Peer-reviewed | Manuscript received: February 22, 2018 | Revision accepted: May 22, 2018

Corrected version (Erratum)

Dietary habits and obesity in European children[1]

Results from the IDEFICS/I.Family cohort

Leonie H. Bogl, Maike Wolters, Claudia Börnhorst, Timm Intemann, Lucia A. Reisch, Wolfgang Ahrens, Antje Hebestreit

Abstract

The IDEFICS/I.Family study (financed by the 6th and 7th European Framework Programs for Research) has investigated the eating behavior of children and adolescents from eight European countries with particular regard to obesity and its health consequences.

In almost all countries, sugar consumption made up more than 20% of overall energy intake. In Germany the proportion was actually 30%. In summary, our results show that improving the quality of food consumed, i.e. increasing the consumption of fruits, vegetables and whole meal products and reducing sugar-added and industrially processed foods, may prevent the development of childhood obesity. A dietary pattern characterized by high levels of vegetables, fruits and whole meal bread, for instance, was associated with a 36% lower risk of overweight and obesity. Moreover, similarities could be seen between the dietary patterns of family members. An association was also observed between lower social status and unfavorable dietary patterns in children.

The results recommend political measures to support children, particularly those from socially disadvantaged families, to eat more healthily and thus prevent the development of overweight and obesity already in childhood.

Keywords: child health, overweight, familial resemblance, dietary patterns, socioeconomic status

Citation:
Bogl LH, Wolters M, Börnhorst C, Intemann T, Reisch LA, Ahrens W, Hebestreit A (2018) Dietary habits and obesity in European children. Results from the IDEFICS/I.Family cohort. Ernahrungs Umschau 65(10): 164–169. Erratum in: 66(1): M7

This article is available online: DOI: 10.4455/eu.2018.037

Introduction

In recent years it has been shown that differences in diet contribute significantly to health inequality in Europe and that poor diet is one of the main causes of the overall disease burden [2]. Worldwide, dietary-related diseases have become a major concern for healthcare systems and caused a loss of over 56 million years of healthy life for Europeans in 2000 only [3]. One particularly troubling aspect of this is the global increase in obese children and adolescents: if the current trend continues to 2022, there will be for the first time more obese than underweight children and adolescents worldwide. On a global scale the number of obese children and adolescents has increased within 40 years from 11 million in 1975 to 124 million in 2016 [4].

The causes for the development of obesity are very complex and the disease is basically seen as multifactorial [5]. Parents influence their children's diets through their own eating habits and through the eating environment they create at home [6]. Scientific evidence indicates that an unhealthy diet, sedentary behaviors and a lack of physical activity are major factors in the development of overweight and obesity in childhood and adolescence [7, 8].

This article provides an overview of the nutrition-relevant results of the IDEFICS study (2006–2011) and its subsequent follow-up study I.Family (2012–2017) [9, 10], which were financed by the 6th and 7th European Framework Programs for Research. We summarize below how the various eating habits and the energy and food consumption of children and their parents from eight European countries influence the development of childhood obesity. This overview also describes the results of the derived dietary patterns, which are attracting in-

[1] Parts of this article were published in a similar form in 2017 [1].

Glossary

IDEFICS = **I**dentification and prevention of **D**ietary- and lifestyle-induced health **EF**fects **I**n **C**hildren and infant**S**
I.Family = Investigating the determinants of food choice, lifestyle and health in European children, adolescents and their parents

creasing attention in nutritional epidemiology. Unlike the analysis of individual foods and food groups, the study of dietary patterns offers a more comprehensive picture of individual nutrition. Additionally, we summarize the results of our investigations into social inequality as an important determinant of childhood eating habits.

Methods

IDEFICS/I.Family cohort

The IDEFICS/I.Family cohort aimed to investigate associations between health, diet and lifestyle in European children and adolescents. In 2007/2008, 16,228 children aged from 2 to under 10 from Belgium, Germany, Estonia, Italy, Sweden, Spain, Hungary and Cyprus took part in the baseline survey of the IDEFICS study. Two years later, 13,596 children were examined again (1st follow-up study), of which 11,041 had already participated in the baseline survey.
Between the two study waves, a community-based intervention was conducted for half of the children in each country. The IDEFICS intervention was developed as a community-oriented program using a setting-based approach and aimed to enhance diet, physical activity and lower stress in order to reduce the prevalence of dietary and lifestyle-related diseases. In the case of diet the focus was on increasing daily consumption of water, fruits and vegetables; physical activity was to be enhanced by increasing the active time each day and lowering the time watching television; stress was to be reduced by more family time and sufficient sleep.
The follow-up study I.Family followed the development of the participating children and their families during the transition from childhood to adolescence. It further aimed to investigate how the health of the children and adolescents could be improved and diseases such as obesity avoided. To this end, the I.Family study examined biological markers and behavioral, social and environmental factors affecting the diet and health of children. In the I.Family study 9,617 children and their families (i.e. parents, siblings and any other carers) were involved. 7,105 of these children had already taken part in IDEFICS studies (baseline and/or initial follow-up surveys). At the time of the I.Family survey they were between 7 and 17 years old.

Instruments and indicators

For the dietary assessment two instruments were used: a food frequency questionnaire (FFQ) [11] and at least one 24-hour dietary recall [12, 13]. It should be noted that dietary assessment in children under 10 years of age is methodologically challenging by the "proxy reports"[2] of the parents [14], as already discussed elsewhere [15].
Height was measured using a SECA stadiometer and body weight determined using TANITA body analysis scales. The measurements were taken in fasting condition and light clothing (underwear). Body mass index (BMI) was calculated using the following formula: body weight (kg) divided by height (m) squared and converted into age- and sex-specific percentiles [16]. Overweight and obesity were defined using the age- and sex-specific cut-off values according to Cole and Lobstein [17].

As important determinants of eating habits three different indicators of socioeconomic status were recorded in a parent questionnaire: net household income, occupational level according to the European Socioeconomic Classification (ESeC) [18] and parental education status in line with the International Standard Classification of Education (ISCED) [19].
The statutory, data protection law and ethical stipulations of the Declaration of Helsinki on the conduct of studies in the case of voluntary participants were complied with. Every study center was granted authorization by the relevant ethics commission. All measurements were provided on a voluntary basis.

Results

Dietary Patterns

In IDEFICS/I.Family, dietary patterns were derived for various study questions based on different study populations, different dietary survey methods and various statistical methods. The derived patterns are similar, but do not correspond exactly due to the different methods and populations used and were therefore given different names in the individual analyses. For instance, the pattern "Vegetables and Whole meal" [11] is characterized by vegetables, fruits and whole meal bread. The same foods are also a significant component of the "Mediterranean" dietary pattern [20] and of the pattern "Healthy" [21–24]. A breakdown of this is provided in

[2] „Proxy reports": The parents completed the 24-hour dietary recall(s) on the food consumption of their children.

Authors (year) [reference]	Study population (sample size, age range)	Dietary assessment method	Statistical methods	Identified dietary patterns
Pala et al. (2013) [11]	n = 14,989 2 ≤ 10 years	food frequency questionnaire (FFQ)	principal component analysis	1) "Snacking" 2) "Sweet and Fat" 3) "Vegetables and Whole meal" 4) "Protein and Water"
Hebestreit et al. (2017) [13]	n = 1,662 mother-child pairs n = 789 father-child pairs parents: 28–59 years of age children: 6–16 years of age	combination of 24-hour dietary recalls and food frequency questionnaires (FFQ)	cluster analysis (k-means algorithm)	1) "Sweet and Fat" 2) "Refined Cereals" 3) "Animal Products"
Tognon et al. (2014) [20]	n = 7,940 2 ≤ 10 years	food frequency questionnaire (FFQ)	score based on 6 food groups	1) "Mediterranean" dietary pattern
Fernandez et al. (2014) [22]	n = 14,233 2 ≤ 10 years	food frequency questionnaire (FFQ)	country-specific principal component analyses	1) "Processed" (in 8 countries) 2) "Healthy" (in 7 countries)
Fernandez et al. (2015) Fernandez et al. (2017) Iguael et al (2016) [21, 23, 24]	n = 9,301 2 ≤ 10 years	food frequency questionnaire (FFQ)	cluster analysis at two points in time (k-means algorithm)	1) "Processed" 2) "Sweet" 3) "Healthy"

Table 1: **Identification of dietary patterns in the IDEFICS/I.Family cohort**

◆ Table 1. In the results section we refer to the dietary patterns derived in the individual studies, which explains the large number of patterns mentioned.

Dietary behavior

In the baseline study the average energy intake and distribution of macronutrients for 2 to under 10 year old children within the IDEFICS cohort was estimated and compared with D-A-CH reference values (nutritional guidelines for Germany, Switzerland and Austria including age-related reference values which are generally accepted for European populations). This showed that around one third of the IDEFICS children did not reach the guidelines for the relative consumption of carbohydrates (at least 50% of energy consumption) and around one third of the children exceeded the guidelines for fat consumption (maximum 35% of energy consumption). Less than 10% of the children achieved the recommendation for daily water intake [25].

In other countries, except for Estonia, sugar consumption made up more than 20% and in Germany it was as much as 30% of the children's overall energy intake [26]. Sugar intake here was defined as all mono- and disaccharides, regardless of whether they were natural or added. The consumption of overall sugar and of foods and drinks with high sugar content was higher at weekends than during the week. These variations in sugar content on weekdays and weekends did not however make any difference to overall energy intake on these days. Energy density (ED, in kcal/g) describes the energy intake in kilocalories (kcal) divided by the overall intake of solid food in grams per day. In most definitions drinks are excluded since they "water down" the true energy density and results can be easily misinterpreted [12]. Children whose food had a low ED had a lower overall energy intake per day, but consumed less cereal products, larger quantities of fruits, vegetables and milk products (compared to children with a higher ED) [12]. The diet composition of the children with a lower ED was thus comparatively healthier: they consumed less fat and sugar, whilst also consuming more protein and total carbohydrates. Furthermore, school children tended to consume food with a higher ED than preschool-age children.

We recorded the dietary patterns of children and their parents with regard to similarities and differences [13]. Three dietary patterns could be identified which were comparable in parents and children: a so-called "Sweet and Fat" pattern characterized by an above-average intake of sugar and sweets, animal or processed fats, sweetened drinks, sweetened milk and milk products; a "Refined Cereal" pattern characterized by an above-average intake of refined cereals or cereal products (which also contained a lot of sugar and/or fat, such as breakfast cereals or baked goods), vegetable fats and oils and energy-free and unprocessed drinks (water, tea); a pattern called "Animal Products" characterized by an above-average consumption of all kinds of meat and meat alterna-

tives, mixed meals (stews, pasta and rice dishes made up mainly of cereals, pulses and vegetables/potatoes) but also fruits and vegetables (raw and cooked). In the so-called "Animal Products" pattern the energy consumption was lowest.
Associations could be identified between the dietary patterns of parents and their children. The probability that a child could be allocated to the pattern "Sweet and Fat", "Refined Cereals" or "Animal Products" was higher if the mother or father followed the same pattern. The availability of soft drinks during meals increased the probability that children were allocated to the pattern "Sweet and Fat" and correspondingly reduced the probability of them being allocated to the other two categories.

In addition, we examined the similarities of family members with regard to the selection of food groups classified as "healthy" or "unhealthy" [27]. Family members were similar in their food choices, whereby siblings among themselves were more similar than parents and children. Younger children (< 12 years) showed more similar dietary intakes to their parents than older children (> 12 years).

Dietary behavior and weight status

In our investigations we observed positive associations between daily overall food intake (g/day), overall energy intake (kcal/day) and age- and sex-specific BMI. However, overall energy intake was a stronger predictor of unhealthy weight development than overall food intake [28]. In a longitudinal analysis of the IDEFICS cohort, there was also a positive association between energy intake and BMI; this applied equally when the objectively measured physical activity of the children was taken into consideration [29].

In another longitudinal analysis three food patterns were identified in the baseline and subsequent surveys. The first pattern was called "Processed" on account of the high consumption of fast food and snacks. The second pattern, called "Sweet," was rich in sweet foods and drinks and the third pattern "Healthy" was characterized by a high proportion of fruits and vegetables and whole meal products [21–24]. In comparison to children from the healthy food pattern, children with a combination of the patterns "Processed" and "Sweet" had a higher BMI after 2 years, a larger waist measurement and an increased percentage of body fat [21]. On the other hand the food pattern "Vegetable and Whole meal" was associated with a 36% lower risk of excess weight and obesity after 2 years [11].
In a further analysis, a so-called "Mediterranean" dietary pattern characterized by an above-average consumption of vegetables, pulses, fruits, nuts, cereals, all kinds of fish and an above-average consumption of milk products, meat, and meat products also showed negative associations with excess weight in children and childhood obesity [20]. Surprisingly, the Mediterranean pattern was adhered to most frequently by Swedish children and less often by children in the Mediterranean regions. This observation agrees with the finding that Swedish children from our cohort are less often overweight or obese than children from Italy, Cyprus and Spain [30].

Socioeconomic status of the parents and dietary habits of the children

To what extent the socio-economic status (SES) of the parents affects the dietary behaviors of their children was analyzed in several cross-sectional and longitudinal investigations. A cross-sectional analysis of the IDEFICS study showed that children from families with a low educational background consumed high-sugar and high-fat foods more frequently than children from families with a background of higher education [31]. In another cross-sectional analysis, country-specific patterns were identified [22]. It is noteworthy that the dietary patterns "Processed" and "Healthy" were identified in almost all countries. In all countries except Sweden, the dietary pattern "Processed" showed a negative correlation with a SES indicator which combined the educational status of the parents, their income and occupational level. The dietary pattern "Healthy" correlated positively with the SES indicator of the Belgian, German, Hungarian and Estonian families [22].

To what extent the educational status of the parents is related to the above-mentioned dietary patterns "Processed", "Sweet" and "Healthy" was the focus of two longitudinal analyses. Children from parents with high educational levels from the highest income brackets were more often allocated to a healthy dietary pattern in both IDEFICS surveys and less often to the "Sweet" pattern than children of parents with a lower level of education. Furthermore, children of parents with a migration background were more often allocated to the pattern "Processed" than were children of parents without a migration background [23].
In a comparable analysis the classic definition of SES was expanded by factors of social vulnerability. Here migration status, social network, family structure and employment status were taken into account [24]. The more factors of these social vulnerabilities applied, the higher the probability that the children were allocated to the pattern "Processed" at both survey times and the more rarely they displayed the dietary pattern "Healthy".

Conclusions

In order to prevent overweight and obesity in childhood, energy density and the intake of sugar and highly processed foods should be reduced, whilst aiming to increase the proportions of fruits, vegetables and whole meal cereals in the habitual diet.

Parents and siblings act as role models of healthy dietary behavior. Particularly young children are influenced strongly by the example set by adults and this example should be healthy eating habits. The dietary patterns of children and adolescents are negatively influenced by the availability of unhealthy foods at home, especially soft drinks.

Interventions aiming to reduce unhealthy eating habits in families and to encourage a healthy food environment at home have the potential to prevent the development of dietary-related diseases in childhood. Particularly for children from socially disadvantaged families it would be necessary to facilitate access to healthy foods and reduce the burden on these families through policy action. In this respect, the German Prevention Act *[PrävG]* partly implemented in 2015 offers an excellent opportunity to support families in improving their health literacy and to create a health-promoting living environment.

Dr. Leonie H. Bogl[1]
Dr. Maike Wolters[1]
Dr. Claudia Börnhorst[1]
Timm Intemann[1, 2]
Prof. Dr. Lucia A. Reisch[1, 3]
Prof. Dr. Wolfgang Ahrens[1, 2]
Dr. Antje Hebestreit[1, 4]

[1] Leibniz-Institut für Präventionsforschung und Epidemiologie – BIPS
Achterstr. 30, 28359 Bremen
[2] Institut für Statistik
Universität Bremen
[3] Department of Management, Society and Communication
Copenhagen Business School
Kopenhagen/Dänemark
[4] hebestr@leibniz-bips.de

Conflict of interest
The authors declare no conflict of interest.

Acknowledgments
We are grateful for the financial support from the European Commission (IDEFICS Study, 6th Framework Program Contract No. 016181 [FOOD]); I.Family study (7th Framework Program Contract No. 266044 [KBBE 2010-14]). We would like to thank IDEFICS and I.Family children and their parents for participating in the extensive studies.
Special thanks are due to the education authorities, head teachers and municipal/local authorities for their support. Our thanks also to Eva Gahler for her help in preparing the manuscript.

References

1. *Intemann T, Hebestreit A, Reisch L et al. (2017) Obesogenic diets in European children. From nutrients to upstream factors. Public Health Panorama 3: 663–676*
2. *WHO. Report of the Commission on Ending Childhood Obesity: implementation plan. World Health Organization (2017). URL: http://apps.who.int/iris/bitstream/10665/259349/1/WHO-NMH-PND-ECHO-17.1-eng.pdf Zugriff 29.01.18*
3. *Robertson A, Tirado C, Lobstein T et al. Food and health in Europe: a new basis for action. WHO Regional Publications European Series, No 96. (2004), S. 1–385*
4. *NCD Risk Factor Collaboration (NCD-RisC) (2017) Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128.9 million children, adolescents, and adults. Lancet 16: 2627–2642*
5. *Grundy SM (1998) Multifactorial causation of obesity: implications for prevention. Am J Clin Nutr 67: 563s–572s*
6. *Birch LL, Fisher JO (1998) Development of eating behaviors among children and adolescents. Pediatrics 101: 539–549*
7. *Summerbell CD, Douthwaite W, Whittaker V et al. (2009) The association between diet and physical activity and subsequent excess weight gain and obesity assessed at 5 years of age or older: a systematic review of the epidemiological evidence. Int J Obes (Lond) 33: S1–92*
8. *Prentice-Dunn H, Prentice-Dunn S (2012) Physical activity, sedentary behavior, and childhood obesity: a review of cross-sectional studies. Psychol Health Med 17: 255–273*
9. *Ahrens W, Bammann K, Siani A et al. (2011) The IDEFICS cohort: design, characteristics and participation in the baseline survey. Int J Obes (Lond) 35: S3–S15*
10. *Ahrens W, Siani A, Adan R et al. (2017) Cohort profile: the transition from childhood to adolescence in European children. How I.Family extends the IDEFICS cohort. Int J Epidemiol 46: 1394–1395j*
11. *Pala V, Lissner L, Hebestreit A et al. (2013) Dietary patterns and longitudinal change in body mass in European children: a follow-up study on the IDEFICS multicenter cohort. Eur J Clin Nutr 67: 1042–1049*
12. *Hebestreit A, Börnhorst C, Pala V et al. (2014) Dietary energy density in young chil-*

dren across Europe. Int J Obes (Lond) 38: S124–S134

13. *Hebestreit A, Intemann T, Siani A et al. (2017) Dietary patterns of European children and their parents in association with family food environment: Results from the I.Family study. Nutrients 9: 126*
14. *Livingstone MB, Robson PJ (2000) Measurement of dietary intake in children. Proc Nutr Soc 59: 279–293*
15. *Börnhorst C, Huybrechts I, Hebestreit A et al. (2013) Diet-obesity associations in children: approaches to counteract attenuation caused by misreporting. Public Health Nutr 16: 256–266*
16. *Cole TJ, Freeman JV, Preece MA (1998) British 1990 growth reference centiles for weight, height, body mass index and head circumference fitted by maximum penalized likelihood. Stat Med 17: 407–429*
17. *Cole TJ, Lobstein T (2012) Extended international (IOTF) body mass index cut-offs for thinness, overweight and obesity. Pediatr Obes 7: 284–294*
18. *Harrison E, Rose D. The European socio-economic classification (ESeC) user guide. Cholchester (2006). URL: www.iser.essex.ac.uk/files/esec/guide/docs/UserGuide.pdf Zugriff 29.01.18*
19. *United Nations Educational, Scientific and Cultural Organization (UNESCO). International Standard Classification of Education: ISCED 2011. UNESCO (2012). URL: http://uis.unesco.org/sites/default/files/documents/international-standard-classification-of-education-isced-2011-en.pdf Zugriff 29.01.18*
20. *Tognon G, Hebestreit A, Lanfer A et al. (2014) 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 24: 205–213*
21. *Fernandez-Alvira JM, Bammann K, Eiben G et al. (2017) Prospective associations between dietary patterns and body composition changes in European children: the IDEFICS study. Public Health Nutr 20: 3257–3265*
22. *Fernandez-Alvira JM, Bammann K, Pala V et al. (2014) Country-specific dietary patterns and associations with socioeconomic status in European children: the IDEFICS study. Eur J Clin Nutr 68: 811–821*
23. *Fernandez-Alvira JM, Börnhorst C, Bammann K et al. (2015) Prospective associations between socio-economic status and dietary patterns in European children: the Identification and Prevention of Dietary- and Lifestyle-induced Health Effects in Children and Infants (IDEFICS) Study. Br J Nutr 113: 517–525*
24. *Iguacel I, Fernandez-Alvira JM, Bammann K et al. (2016) Associations between social vulnerabilities and dietary patterns in European children: the Identification and prevention of Dietary- and lifestyle-induced health EFfects In Children and infantS (IDEFICS) study. Br J Nutr 116: 1288–1297*
25. *Börnhorst C, Huybrechts I, Hebestreit A et al. (2014) Usual energy and macronutrient intakes in 2-9-year-old European children. Int J Obes (Lond) 38: S115–S123*
26. *Svensson A, Larsson C, Eiben G et al. (2014) European children's sugar intake on weekdays versus weekends: the IDEFICS study. Eur J Clin Nutr 68: 822–828*
27. *Bogl LH, Silventoinen K, Hebestreit A et al. (2017) Familial resemblance in dietary intakes of children, adolescents, and parents: does dietary quality play a role? Nutrients 9 [DOI: 10.3390/nu9080892]*
28. *Hebestreit A, Börnhorst C, Barba G et al. (2014) 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 53: 673–681*
29. *Hebestreit A, Barba G, De Henauw S et al. (2016) Cross-sectional and longitudinal associations between energy intake and BMI z-score in European children. Int J Behav Nutr Phys Act 13: 23*
30. *Ahrens W, Pigeot I, Pohlabeln H et al. (2014) Prevalence of overweight and obesity in European children below the age of 10. Int J Obes (Lond) 38: S99–S107*
31. *Fernandez-Alvira JM, Mouratidou T, Bammann K et al. (2013) Parental education and frequency of food consumption in European children: the IDEFICS study. Public Health Nutr 16: 487–498.37*

DOI: 10.4455/eu.2018.037