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 become progressively more sedentary as they mature. At 5-7 years, they spend 40% of their time sitting, compared to 62% of their time at 14-16 years.

This age and gender gap exists in all European countries participating in our study[38]. However, the size of the difference varies, as does the degree of inequality in physical activity. While eliminating the gender gap is challenging, there is no reason it could not be narrowed. And there is no reason why absolute activity levels could not be increased in both boys and girls.

**Where a child lives relates to how active she/ he is**

The place of residence also affects the gender gap in physical activity. There is 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 between the least active population (Italy) and the most active (Sweden) is 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).

The less gender-equal countries could learn from the more gender-equal countries in how to promote physical activity among girls as well as boys outside of school hours. The more gender-equal countries might want to focus on promoting physical activity among girls within the school hours, as this is the time period with the largest absolute gender differences.

[39] World Health Organization (WHO). Global recommendations on physical activity and health. 2011. Available from http://www.who.int/dietphysicalactivity/physical-activity-recommendations-5-17years.pdf

**Improved social opportunities enhance opportunities for physical activity**

There was a weak trend towards increasing physical activity with increasing parental education and income in the whole sample. This trend was similar across the eight countries. We do see some differences in the social gradient for particular behaviours (e.g. active transport, structured sports). However, these do not necessarily show up when we look at overall activity levels.

Social differences interact with environmental and policy factors. For example, where affordable public transport is widely available, this will likely reduce the negative impact of income on physical activity.

**An unhealthy weight restricts physical activity**

Looking at our data longitudinally, we observed a bi-directional association between overweight and obesity in young people, i.e. overweight/ obesity leads to lower levels of physical activity and vice versa.

It is clear that we need to intervene early to stop children becoming so overweight that it inhibits their physical activity. Just 10 minutes extra of moderate to physical activity in young children could reduce their risk of becoming overweight. It is also important to note that, as in adults, increased physical activity in young people creates health benefits, independent of change in weight status.

**Physical activity is related in families**

Physical activity is clearly related in families in a straightforward way: more active children have more active parents and siblings. This relationship is strongest between siblings; it is not quite so strong when we compare parents/ carers and children.

Policy needs to strengthen the focus on family influences on physical activity and provide both guidelines and opportunities for parents. For example, these data suggest that successfully boosting physical activity in one child might have knock-on benefits to their siblings, particularly siblings who are close to them in age. There might also be knock-on benefits to parents (or vice versa), perhaps particularly mothers or younger parents. The relationship between family members' activity is considerably stronger at the weekend and during holidays. This indicates that shared weekend and holiday activities are important independent targets for promoting physical activity in European young people.

**Conclusions**

Levels of active commuting to school and other destinations vary considerably across Europe. This underpins differences in physical activity levels between countries. Providing environmental support for active travel in young people (e.g. cycle lanes, accessible public transport, safe pedestrian areas including pavements) will increase physical activity in young people. Where active transport is not possible (very rural areas) or difficult (due to very hot weather), people need ways to compensate for lack of active travel – for example, access to cheap indoor sport and leisure activities near to their homes.

## 3.7 LOCAL NEIGHBOURHOODS – WHAT DIFFERENCE DO THEY MAKE?

Insufficient physical activity is responsible for up to 10% of non-communicable diseases such as cardiovascular disease, diabetes and obesity. Lack of exercise has also been found to be an important risk factor for cancer and cardiovascular mortality. However, interventions focusing on individual behavioural change show only small effects, are costly, and rarely lead participants to make lasting changes in their behaviour. In addition, such interventions attract people who are already interested in lifestyle changes, leading to increased health inequalities[40].

Public health researchers have become increasingly interested in environmental factors that can promote – or hinder – healthier behaviour in a broader population. For example, attractive parks and useable cycle paths encourage active travel or recreational physical activity. This has given rise to the concept of 'walkability', which has three main components: residential density, street connectivity, and destination diversity[41]. In other words, densely populated areas allow people to pursue many different everyday purposes – such as employment, shopping, entertainment, etc. by walking or cycling[42]. Measuring these dimensions tells us the walkability of an urban neighbourhood. We know that more walkable neighbourhoods support physical activity among adults. But in children the picture is less clear.

In the I.Family study, we evaluated the walkability of local neighbourhoods in study areas of Germany, Italy and Sweden. An example is given in Figure 13 illustrating the German study region.

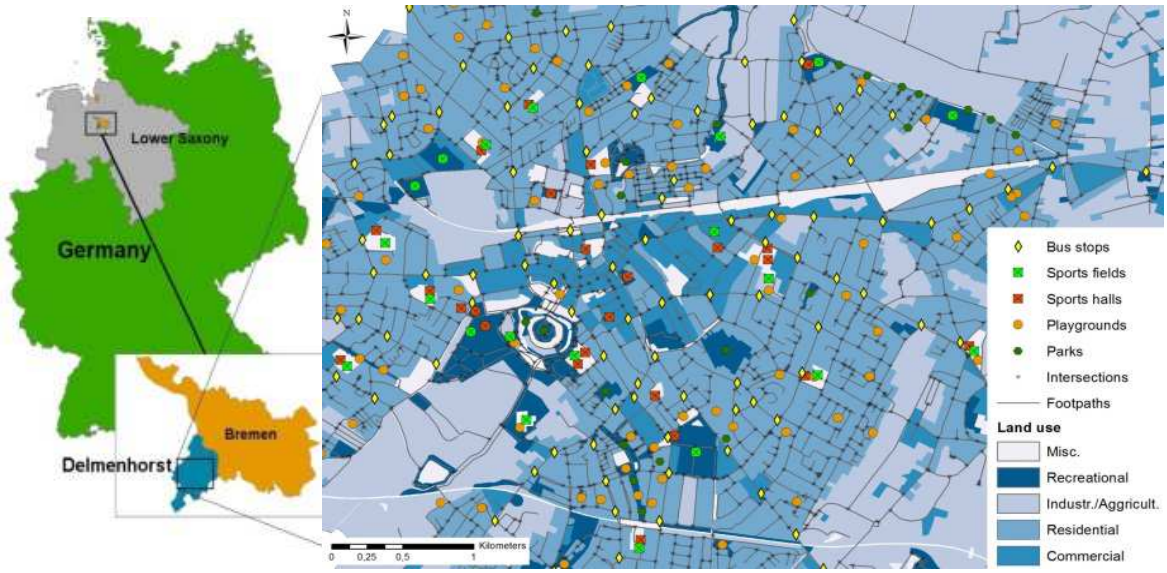



**Figure 13:** Example of spatial data collected to evaluate moveability in one I.Family study region in Germany

We also extended the walkability concept to factor in public open spaces such as parks and playgrounds that provide opportunities for active leisure, thus creating the broader concept of 'moveability'. Moveability incorporates various layers of environmental characteristics such as land use mix, residential density, street connectivity, availability of public transit and of public open spaces, especially playgrounds and parks, into a single quantitative score (see Figure 14). We looked at how moveability affects physical

[40] Sallis JF, Cervero RB, Ascher W, Henderson KA, Kraft MK, Kerr J. An ecological approach to creating active living communities. Annu Rev Public Health. 2006;27: 297-322.
[41] Sallis JF. Measuring physical activity environments: a brief history. Am J Prev Med. 2006;36: 86-S92.
[42] Freeman L, Neckerman K, Schwartz-Soicher O, Quinn J, Richards C, Bader MD, et al. Neighborhood walkability and active travel (walking and cycling) in New York City. Journal of Urban Health. 2013;90(4): 575-585.

activity levels in children and adolescents using accelerometers (small devices worn on the body that measure activity)[43].

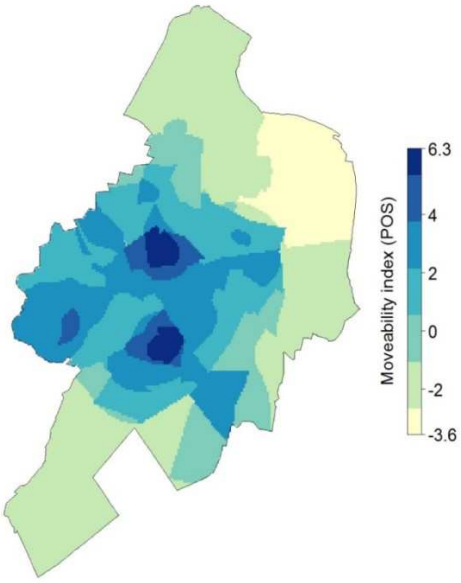



**Figure 14:** Areas with many opportunities (blue) and few opportunities (green) for physical activity in one German study region

**Public open spaces promote children's physical activity**

For children, physical activity is encouraged by the availability of public open spaces within densely residential areas. However, this association is modified by safety concerns, age and sex. If parents feel that the neighbourhood is not safe for children, they tend to restrict children's outdoor activity. This is especially true if their child is female[44]. For adolescents, good walking and cycling facilities as well as diverse destinations matter, while public open spaces become 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 seem to promote an active lifestyle in girls. For adolescent boys, public open spaces remain an important factor to support adequate physical activity.

**Conclusions**

Well-designed public open spaces and safe and well-connected facilities for walking and cycling are key to increasing physical activity. The moveability concept can thus be used to identify poorly designed neighbourhoods and opportunities to improve public health. Changing the built environment in deprived areas can play a special role in reducing health inequalities. Urban planning and public health need to collaborate to identify suitable interventions targeting vulnerable populations.

[43] Buck C, Pohlabeln H, Huybrechts I, De Bourdeaudhuij I, Pitsiladis Y, Reisch L, et al. Development and application of a moveability index to quantify possibilities for physical activity in the built environment of children. Health Place. 2011;17(6): 1191-1201.

[44] Buck C, Tkaczick T, Pitsiladis Y, De Bourdehaudhuij I, Reisch L, Ahrens W, et al. Objective measures of the built environment and physical activity in children: from walkability to moveability. J Urban Health. 2015;92(1): 24-38.

Besides their effects on physical activity, 'walkability' and 'moveability' are also important for emotional well-being, social cohesion and social support. Beyond health and physical fitness, policy-makers and urban planners have many reasons to pay attention to these factors.

## 3.8 How family relations influence children's health

The notion that 'obesity runs in families' has been supported by many previous twin and family studies, and large scale genetic studies have identified multiple common genetic variants that account for up to 20% of the variance in BMI[45]. Comparatively little is known as to how similar family members are in dietary intake, and whether this resemblance differs for different types of foods or depends on the children's age. Family resemblance can arise from shared genes and shared environments. Parents and their children have a similar genetic make-up – they share 50% of their segregating genes. They also share the same home environment. Spouses can also be similar because of assortative mating (partners choose each other on the basis of shared characteristics) or social interaction. Nonetheless, each individual in a family has unique experiences. Environmental influences that lead to differences among children from the same family could include accidents, illnesses, trauma, friendships, experiences of school, etc.

How can we tease apart familial and non-familial influences? The only way to learn about these differences is to conduct family studies. I.Family provides us with the unique opportunity to find out how much of the variation in a trait is determined by the family and how much is explained by factors outside the family.

**What we did in I.Family**

In order to examine the effects of family influence versus external influences on obesity-related traits and behaviours, we studied parent-child pairs, brother/sister (sibling) pairs and parental pairs and examined their resemblance. Altogether, we looked at about 4,800 families. One of the factors we examined was diet. We used a food frequency questionnaire and an online tool called SACANA (24-hour diet recall) developed especially for the study. We calculated nutrient intakes and characterised foods as healthy and unhealthy based on their sugar, fat and fibre content. The findings presented here are based on current analyses of I.Family data.

**Resemblance of family members**

Family members resemble one another in terms of height, body fat measures and cardiovascular disease risk (e.g. total cholesterol). This is shown in Figure 15, which gives correlations for height, body fat percentage and total cholesterol. The resemblance is stronger for biological relatives (sibling pairs, parent-child pairs) than non-biological relatives (parental pairs). This indicates that these traits are likely under strong genetic influence; however other factors such as assortative mating for height and body fatness (for parents) could also play a role. Sibling correlations for body fatness and total cholesterol are stronger than parent-child correlations. One explanation could be that the environment shared by siblings is important for these traits too.

[45] Locke AE, Kahali B, Berndt SI, Justice AE, Pers TH, Day FR, et al. Genetic studies of body mass index yield new insights for obesity biology. Nature. 2015;518(7538):197-206.

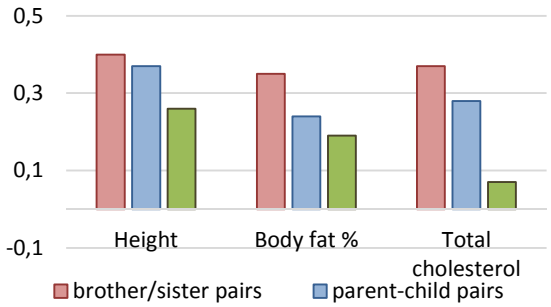



**Figure 15:** Correlations for height, body fat % and total cholesterol among family members

Family members also have similar diets. Figure 16 shows correlations for sugar, fat, and fruit and vegetable intake. Interestingly, the resemblance is strongest for sibling pairs and a bit less for parent-child and parental pairs. Since the correlation is similar in genetically related and non-genetically related family members, we can infer that the shared household is an important factor in dietary intake. The dietary intake of brothers and sisters is more similar – they are likely to share more environmental influences on their food intake, such as friends or schooling.

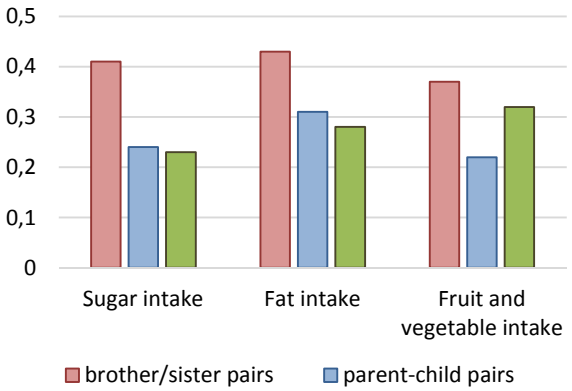



**Figure 16:** Correlations for sugar, fat, and fruit and vegetable intake within families

### Food intake of parents and their children

Parents and their children have similar food intakes (Figure 17). This is especially true for the intake of healthy foods, but less so for the intake of unhealthy foods. One possible explanation goes as follows: In the developed European societies in which the I.Family study was conducted, there are many external influences promoting unhealthy foods to children (e.g. supermarkets, advertising, pester power, etc.). However, there are few external influences for healthy foods.

As younger children consume most of their main meals at home, the home environment is likely to be the main factor explaining intake of healthy foods, including fruit and vegetables. If such foods are not made available to children at home, children are unlikely to consume them outside the home with the possible exception of meals provided at school or daycare. In addition, children have a higher natural preference for sweet tastes than adults. So it is not surprising that we see more variation between children and parents when it comes to eating unhealthy foods.


**Figure 17:** Parent-child correlations for healthy (green bar) and unhealthy (red bar) food intake

Familial factors explain 60% of the variability in the intake of healthy foods but only half as much (30%) in the intake of unhealthy foods (see Figure 18).

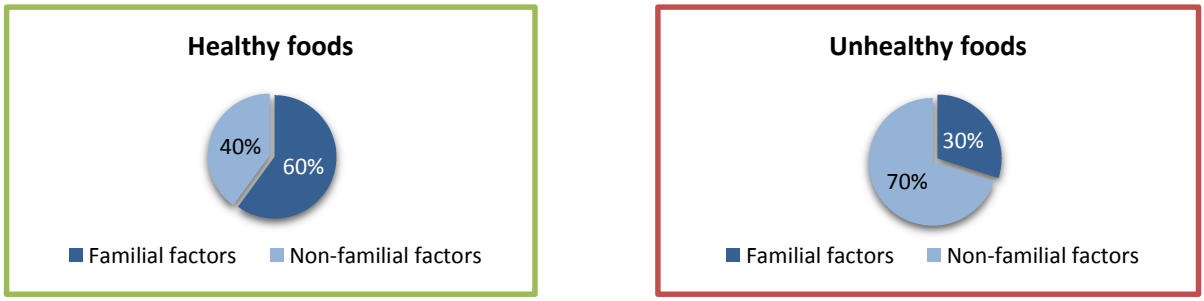



**Figure 18:** Proportion of variability in the intake of healthy foods and unhealthy foods explained by familial factors

### Resemblance of family members in terms of healthy food intake

In terms of the intake of healthy foods, there is 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 19). 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.

### Future research

In the future, we aim to study whether special factors are at work in families where one child is overweight and another child is not. Using our study data, we may disentangle the most important factors and by this identify leverage points for interventions in such cases.

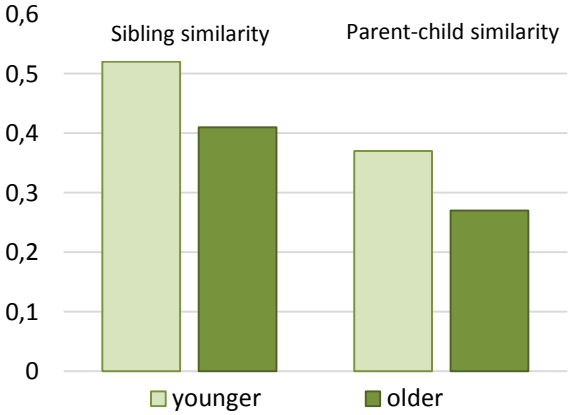



**Figure 19:** Sibling and parent-child correlations for healthy food groups, comparing younger and older children

**Conclusions**

Our results show that family members resemble one another in terms of diet and obesity-related traits – there are many reasons for this. Because the family environment is so important, interventions aimed at reducing obesity and improving diet quality may be more effective when targeting the entire family rather than individuals. We would also expect family-based interventions to be most successful when promoting healthier diets (rather than discouraging less healthy diets) and when they target families with younger children. Familial factors play a larger role in explaining healthy food intake and a smaller role in explaining unhealthy food intake. This underscores the importance of parents' role modelling in making healthy food choices available at home, which remains important when children enter their teens. It also highlights the major role of contemporary food environments in promoting unhealthy foods to children and their effects on children's dietary intake already at early ages.

## 3.9 How do friends affect teenagers' health behaviours?

How friends affect one another's health and behaviour has gained attention in public and academic debates around obesity and health in general. Identifying how peers influence one another is valuable because it implies that policies to combat obesity can have a 'social multiplier effect'. Existing evidence suggests that peers do affect one another's weight status. But most studies were conducted in Anglo-Saxon countries and were restricted to adults. In I.Family we explored this influence among European children – both its extent and the ways in which it occurs. We looked at the two most important routes through which teenage friends could affect one another: first, norms about acceptable and desired weights and second, weight-related behaviours such as eating and physical activity habits. We also considered some wider peer effects, going beyond friendship circles and looking at some effects among parents.

**Peers are more influential in collectivistic societies**

For children, teenagers and adults, we observed that a subject's body weight was similar to that of his/her peers. This was true right across Europe. The degree of these similarities differed by population level. Using the widest possible definition of 'peers,' meaning all the people in a similar age group in a country, we found weak relationships. At the more local level, grouping together all children in the same kindergarten/ school and of the same sex and age, we observed stronger relationships. In addition, by asking teenagers who their friends were, I.Family was able to go into more depth than previous studies and look at peers, in the narrower sense of friendship groups. We have found several pathways through which peers influence one another:

1. On a national level, we observed stronger associations between peers' body weight in collectivistic societies, as compared to more individualistic societies (Figure 20), indicating that the community is more influential in collectivistic societies[46].

[46] Nie P, Gwozdz W, Reisch L, Sousa-Poza A. Values, norms, and peer effects on weight status. J Obes; 2017:2849674.


**Figure 20:** Collectivistic and individualistic countries included in the study (based on Hofstede et al. 2010[47])

2. Parents' perception of their child's weight is influenced by how much other children weigh. Parents perceive their child to be thinner than he or she is when their peers are heavier. The opposite effect occurs when other children around are slimmer[48].

3. We found that teenagers' unhealthy food consumption is strongly associated with their friends' unhealthy food consumption (sugar sweetened beverages, fatty foods, food high in sugar and fast foods). However, we did not observe an association for healthy foods among peers (vegetable/fruit consumption, fibre rich foods)[49].

4. Patterns of sedentary behaviour and leisure time activity also tend to be more similar between teenagers and their friends[49].

## Conclusions

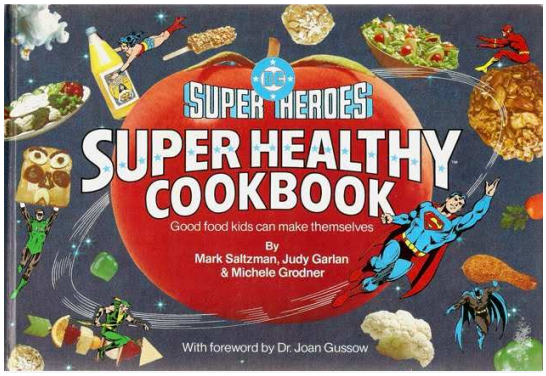
Greater knowledge about how peers affect one another's weight has important practical implications for interventions. Thus, we should tailor interventions to the relevant social norms and value systems (Figure 21). In collectivistic societies, it makes more sense to target the group and social norms. In individualistic societies, interventions should address the individual.

[47] Hofstede G, Hofstede GJ, Minkov M. Cultures and organizations: software of the mind. 3rd ed. McGraw Hill USA; 2010.
[48] Gwozdz W, Sousa-Poza A, Reisch LA, Bammann K, Eiben G, Kourides Y, et al. Peer Effects on Obesity in a Sample of European Children. Econ Hum Biol. 2015;18: 139-152.
[49] Gwozdz W et al. Peer effects on weight status, dietary behaviour and physical activity among adolescents in Europe: findings from the I.Family study. 2016. Paper in submission.

**Example for collectivistic societies**


**Social norms marketing campaign at Evanston Township High School (2001)**[50]

**Example for individualistic societies**




**Cover of *DC Super Heroes Super Healthy Cookbook* (1981)**[51]

**Figure 21:** Examples for interventions in collectivistic and individualistic societies

A greater knowledge about how peers affect one another's weight also helps to understand how parents' perceptions of their child's weight are affected. For instance, we should make parents aware of misperceptions, for example, by showing how common childhood obesity is in general or in their community (for an example see Figure 22).


**Figure 22:** Example for making people aware of the obesity epidemic in children[52]

Thus, social norms can be used to discourage unhealthy eating and sedentary behaviour. Figure 23 gives an example of a grassroot initiative to decrease fast food consumption among adolescents.


**Figure 23:** Grassroot campaign 'Stick it to Fast Food' by the Ontario Student Trustees Association (2012)[53]

[50] http://www.socialnormsresources.org/casestudies/evanston2.php
[51] https://playingwithresearch.com/2011/03/31/awesomest-cookbook-ever/
[52] Obese enablement: a gut check for families of overweight children. 2013 [20 Sept 2013]. Available from: http://www.theravive.com/today/post/Obese-Denial-A-Gut-Check-For-Parents-of-Overweight-Children-0000215.aspx
[53] http://www.ottawafamilyliving.com/stick_it_to_fast_food_

## 3.10 ROLE OF GENETIC AND EPIGENETIC FACTORS FOR FOOD CHOICE/ EATING HABITS

Genetic factors play a significant role in a person's food choices and dietary habits[54], in turn influencing the health consequences of eating behaviours, including excess body weight. Although eating behaviour, and the resulting food intake, is under the complex influence of physiologic, psychological, social, and genetic factors, the role of genetics in not negligible, with about 20–40 % of the variance in energy and macronutrient intake explained by genetic factors[55]. In contrast, diet is an important regulator of gene expression. Dietary components may influence gene expression through several mechanisms[56], but may also modulate the expression of non-coding RNA, in particular microRNAs, whose role in phenotypes of health and disease, including obesity, is now clearly established[57]. Thus, the early understanding of the biological mechanisms involved in eating behaviour can inform risk reduction, primary prevention, and intervention strategies.

**Genetic studies**

Genetic analyses in the I.Family study aim to investigate to what extent variations in genes implicated in the neural processing related to food choice, e.g. genes constituting the (an)orexigenic neurotransmitter pathways (neurotransmitters signalling study) or in implicated perception of food taste (taste receptors study) contribute to explain the observed variance in unhealthy eating patterns.

In the past few years, genome-wide association studies (GWAS) that involve scanning of thousands of samples using the latest advances in genotyping technology (i.e. high-density, genome-wide arrays to assay hundreds of thousands of single nucleotide polymorphisms [SNPs] that capture the majority of common variation in the human genome) have led to impressive advances in the identification of susceptibility genes.

In I.Family, a genotyped dataset was available for 2,055 children. Preliminary analyses led to the identification of genetic loci showing different degrees of association with the neuropsychological and food preference phenotypes under study. Further and in-depth analyses on a larger population of children belonging to the I.Family cohort are currently planned.

**Gene expression studies**

These studies aimed to identify novel transcriptome-based biomarkers of food choices and eating behaviour. These biomarkers were assayed in peripheral blood cells (PBCs) because these cells have the advantage that they can be easily obtained in humans with minimally invasive techniques, and because changes in gene expression may reflect changes in key processes occurring in other tissues of the body not easily reachable. In the course of the I.Family project, several candidate genes were identified,

[54] Grimm ER, Steinle NI. Genetics of eating behavior: established and emerging concepts. Nutr Rev. 2011;69(1): 52-60.
[55] Rankinen T, Bouchard C. Genetics of food intake and eating behavior phenotypes in humans. Annu Rev Nutr. 2006;26: 413–434.
[56] Reynés B, Palou M, Palou A. Gene expression modulation of lipid and central energetic metabolism related genes by high-fat diet intake in the main homeostatic tissues. Food Funct. 2017;8(2): 629-650.
[57] Paul P, Chakraborty A, Sarkar D, Langthasa M, Rahman M, Bari M, et al. Interplay between miRNAs and human diseases: a review. J Cell Physiol. 2017. doi: 10.1002/jcp.25854

differently expressed between overweight and normal weight children, whose expression was modulated by dietary factors like sugar and fat intake[58].

**miRNA profiling**

MicroRNAs are small non-coding RNAs involved in the modulation of gene expression and in the control of numerous cell functions. Alterations of microRNAs patterns frequently occur in cancer and metabolic disorders, including obesity. Recent studies showed remarkable stability of microRNAs in both plasma and serum making them suitable as potential circulating biomarkers for a variety of diseases and conditions.

The results of a pilot study on a sub-sample of the I.Family population show that a set of circulating microRNAs are differentially regulated in overweight or obese as compared with normal weight children[59]. In-depth bioinformatics analysis are currently in progress (a) to investigate differences in miRNAs expression patterns in sub-groups of the diverse countries of the European survey, and (b) to study the correlation between the expression levels of selected miRNAs and anthropometric and biochemical variables.

**Conclusions**

The advance of the -omics technologies largely increased the possibility to investigate the functional response of the individual to dietary patterns or bioactive nutrients. In I.Family we addressed different aspects of the complex interplay between genetics/epigenetics/environmental factors in shaping dietary behaviours and, ultimately, body fat accumulation. The biobank that was built up during the IDEFICS study and further extended in the I.Family, along with robust and repeated measurements over time of environmental exposures will allow further research in this challenging field.

[58] Priego T, Sánchez J, Picó C, Ahrens W, De Henauw S, Kourides Y, et al. TAS1R3 and UCN2 Transcript levels in blood cells are associated with sugary and fatty food consumption in children. J Clin Endocrinol Metab. 2015;100(9): 3556-3564.
[59] Iacomino G, Russo P, Stillitano I, Lauria F, Marena P, Ahrens W, et al. Circulating microRNAs are deregulated in overweight/obese children: preliminary results of the I.Family study. Genes Nutr. 2016; 11: 7

# 4. Description of the potential impact (including the socio-economic impact and the wider societal implications of the project so far) and the main dissemination activities and the exploitation of results

## 4.1 I.FAMILY – A UNIQUE RESEARCH INFRASTRUCTURE FOR THE FUTURE

**Geographic and scientific scope of the I.Family study**

Rates of obesity and overweight remain at an unprecedented level among European children. Our research showed just how few European children actually meet guidelines for healthy diets, physical activity rates and sleep[60]. The geographic spread of the children's cohort represents the different lifestyles and living conditions across Europe. This spread is an important prerequisite to derive results and conclusions that are valid for a large part of the European population (Figure 24).


**Figure 24:** I.Family worked with a pan-European child cohort enumerated in eight countries (Belgium, Cyprus, Estonia, Germany, Hungary, Italy, Spain, Sweden) and scientific partners from another four countries (Denmark, Finland, Netherlands and UK)

The I.Family consortium formed a multi-disciplinary research group that has drawn on a wide range of scientific disciplines to build an integrated picture, examining:

- epidemiology
- dietary behaviours
- biological and neuro-behavioural susceptibility factors
- metabolic health
- genomics (genetic factors and gene expression patterns)
- physical activity and the built environment
- the family and its environment
- sleep duration and quality

[60] Kovács E, Siani A, Konstabel K, Hadjigeorgiou C, de Bourdeaudhuij I, Eiben G, et al. Adherence to the Obesity-Related Lifestyle Intervention Targets in the IDEFICS Study. Int J Obes. 2014; 38 Suppl 2: 144–151

- the influence of friends and peer groups during adolescence
- media consumption and its effects
- economic and policy aspects of food systems.

This multi-disciplinary network of scientists that evolved over the project duration will go on working together in the future. In addition, the project was extremely successful in building up a young researchers' platform including joint PhD theses and an exchange programme that will enhance the sustainability of our network and of our research.

**Further exploitation**

The measures that were taken to enable further exploitation of the rich research infrastructure established by I.Family can be roughly distinguished as follows: (1) the cohort itself that was established in 2007/08, (2) the biobank that was built up by intramural funds during the IDEFICS study and further extended in the I.Family study and (3) the rich dataset that will be maintained for the research network.

Early on the project, the partners agreed on principles for the governance of the IDEFICS/I.Family Biobank. From a practical perspective, this I.Biobank policy specifies principles for governing storage of and access to samples by accounting for the interests of the IDEFICS and the I.Family consortium, since equitable access and fair procedures need to be guaranteed when managing such a valuable shared resource that builds on major investment of time and resources from each survey centre. From an ethical perspective, we had to reassure our study participants that a responsible governance structure was set up to oversee the storage and use of samples, also after the I.Family funding period has ended. Since this biobank is both a very valuable and a strictly limited resource, samples should only be used for joint research activities. A major achievement based for the most part on our biobank was the provision of reference curves for anthropometric measures, for blood markers like insulin and glucose, for blood lipids, cholesterol, and C-reactive protein, recently published in a supplement volume of the International Journal of Obesity[61]. These reference values offer an excellent basis particularly for the identification of metabolic dysfunctions and will contribute to the improvement of diagnosis and treatment of children in daily practice.

In light of the 'Open Research Data Pilot' and the 'Guidelines on FAIR Data Management in Horizon 2020', the IDEFICS and I.Family consortia will develop a policy and principles to guide collaborations with other researchers who wish to analyse our project data, taking careful account of relevant data protection regulations. A use and access strategy for this rich database is all the more necessary since partners are increasingly approached by external researchers who would like to make use of the data. In the past, such requests were decided on a case-by-case basis where access was only possible in form of collaborations with one of the I.Family partners. For instance, IDEFICS/I.Family SCs decided to provide data to the DEDIPAC Determinants of Diet & Physical Activity consortium (a project funded by the Joint Programming Initiative (JPI) "A Healthy Diet for a Healthy Life" (HDHL)) to boost the scientific exploitation of our database and to increase sustainability. The project also contributed its accelerometer data to the International Children's Accelerometry Database (ICAD) to support international research on time trends, regional variation and the associations between age, sex, weight status, country and physical activity outcomes in children and adolescents. On occasion, our data have been requested in form of summary statistics for example, for a recent paper on trends in body mass index among children and adolescents

[61] Ahrens W, Moreno LA, Pigeot I. Filling the gap: international reference values for health care in children. Int J Obes. 2014;38 Suppl 2: 2-3.

worldwide. We will provide such data subject to proper assurances as to the scientific credibility of the study and agreement from the principal investigators of all survey centres.

**Conclusions**

The IDEFICS/ I.Family cohort is a unique resource to investigate the aetiology of nutrition and lifestyle-related disorders in children, adolescents and young adults. The wealth of data collected in three subsequent examination waves over nearly ten years, in combination with the samples stored in the central biorepository, offer unequalled opportunities for further research in this area. It was impossible to fully exploit this resource within the funding period of the I.Family study, and the database offers multiple opportunities for further innovative research. The existing network of consortium members will continue to collaborate and seek collaboration with external partners to advance its research with these data.

The acquisition of funding for this continuation will be critical. In particular, the established infrastructure is ideally suited to another follow-up examination when study participants have become young adults. Of course, another follow-up would require a corresponding funding opportunity. The prospective nature of this study would then allow us to compare the different health trajectories of children and to filter out those factors from the complex web of causes of ill-health that are modifiable. This focus may thus provide more effective leverage points for prevention of non-communicable diseases than those targeted in the past.

## 4.2 Challenging health inequalities in European families

Consumer policy and health policy have long realised that policy instruments such as information, education, and advice have to be targeted to the group of people one wants to reach.

Young and old, men and women, educated and less formally educated people, people with different cultural backgrounds and so on react to different messages, believe different sources of information, find different stories interesting and also worry about different issues. Likewise, social norms and assumptions about 'proper' behaviour and 'proper' food intake vary between different groups. People are 'social animals' and tend to do what others do and (what they think) is expected from others. So it is key to identify relevant social norms and work with, not against them. Social health marketing has developed a good sense of how to design messages to reach specific groups.

Beyond information and education, behaviourally based policies such as changes in the urban environment to promote biking and walking have been tested. A strong movement in policy today is to nudge people to choose healthier food in canteens and supermarkets by promoting the healthier options 'by design.' This could be store design, assortment choice, digital reminders, or similar cues. A good way to test whether such an intervention works is to try it on a small scale in neighbourhoods, schools or supermarkets: test it, learn from it, adapt the instrument to the specific setting and group of people – and therewith make it more effective and attractive.

'Vulnerable' consumers are particularly difficult to reach. Some consumers are systematically disadvantaged – for instance, children are young and inexperienced so easily manipulated, while poorer people tend to be less mobile and hence must shop in their immediate environment. Poor neighbourhoods are often characterised as 'food deserts' in which healthier food is less easy to get and

where more fast food outlets can be found. Some consumers are less educated and have difficulties making truly informed choices – weighing costs and benefits of offers and actively choosing healthier options. More generally, poor consumers are often under time and social stress, find other problems more pressing (money, rent, crime, jobs...). They therefore might have only a limited 'cognitive band-with'[62] available for health, nutrition and physical activity. Last but not least, migrant consumers might lack the knowledge of the local food culture and not speak the language; food smartness is always also culture-specific and has to be learned much like a language.

For different reasons, then, healthier choices are often not known, are too complicated, too difficult to access, or simply not affordable to these disadvantaged or 'vulnerable' consumers. At the same time, this group is the most important group to reach with policy measures: poorer and less educated people (in particular: women) tend to be more overweight and less healthy. People who are already disadvantaged would gain the most from healthier food and more physical activity, helping them to escape the vicious circle of poverty, ill-health, low paid jobs, the 'time crunch,' and obesity. A Euro spent on interventions helping these groups would result in a larger effect than a Euro spent on well-educated and wealthier people. It might also be fairer, given existing inequality, to direct scarce resources to the worst off.

All the current policy reports on how to cut childhood obesity identify low income and low education as a prime risk factor (Figure 25). As research with poor consumers has shown, any policy measure that simplifies healthier consumption options, saves time and energy, makes access to healthier options easier and more acceptable, will help to overcome such barriers. 'Making the healthy choice the easy choice' works for all consumers. However, it might be most helpful for vulnerable consumers and would ease their everyday struggle. Information and education campaigns against overweight and obesity, however, might widen rather than narrow inequalities, especially if not specifically targeted to this group.

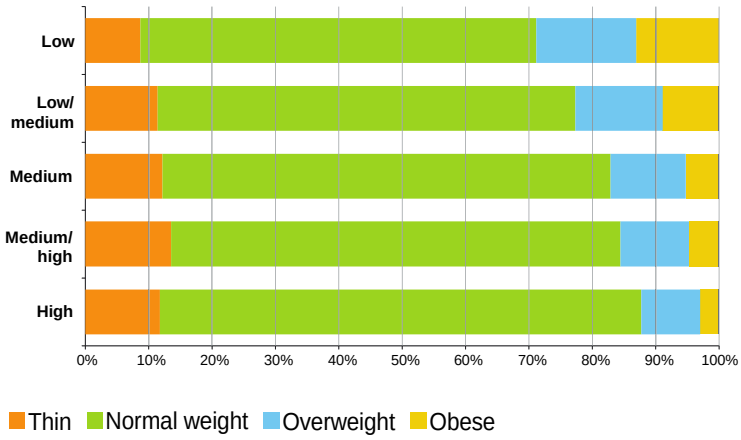



**Figure 25:** Illustration of how social position affects health: percentage of IDEFICS children in each weight category by parental income level (adapted from Ahrens et al. 2016)[63]

In I.Family, we worked with low income immigrant families to create digital and printed materials to change unhealthy food habits. As the pilot test showed, basic nutritional knowledge and 'food smartness' (e.g. knowledge on nutritional labels) is comparatively low in this group. All information and advice should be as simple and easily accessible as possible. As suggested by other studies, a family-based coaching

[62] Mullainathan S, Shafir E. Scarcity: why having too little means so much. New York: Time Books; 2013.
[63] Ahrens W, Pigeot I, Pohlabeln H, De Henauw S, Lissner L, Molnár D, et al. Prevalence of overweight and obesity in European children below the age of 10. Int JObes. 2014;38 Suppl 2: S99-107.

approach by health workers seems promising for these families; one-off interventions, however, are ineffective.

Pricing of healthier food items is also an issue. Both, the actual price and the perceived value matter here. Families with very limited food budgets simply cannot afford 'bad buys' and food that nobody eats. Eating habits and tastes are developed over a longer time frame and do not change overnight. For instance, deliveries of weekly vegetable and salad boxes are now quite common. But to make use of these might require new know-how or equipment that are beyond the interest, time and money of these groups. For parents who want to feed their kids more vegetables (for example), these might be barriers that an information campaign cannot overcome.

**Conclusions**

Overall, our findings echo those of the World Health Organisation and the European Commission[9,64]. It is not only lack of knowledge that needs to be addressed. For disadvantaged consumers, the priority is to address affordability, accessibility, and availability – all the practicalities relating to healthy food. In general, then, we need population level interventions that ensure healthier living conditions. But there is also an important role for extra efforts that target the worst-off groups and the specific barriers they face.

## 4.3 'BIG FOOD' AND CHILDREN'S HEALTH

To understand children's diets and obesity rates, we need to consider the commercial influences on what children eat and drink. I.Family data show that children who view more television advertising consume more sugar-sweetened drinks[65]. Even children who have less preference for sweetened foods eat more of them if they see more television adverts[22]. The children we studied also tend to eat foods that are more energy-dense than recommended[10]. We found that about 80% of children asked for items advertised on television, at least sometimes; where parents agreed to these requests more often, the child's diet was higher in sugar and fat; and the children who asked for advertised foods were more likely to become overweight[66].

These results correspond to well-known findings. Food and drink marketing focuses on less healthy, processed foods. The overwhelming majority of foods aimed at children are high in fat, sugar and/or salt[67]. How can we explain these facts, and what can be done to change things?

**Why aren't cabbages advertised?**

The answer lies with the commercial opportunities presented by different types of food (Figure 26). Modern economies are dominated by business corporations. Compared to individual entrepreneurs or

[64] EU Action Plan on Childhood Obesity 2014-2020 [updated 12 Mar & 28 July 2014]. Available from: https://ec.europa.eu/health/sites/health/files/nutrition_physical_activity/docs/childhoodobesity_actionplan_2014_2020_en.pdf
[65] Olafsdottir S, Berg C, Eiben G, Lanfer A, Reisch L, Ahrens W, et al. Young children's screen activities, sweet drink consumption and anthropometry. Eur JClin Nutr. 2014;68(2): 223–228.
[66] Huang CY, Reisch LA, Gwozdz W, Molnár D, Konstabel K, Michels N, et al. Pester power and its consequences: do European children's food purchasing requests relate to diet and weight outcomes? Public Health Nutr. 2016;19(13): 2393–2403.
[67] Cairns C, Angus K, Hastings G, Caraher M. Systematic reviews of the evidence on the nature, extent and effects of food marketing to children. A retrospective summary. Appetite 2013;62: 209–215.

other ways of doing business, the strength of corporations is long-term, capital-intensive production. Corporations can own and manage factories, research facilities, trademarks and brands.

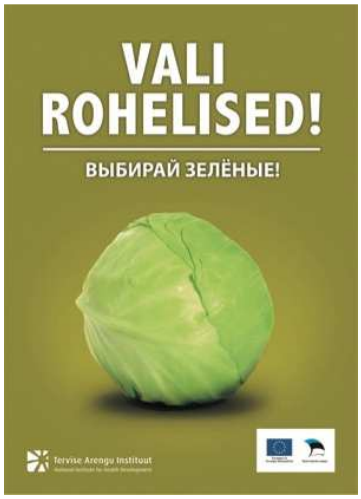



**Figure 26:** "Go green!" – Estonian public health campaign[68]

Less well-known is how business corporations depend on the state for their existence[69]. Corporate markets are not 'free.' They rest on laws that require everyone to recognize them as legal and economic actors. In other words, business corporations could not exist without state coercion. The law requires all of us to treat corporate employees and directors, when they are doing their jobs, as representatives of 'the corporation.'

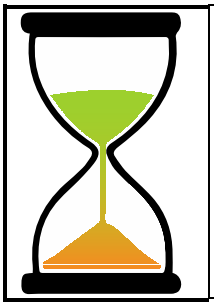



**Figure 27:** The hourglass shape of modern food systems in Europe[70]

As organisations, then, corporations persist even when individual members leave. They can grow to an immense size. Hence their special ability to engage in capital-intensive production and marketing shapes the food chain in the European Union (Figure 27).

**So far as food and drinks are concerned, this means food processing**

To get cabbages to consumers, you need a distribution network and shops. The special strength of corporations lies elsewhere – in creating branded, factory-made products. Factories need reliable inputs – for example, commodity crops like wheat, soya, maize, sugar and oils that don't depend on seasonal factors. Brands and trademarks can only be applied to specially formulated products.

[68] http://www.toitumine.ee/kampaania/viisvilja/tai-plakatid.pdf
[69] Ciepley D. Beyond public and private: toward a political theory of the corporation. Am Polit Sci Rev. 2013;07(107): 139-158.
[70] Figures are approximate. See Eurostat. 2017. Farm Structure Statistics (http://ec.europa.eu/eurostat/statistics-explained/index.php/Farm_structure_statistics) and DG Agriculture and Rural Development. 2015. EU Agricultural Economic Briefs No. 4 (http://ec.europa.eu/agriculture/markets-and-prices/market-briefs/pdf/04_en.pdf).

By contrast, whole foods like cabbages are hard to brand, more perishable, and more seasonal. They don't present comparable commercial opportunities.

**Food processing is problematic from a health point of view**

Food processing works best with reliable, storable ingredients. Unlike home cooking, it aims to create products that will keep as long as possible. Both these factors reduce water content. This means products are more energy dense – they tend to contain more calories by weight than whole foods or home-cooked foods.

If used at all, fruits and vegetables tend to be already processed – for example, as extracts or concentrates. So the fibre content of processed foods tends to be low, too. Sugar, fat and salt are cheap ways to make a product taste better. These factors also increase energy density. Sugar and salt also help to increase shelf life. Heat treatments prolong shelf life and improve food safety, by killing pathogens, but they have the side effect of reducing the amount of nutrients.

The upshot is that processed foods tend to be more energy dense, making it easier for people to consume more calories. At the same time, they tend to have lower nutrient content. In general, it's more difficult and expensive to make healthy processed foods and drinks.

**Can companies change this?**

Many governments have hoped that food and drink corporations can focus on making healthier products or limit their marketing of unhealthy products. 'Self-regulation' is the idea that companies will do this voluntarily – for example, by not marketing 'kids' food.' These hopes go against the basic economics of food processing.

In some respects, 'Big Food' is immensely powerful. Food and drink markets have been profoundly reshaped by corporate business models. The relative prices of processed foods have fallen; opportunities to buy them have become ubiquitous. The companies involved have grown very large; they advertise, lobby politicians, and influence international trade agreements. At the same time, local produce markets and independent retailers of whole foods (high-street green-grocers, for example) play an ever smaller role.

Nonetheless, big food and drink companies are caught by their own business models. Competition drives them to maximise sales in all possible markets – including 'kids' food.' Products that don't rely heavily on cheap, storable ingredients are bound to be more expensive. In other words, 'Big Food' is less powerful than it seems.

**Regulation in the cause of freedom**

Regulations that limit marketing to children, or taxes that increase the price of sugar-sweetened drinks, are often presented as restrictive or interfering. But corporate markets are not free markets. Only legal regimes, and ultimately state coercion, enable corporations to exist in the first place. In food and drink markets, this leads to the sort of public health problems highlighted by I.Family's research. Competitive pressures leave companies no choice: they must promote processed foods and drinks, even to children (Figure 28).


**Figure 28:** Foods and drinks marketed to children by companies that have signed the EU Pledge. This is a self-regulatory pledge not to advertise products to under 12s unless they fulfil specific nutritional criteria. The German NGO Foodwatch found that only 10% of these products (right) met World Health Organization criteria for a balanced diet.[71]

Like the legal restrictions that enable business corporations to exist in the first place, regulations can enable companies. For example, rules against marketing to children free companies from the worry that competitors will take over this market. They can relieve the pressures on parents that arise from marketing to children. They can free children from commercial influences they don't yet understand. Regulation sounds limiting. But it can create freedoms that really matter.

## Conclusions

Environments shape children's and families' diets and behaviour – to improve health, policy needs to address systemic factors and obesogenic environments. We have learnt that interventions only targeting health behaviours directly without considering the upstream factors that drive such behaviours will only have limited effects. To be effective and to reduce social inequalities in health, future prevention strategies need to target these upstream factors (Figure 29).

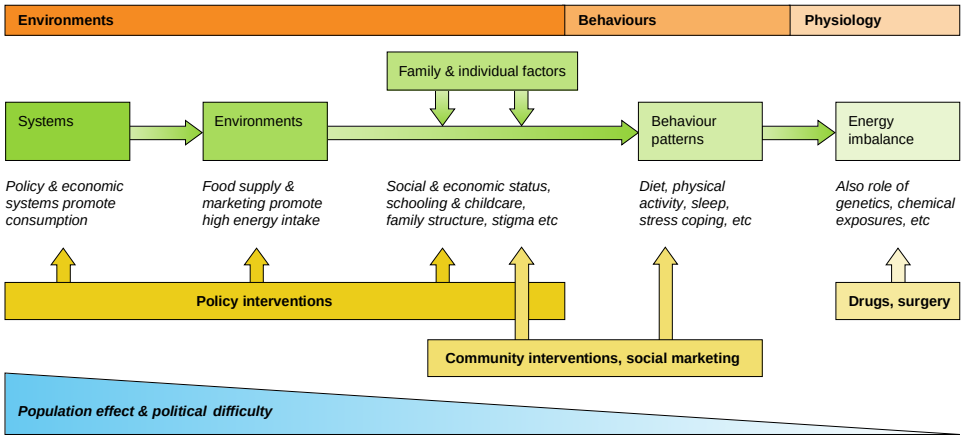



**Figure 29:** The Global Obesity Pandemic: Shaped by Global Drivers and Local Environments (adapted from Swinburn et al. 2011[72])

[71] On the EU Pledge, see http://www.eu-pledge.eu. Photo and findings from Foodwatch. 2015. Kindermarketing für Lebensmittel: Freiwillige Selbstverpflichtung der Lebensmittelwirtschaft ('EU Pledge') auf dem Prüfstand. Available from: https://www.foodwatch.org/de/informieren/kinderernaehrung/mehr-zum-thema/produkttest-selbstverpflichtung/.

[72] Swinburn BA, Sacks G, Hall KD, McPherson K, Finegood DT, Moodie ML, et al. The global obesity pandemic: shaped by global drivers and local environments. Lancet. 2011;378(9793): 804–814.

The consortium will continue to support efforts to ensure I.Family's findings will inform future obesity research, support policy-makers and healthcare professionals in deciding where they can most effectively target resources, and help families and individuals enjoy longer, healthier lives. Details on the dissemination activities can be found in the attached plan for use and dissemination of our findings.