The cumulative effect of small dietary changes may significantly improve nutritional intakes in free-living children and adults

Francis Bornet, Damien Paineau, François Beaufils, Alain Boulier, Dominique-Adèle Cassuto, Judith Chwalow, Pierre Combris, Charles Couet, Béatrice Jouret, Lionel Lafay, et al.

Title: The cumulative effect of small dietary changes may significantly improve nutritional intakes in free-living children and adults.

Running title: Nutritional effects of small dietary changes

Damien PAINEAU[(1)] (PhD), François BEAUFILS[(2)] (MD), Alain BOULIER[(3)] (MD, PhD), Dominique-Adèle CASSUTO[(4)] (MD), Judith CHWALOW[(5)] (PhD), Pierre COMBRIS[(6)] (PhD), Charles COUET[(7)] (MD), Béatrice JOURET[(8)] (MD), Lionel LAFAY[(9)] (PhD), Martine LAVILLE[(10)] (MD, PhD), Sylvain MAHE[(11)] (PhD), Claude RICOUR[(12)] (MD), Monique ROMON[(13)] (MD), Chantal SIMON[(14)] (MD, PhD), Maïté TAUBER[(15)] (MD), Paul VALENSI[(16)] (MD), Véronique CHAPALAIN[(17)] (MS), Othar ZOURABICHVILI[(17)] (MD, PhD), Francis BORNET[(18)] (MD, PhD).

Author affiliations:

[(1)] Nutri-Health, Rueil-Malmaison, France (new affiliation: Danone Research, Palaiseau, France)

[(2)] Department of Internal Medicine, Poissy St-Germain-en-Laye Hospital, St-Germain-en-Laye, France

[(3)] Department of Nutrition and Functional Investigations, INSERM U695, Bichat-Claude Bernard Hospital, Paris, France

[(4)] Paris, France

[(5)] National Federation of the Blind, Baltimore, United States

[(6)] INRA-CORELA, Ivry-sur-Seine, France

[(7)] INSERM E211, Tours Hospital, Tours, France

[(8)] Department of Pediatrics, Children's Hospital, Toulouse, France

[(9)] AFSSA/DERNS/PASER/OCA-EN, Maisons-Alfort, France

[(10)] CRNH Rhône-Alpes, Lyon 1 University, Hospices Civils de Lyon, INSERM U 870, INRA U 1235, Lyon, France

[11] French Ministry of Research, Paris, France
[12] Department of Pediatrics, Necker Hospital, Paris, France
[13] Department of Nutrition, EA2694 Lille2 University, Lille, France
[14] Louis Pasteur University, Medical Faculty, EA 1801, Strasbourg, France
[15] Department of Pediatrics, Children's Hospital, Toulouse, France
[16] Department of Endocrinology Diabetology Nutrition, CRNH-IdF, Jean Verdier Hospital, Paris-Nord University, Bondy, France
[17] Quanta Medical, Rueil-Malmaison, France
[18] Nutri-Health, Rueil-Malmaison, France (new affiliation: Nealth, Bobigny, France)

Corresponding author and reprints: Francis R.J. Bornet, MD, PhD, NEALTH, Département Etudes Cliniques - CRV - Service de Gastroentérologie - Hôpital Avicenne, 125 rue de Stalingrad, 93009 Bobigny Cedex, France (frj.bornet@nealth.eu). Tel: +33 (0)1 48 95 74 06. Fax: +33 (0)1 48 95 74 07.

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Abstract:

Background/Objectives: The ELPAS study was an 8-month randomized controlled dietary modification trial designed to test the hypothesis that family dietary coaching would improve nutritional intakes and weight control in 2026 free-living children and parents (Paineau *et al.*, 2008). It resulted in significant nutritional changes, with beneficial effects on body mass index in adults. In these ancillary analyses, we investigated dietary changes throughout the intervention.

Subjects/Methods: Before the study, modeling analyses were carried out on the French ASPCC food-consumption database to identify the most efficient dietary intervention strategy. During the study, all participants performed monthly 3 non-consecutive 24-h dietary recalls: this allowed for measuring changes in number-of-serving per day and serving size for each targeted food categories throughout the intervention.

Results: Modeling analyses showed that targeting only the 10 main foods contributing to fat and carbohydrate intakes did not allow for reaching the ELPAS nutritional goals. As a result it was decided to target more foods and to propose several types of dietary advice (change in serving size, change in cooking method, food substitution). This strategy led to many appropriate dietary changes during the intervention, but only a few of them reached significance. The mean number-of-serving per day was indeed significantly modified for only 7% of targeted food categories in children and 17% in parents. Mean serving size was modified for only 12% of targeted food categories in children and 9% in parents.

Conclusion: The cumulative effect of small dietary changes may induce significant nutritional improvements, with limited burden for populations.

Keywords: obesity, food habits, dietary modification, nutrition policy, modeling analyses

Introduction

Current nutritional recommendations for macronutrients are based on a decrease in fats and sugars and an increase in complex carbohydrates (Eurodiet, 2001, Institute of Medicine, 2005, World Health Organization & Food and Agriculture Organization of the United Nations, 2003). To help consumers apply such recommendations, public health authorities have developed food-based dietary guidelines (Department of Health and Human Services & Department of Agriculture, 2005, European Food Safety Authority, 2008). Such guidelines are often considered key elements to promote health and reduce risk for major chronic diseases (Estaquio *et al.*, 2008). However data are still lacking to identify the best strategies to induce beneficial dietary changes (European Food Safety Authority, 2008, Vandevijvere *et al.*, 2008).

The ELPAS study (*Etude Longitudinale Prospective Alimentation et Santé*, Longitudinal study on Health and Diet) was a randomized controlled dietary modification trial designed to test efficacy of family dietary coaching to improve nutritional intakes toward current recommendations for fats and carbohydrates (Paineau *et al.*, 2008). It was carried out among 1013 families for one school year. Detailed dietary intakes were measured monthly using three non-consecutive 24-h recalls in both parents and children. The ELPAS intervention led to significant nutritional changes, in line with the study objectives.

Food-based changes have not previously been presented. Analyzing those changes would improve our understanding of adherence to dietary advice in free-living (non-institutionalized) children and parents and may contribute to improve dietary guidelines and public health strategies regarding food-related diseases. In this ancillary study, we therefore analyzed in details dietary changes throughout the intervention. Our results were compared to data obtained from preliminary modeling analyses, which were designed to determine the most appropriate intervention strategy in the context of the ELPAS study.

Subjects and methods

Summary of the ELPAS study design and results

The ELPAS study design and results have been described in detail elsewhere (Paineau *et al.*, 2008). A total of 1013 Parisian families participated in this 8-month dietary modification trial. All participants gave written consent to their participation and ethical approval was given by the ethics committee of Poissy St-Germain-en-Laye Hospital, St-Germain-en-Laye, France. The ELPAS study was registered (ClinicalTrials.gov Identifier: NCT00456911). Families were randomized into two intervention groups, group A (GA) and group B (GB) or a control group (CG) (**Table 1**). In line with international nutritional recommendations for fats and carbohydrates, both intervention groups received advice on how to reduce dietary fats (<35% of total energy intake) and how to increase complex carbohydrates (so that total carbohydrates > 50% of total energy intake). GB received additional advice on how to reduce sugars (−25% of initial crude intake). Since current nutritional recommendations do not include a decrease in energy intake, both dietary interventions aimed at maintaining isocaloric diets. CG did not receive dietary advice.

The nutritional and clinical outcomes are presented in **Table 2** and **Table 3**. Of the baseline sample, 84.8% (859 families) completed the study, indicating a dropout rate of 15.2%, with no significant difference between groups (P=.46).

The following paragraphs present dietary intervention strategy and dietary changes in the ELPAS study.

Dietary modeling analyses

Dietary changes are hard to achieve and to maintain over time (King & Dietary Guidelines Advisory Committee, 2007). Building an efficient strategy for dietary interventions is thus challenging, especially when multiple nutritional targets are defined. Prior to the ELPAS study we therefore carried out computer-based modeling analyses to test several intervention strategies on a pre-existing food consumption database.

A dedicated computer program using stepwise modeling analyses and bootstrap procedures was developed using SAS 8.2 (SAS Institute Incorporated, Cary, NC, USA). This program was designed to model dietary changes in a food-consumption database and to analyze resulting nutritional changes. We used the French ASPCC food consumption database, which contains 7-day dietary records for 1500 subjects aged 2 to 85 years (Couet *et al.*, 2000, Rigaud *et al.*, 1997). To be consistent with the ELPAS cohort we only used data from subjects aged 25 to 44 (parents) and subjects aged 6 to 10 (children). Under-reporters were excluded using Schofield equations and Goldberg criteria (Goldberg *et al.*, 1991, Schofield, 1985), leading to final populations of 402 parents and 98 children. Food nutritional composition was obtained from the French REGAL table (Favier *et al.*, 1995).

Figure 1 summarizes the 4 steps of the modeling analyses: 1) identification of the main 50 dietary sources of fats, sugars and complex carbohydrates from the ASPCC food consumption database, 2) definition of dietary advice for each of these food items according to the ELPAS study nutritional goals, 3) programming of modeling parameters, and 4) running of modeling analyses. Four types of dietary advice were defined: T1) change in serving size, T2) substitution of a high-fat/high-sugar food item by its low-fat/low-sugar equivalent, T3) substitution of a food item from a different food category, and T4) change towards low-fat cooking methods. Input variables were the distribution among these 4 types of advice, the number of targeted food items and the overall compliance (percentage of potential dietary modifications that are modeled during analyses); the outputs variables were the nutritional changes towards fat and sugar, along with the modifications in serving size and the cost of the diet (which were used to control feasibility of dietary changes).

Different modeling parameters were used to test various intervention strategies and to identify the most efficient one(s) **(Table 3)**.

Dietary intervention

As suggested by previous studies, dietary adherence may be improved through family-based intervention, dietary education, intensive counseling programs, and involvement of key academic partners (Nicklas *et al.*, 2008, Ritchie *et al.*, 2005). The ELPAS intervention was therefore based on these 4 key elements. Families were recruited from elementary schools, with strong administrative support from academic partners (Richards *et al.*, 2006). Dietary education was provided using a number of education tools and events. Tools were developed prior to the intervention by dieticians and nutritionists and adapted to groups (GA/GB/CG) and populations (children/parents). Families in the intervention groups were provided with booklets presenting specific dietary advice by means of a synthetic table showing for each food group food items to be limited and food items to be encouraged. No food groups or food items were forbidden to limit dietary constraints. Recommendations were to change both number-of-servings per day and serving sizes in order to increase consumption of recommended food items and to decrease consumption of food items to avoid. Newsletters were sent to participants on a monthly basis: each of them highlighted one key food group and provided recipes to improve consumption of recommended food items. Along with booklets and newsletters, parents were invited to sessions dedicated to specific nutrition topics in relation with their nutritional objectives. Entertainment about food items and gastronomy were proposed to children. In schools more than 400 sessions were organized about healthy eating, since it may contribute to participant motivation (Sharma, 2006).

Family dietary coaching was developed within the framework of the ELPAS study to provide participants with personalized dietary advice. This method relies on monthly phone calls between dieticians and families to analyze dietary recalls (Paineau *et al.*, 2008). Taking into account individual characteristics (socio-economic status, education, food preferences…) allows for optimized counseling. A study website (www.elpas.fr) was developed to facilitate nutrition education, self-monitoring and communication between participants, dieticians and coordinators. Internet-based intervention promoting dietary changes have been found efficient in previous trials (De Bourdeaudhuij *et al.*, 2007, Kroeze *et al.*, 2008, Papadaki & Scott, 2005).

Dietary assessment

Dietary assessment was performed using self-reported 24-h dietary recalls. Each month, participants reported three non-consecutive days of recall within a 7-day period, including 1 weekend day and 1 Wednesday (free day for children). Dates of recalls were not imposed in order to limit constraints for participants and therefore to optimize dietary data quantity and quality. They accessed the study website to perform dietary recalls by means of user-friendly software containing more than 2300 food items along with serving size pictures (NutriXpert, MXS, Paris, France). Recalls were immediately computer-analyzed for nutritional intakes and deviations from a subject's nutritional aims. A detailed analysis was sent to the family's dietician and a summary was published on the participant's personal page of the study website to allow for self-monitoring of dietary adherence (Lanza *et al.*, 2001). Dieticians used these analyses to determine appropriate dietary advice during monthly phone calls. First recalls were systematically analyzed by dieticians to check for potential errors.

Statistical analyses

Statistical analyses were conducted using the SAS statistical program (version 8.2) (SAS Institute Incorporated, Cary, NC, USA) and the CROM'X statistical program (Socio Logiciels, Paris, France). All analyses were completed on an intention-to-treat basis, with a 2-sided .05 significance level (α=.05).

Results from modeling analyses are expressed as means ± SDs. Baseline characteristics and dietary modifications throughout the ELPAS study (changes in number-of-servings per day and changes in serving size between baseline and end of intervention) were calculated for each food group. Baseline characteristics are reported as means ± SDs and changes throughout the study are reported as means with 95% confidence intervals (95% CI). Considering that participants showing a true decrease in energy intake may be wrongly classified as underreporters, we decided not to exclude underreporters from dietary analyses. Intergroup comparisons were performed using nonparametric analyses of variance by ranks (Kruskal-Wallis test).

Results

Modeling analyses

Table 3 presents a selection of modeling analyses in children. They showed that a perfect adherence to dietary advice (analysis 1) allowed for reaching the study objectives, confirming theoretical feasibility of dietary changes. A more realistic adherence level (analysis 2) led to insufficient changes in sugar intake. Advice based on substitution only (analyses 3 and 4) were not more efficient than advice based on all 4 types of dietary change (analysis 2). Targeting only the top 10 food items for fat, sugars and complex carbohydrates reduced efficacy of dietary advice (analyses 5). Whatever the analysis, isocaloricity was maintained through a marked increase in serving sizes for high-complex-carbohydrate food items. Lastly, the economic impact of dietary changes was limited (<1% increase of daily food cost).

Fairly similar results were obtained in parents. The main differences were: 1) even a perfect adherence to dietary advice was insufficient to reach 50% of energy from carbohydrates; 2) a 50% adherence to dietary advice was not sufficient to decrease fat intake to less than 35% of energy; 3) advice based on substitution was slightly more efficient than advice based on all 4 types.

These modeling analyses showed that a high adherence to dietary advice (around 75%) was required to reach ELPAS nutritional objectives, especially for carbohydrates. As a result, dietary advice during the intervention targeted a wide range of food items with several types of advice.

Dietary changes

Changes in number-of-servings per day for targeted food categories are presented in **Table 4** and **Table 5**, respectively for children and for parents. Those changes were mostly in line with dietary advice but only few food categories were significantly modified (7% of them in children and 17% in parents). Significant changes for sources of fats include of high-fat cheeses, high-fat ready-to-eat meals and chocolate. Regarding sugar reduction, a few categories were modified throughout the intervention, i.e. sugar, honey and jam. Parents increased their consumption of low-fat and low-sugar food items. Whatever the intervention group, complex carbohydrate increase was limited since only consumption of bread significantly increased throughout the study.

Consistent findings were obtained for changes in serving sizes. Although most tendencies were in line with dietary advice, only few food categories were significantly changed throughout the intervention (12% of them in children and 9% in parents). In children, significant decreases were found in intervention groups compared to controls for high-fat cheeses (*P(GB/CG)*<.001), oils / butter / cream / dressings (*P(GA/CG)*<.001; *P(GB/CG)*<.001), low-fat butter / cream / dressings (*P(GB/CG)*=.002), honey / sweets (*P(GB/CG)*=.01), high-fat cereals (*P(GB/CG)*=.01), low-fat low-sugar cereals (*P(GB/CG)*=.002). In parents, significant decreases were found in intervention groups compared to controls for oils / butter / cream / dressings (*P(GA/CG)*<.001; *P(GB/CG)*<.001), high-fat ham and sausages (*P(GA/CG)*=.02), sugar (*P(GB/CG)*<.001), and jams (*P(GB/CG)*=.002).

Discussion

In this ancillary study we analyzed dietary changes during the ELPAS study in order to better understand dietary adherence to dietary advice in a large cohort of free-living children and parents. We also compared data with estimates previously obtained through modeling analyses. To our knowledge, few dietary intervention trials have investigated dietary changes in detail, and none of them have pre-tested their intervention strategy by means of modeling analyses.

Modeling analyses

Modeling analyses are interesting tools to predict potential lack of dietary adherence, to identify food groups that may require special intervention approaches and thus to improve intervention strategy. Those performed prior to the ELPAS study indicated that targeting only main contributors of carbohydrate and fat intakes resulted in insufficient efficiency. Targeting a greater range of foods and using multiple types of dietary advices was the better strategy, at least in children. It was therefore decided to provide the ELPAS volunteers with flexible and multiple dietary advice, which permitted food choices based on individual and cultural food preferences, cost and availability.

Modeling analyses also highlighted possible difficulties in changing complex carbohydrate intake and thus maintaining isocaloricity: depending on the analyses, serving size for high-complex-carbohydrate food items had to be multiplied by 1.5 to 2.6 to maintain diet isocaloricity. Such a high increase would be hard to achieve in the general population, especially when considering observed limits to high complex carbohydrate intake, i.e. bulking effects, limited palatability, limited number of food vectors, negative image for weight management, etc. As a result dieticians were explained during initial training how to increase adherence to dietary advice for high-complex-carbohydrate foods.

From a methodological point of view, modeling analyses showed good reproducibility. Running three times the program with the same modeling parameters, we obtained similar results for changes in fats, sugars and complex carbohydrates (SD<0.3%), which suggests that results were poorly impacted by the random choices made throughout the analyses. Modeling analyses would probably benefit from development of user-friendly software, which would allow detailed analyses of both dietary effects and nutritional outcomes of dietary changes. A limit of our work is that modeling analyses were carried out in a limited number of subjects. However, the ASPCC food-consumption database was the only French database available at the time of the ELPAS study.

Modeling approaches may be carried out through different types of models. Their potential applications are numerous: for instance, they may be used to test the impact of new food items on nutritional status (Boushey *et al.*, 2001, De Jong *et al.*, 2004, Johnson-Down *et al.*, 2003, Suojanen *et al.*, 2002) as already required by European authorities for novel foods (European Commission, 1997, European Communities, 1997). They can also be used to assess possible impacts on diet quality of dietary guidelines (Britten *et al.*, 2006), to validate the feasibility of nutritional recommendations (Maillot *et al.*, 2008) and to validate the interest of nutrient profiling systems (Maillot *et al.*, 2008). Whatever the application and the model, quality of modeling analyses relies on the quality of food consumption and nutritional composition databases. This underlines the importance of high-quality national food-consumption surveys.

Dietary changes

Observed dietary changes during the intervention were in line with dietary advice and consistent with findings from modeling analyses. Since all food categories (except alcoholic beverages) were targeted during the intervention, the observed nutritional changes are very probably linked to these dietary changes. Fat reductions came primarily from the decrease in added fats and substitution of lower-fat alternatives for higher-fat options, as already reported (Dixon *et al.*, 1997, Gehling *et al.*, 2005, Patterson *et al.*, 2003). Products containing artificial sweeteners and low-fat products were well accepted by parents. An insufficient decrease in sugar intake was obtained in GB, most likely due to the following reasons: 1) dietary advice targeted foods containing only extrinsic sugars to avoid a decrease in consumption of fruits and vegetables and dairy products, 2) food items containing intense sweeteners were not proposed to children, because they are poorly accepted by French parents, and 3) the study population showed low intake of sweet beverages (children: 190 consumers of sweet beverages; parents: 77 consumers of sweet beverages), which are usually major contributors to extrinsic sugars. Regarding complex carbohydrates, major efforts that were carried out to increase consumption of high-complex-carbohydrate foods had limited effects.

Implications for public health

The ELPAS intervention strategy resulted in few significant dietary changes, but the cumulative effect of small dietary changes was sufficient to induce marked nutritional modifications in line with recommendations (Table 2). For instance fat intake in the intervention groups decreased from around 36% to around 32% of energy intake throughout the intervention (recommendation is to keep total fat intake between 20 to 35% of energy intake). Moreover food-related quality-of-life did not change during the intervention in intervention groups compared to controls (*P*=.94). From a public health perspective, this means that targeting many food items and food categories can be efficient and sustainable in the general, healthy population. Another approach would be to target only food categories that were proved changeable in intervention trials. The choice between different strategies should account for local dietary habits and food perception.

As already reported (Ash *et al.*, 2006, Keller & Lang, 2008), disseminating food-based dietary guidelines is not sufficient to change dietary habits. This study brings an additional demonstration, since control parents, who received nutrition education through official programs and newsletters did not change dietary intakes throughout the study. Family dietary coaching developed within the framework of the ELPAS study may be part of public health strategies to enhance dietary adherence. It should be first validated in the general population, since ELPAS volunteers were of higher socioeconomic status and more highly educated than the general population. If validated in the general population, it may be included in multidisciplinary programs designed to improve dietary intake, exercise and lifestyle in at-risk population. Such multidisciplinary strategies have been found efficient both in children and adults (Drummond, 2007, Van Horn *et al.*, 2005, Women's Health Initiative Study Group, 2004, Zazpe *et al.*, 2008), They are optimized through involvement of all relevant stakeholders, including families (Adamson & Mathers, 2004, 2002, Roblin, 2007, Rodearmel *et al.*, 2006), schools (Anderson *et al.*, 2005, Sharma, 2006), healthcare professionals (McCallum *et al.*, 2007, Rao, 2008), legislators and industry.

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Conflict of interest:

Dr Cassuto served as an independent consultant for the Centre d’Etudes et de Documentation du Sucre. All other authors have no competing financial interests in relation to the work described.

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Table 1. Baseline characteristics of the ELPAS study participants

	Children[§]			Parents[§]		
	Group A[£]	Group B[£]	Control[£]	Group A[£]	Group B[£]	Control[£]
Demographic and clinical characteristics						
Number	297	298	418	297	298	418
Age, y	7.7 (0.6)	7.8 (0.6)[a]	7.6 (0.6)	40.4 (5.3)	40.3 (5.4)	40.6 (5.4)
Male, No. (%)	143 (48.1)	149 (50.0)	189 (45.2)	55 (18.5)	48 (16.1)	79 (18.9)
BMI, kg/m²	16.77 (2.25)	16.80 (2.33)	16.38 (1.98)	24.21 (4.45)	24.64 (5.71)	24.04 (4.39)
BMI, Z-score	0.70 (1.35)	0.70 (1.38)	0.48 (1.25)	-	-	-
Number of servings per day*						
Milk	1.04 (0.43)	1.07 (0.49)	1.07 (0.41)	0.72 (0.35)	0.69 (0.38)	0.68 (0.41)
Dairy products (excluding milk)	1.09 (0.62)	1.07 (0.57)	1.08 (0.58)	0.95 (0.59)	0.91 (0.54)	1.00 (0.63)
Cheese	0.85 (0.53)	0.92 (0.60)	0.85 (0.54)	0.85 (0.53)	0.85 (0.74)	0.89 (0.54)
Fats and oils	2.38 (1.13)[a]	2.03 (0.98)	2.16 (1.11)	2.37 (1.15)	2.27 (1.16)	2.37 (1.14)
Meat and meat products	0.75 (0.38)	0.70 (0.39)	0.73 (0.36)	0.66 (0.35)	0.63 (0.34)	0.66 (0.37)
Cooked pork meat	0.58 (0.36)	0.55 (0.31)	0.54 (0.34)	0.56 (0.35)	0.60 (0.37)	0.52 (0.34)
Fish and fish products	0.54 (0.30)	0.50 (0.30)	0.56 (0.33)	0.57 (0.43)	0.55 (0.36)	0.57 (0.40)
Ready-to-eat meals	0.65 (0.37)	0.69 (0.44)	0.69 (0.39)	0.73 (0.47)	0.79 (0.45)	0.76 (0.47)
Sweeteners	2.50 (1.16)	2.39 (1.15)	2.52 (1.17)	1.99 (1.21)	2.13 (1.28)	2.23 (1.36)

Beverages, excluding dairy products	2.91 (1.04)	2.68 (1.04)	2.83 (0.94)	2.18 (1.03)	2.05 (0.93)	2.22 (0.99)
Breakfast cereals	0.69 (0.37)	0.71 (0.44)	0.69 (0.37)	0.59 (0.44)	0.71 (0.43)	0.60 (0.32)
Fruits	1.38 (0.75)	1.28 (0.74)	1.33 (0.82)	1.36 (0.88)	1.28 (0.86)	1.31 (0.93)
Starchy foods	2.46 (1.02)	2.41 (1.01)	2.40 (0.95)	2.36 (1.04)	2.33 (1.02)	2.38 (0.96)
Croissants	0.66 (0.40)	0.60 (0.37)	0.65 (0.43)	0.52 (0.31)	0.55 (0.29)	0.57 (0.36)
Crackers	0.41 (0.25)	0.37 (0.22)	0.41 (0.24)	0.46 (0.28)	0.44 (0.31)	0.46 (0.27)
Vegetables	1.55 (0.83)	1.47 (0.77)	1.47 (0.79)	1.64 (1.06)	1.55 (0.89)	1.62 (0.87)

[§]Values are means (SD). [a]*P* <.05 between intervention group and control group. [£] Nutritional objectives: GA: decrease in fat intake, increase in complex carbohydrate intake; GB: decrease in fat intake and decrease in sugar intake, increase in complex carbohydrate intake; GC: no nutritional objectives (control group). * Dietary data include underreporters.

Table 2. Main nutritional intakes before and after the ELPAS intervention

	Children[§]			Parents[§]		
	Group A[£]	Group B[£]	Control[£]	Group A[£]	Group B[£]	Control[£]
Nutritional intakes before the intervention*						
Total energy, kcal/d	1679 (357)	1628 (390)	1633 (369)	1619 (480)	1606 (508)	1673 (508)
Fat, energy%	35.7 (5.2)	34.9 (6.0)	35.1 (5.5)	36.8 (6.5)	36.1 (7.7)	36.3 (6.5)
Sugars, energy%	23.9 (4.7)	24.0 (5.2)	24.6 (5.1)	18.4 (5.6)	18.1 (6.3)	18.2 (6.0)
Complex carbohydrates, energy%	23.4 (5.3)	24.4 (5.8)	23.5 (4.9)	24.4 (6.9)	25.4 (7.4)	24.8 (6.8)
Nutritional intakes after the intervention*						
Total energy, kcal/d	1636 (347) [a]	1545 (334) [b]	1656 (333)	1533 (435)	1460 (383) [a]	1611 (452)
Fat, energy%	32.5 (4.1) [b]	32.5 (4.4) [b]	34.6 (4.6)	32.4 (5.2) [b]	32.8 (5.9) [b]	35.6 (5.6)
Sugars, energy%	23.3. (4.3)	22.9 (4.3)	24.2 (4.4)	17.5 (5.4)	17.2 (4.9)	18.2 (5.2)
Complex carbohydrates, energy%	26.8 (4.6) [b]	26.8 (4.8) [b]	24.5 (4.9)	28.6 (6.6)	28.2 (6.8)	25.3 (5.8)

[§]Values are means (SD). [a] *P* <.05, [b] *P*<.01 between intervention group and control group. [£] Nutritional objectives: GA: decrease in fat intake, increase in complex carbohydrate intake; GB: decrease in fat intake and decrease in sugar intake, increase in complex carbohydrate intake; GC: no nutritional objectives (control group). * Dietary data include underreporters.

Table 3. Main nutritional and clinical changes throughout of the ELPAS study

	Change (95% CI)[§ ¶]					
	Children			Parents		
	Group A	Group B	Control	Group A	Group B	Control
Nutritional intakes*						
Total energy, kcal/d	− 60 (− 104 to − 15) [a]	− 96 (− 146 to − 45) [b]	19 (− 19 to 59)	− 107 (− 162 to − 52)	−153 (− 208 to −96) [a]	− 62 (− 106 to − 18)
Fat, energy%	-3.3 [b] (-4.0 to -2.6)	-2.3 [b] (-3.0 to -1.5)	-0.6 (-1.2 to -0.1)	-4.4 [b] (-5.3 to -3.5)	-3.1 [b] (-4.0 to -2.1)	-0.7 (-1.4 to 0.0)
Sugars, energy%	-0.4 (-1.0 to 0.1)	-1.0 (-1.7 to -0.4)	-0.5 (-1.0 to 0.0)	-0.7 (-1.4 to 0.0)	-1.1 (-1.9 to -0.3)	-0.0 (-0.6 to 0.5)
Complex carbohydrates, energy%	3.3 [b] (2.6 to 4.0)	2.4 [b] (1.6 to 3.1)	1.2 (0.6 to 1.7)	4.1 [b] (3.1 to 5.1)	2.7 [b] (1.7 to 3.7)	0.7 (0.0 to 1.4)
Anthropometry						
BMI, kg/m²				0.13 (-0.01 to 0.27)	-0.02 [a] (-0.14 to 0.11)	0.24 (0.13 to 0.34)
BMI, Z-score	-0.13 (-0.20 to -0.05)	-0.09 (-0.18 to -0.01)	-0.06 (-0.13 to 0.01)			

[§] For each group, change estimates and 95% confidence intervals (CIs) are difference from baseline to end of intervention (final value – initial value). [¶] Differences between groups are analyzed using analysis of covariance with the baseline value as a cofactor. When analysis of covariance indicates significant differences between the intervention groups and the control group (*P*<.05), comparisons are made between each intervention group and the control group: [a] *P*<.05, [b] *P*<.01. * Dietary data include underreporters.

Table 4. Examples of modeling analyses applied to children group B (advice to decrease fats /sugars and to increase total carbohydrates)

#	Aim	Adherence*	Number of targeted food items	Change in fat intake (% of energy) §		Change in sugar intake (% of initial intake) §	Change in carbohydrate intake (% of energy) §	
				Initial	Final		Initial	Final
1	To test a perfect adherence to the ELPAS study dietary advices	100%	50 main sources	39	30	-29	45	52
2	To test efficacy of limited adherence to the ELPAS study dietary advices	50%	50 main sources	39	35	-14	45	49
3	To test advice based mostly on substitution for low-fat/low-sugar foods	50%	50 main sources	39	34	-14	45	49
4	To test advice based mostly on substitution for foods from other food categories	50%	50 main sources	39	34	-18	45	49
5	To test efficacy of advice targeting a limited number of foods	50%	10 main sources	39	36	-10	45	47

* Adherence = percentage of potential dietary modifications that are modeled during analyses. § To be consistent with the study objectives, change in sugar intake is presented as a percentage of initial intake, whereas changes in fat intake and total carbohydrate intake are presented as a percentage of energy.

Table 5. Main changes in number-of-servings per day throughout the intervention (children)*

	Group A (n=297)		Group B (n=298)		Control (n=418)	
	Advice[£]	Change (95% CI)[§ ¶]	Advice[£]	Change (95% CI)[§ ¶]	Advice[£]	Change (95% CI)[§ ¶]
Half-skimmed milk and skimmed milk	↑	-0.04 (-0.12 to 0.05)	↑	-0.03 (-0.10 to 0.05)	Null	-0.07 (-0.14 to -0.01)
Whole-milk dairy products	↓	0.03 (-0.06 to 0.12)	↓	-0.02 (-0.13 to 0.09)	Null	0.00 (-0.06 to 0.07)
Low-fat and/or low-sugar dairy products	↑	-0.07 (-0.16 to 0.01)	↑	0.04 (-0.05 to 0.12)	Null	0.00 (-0.06 to 0.07)
Cheese > 22 g fat/100 g	↓	-0.16 (-0.25 to -0.06)	↓	-0.11 (-0.20 to -0.02)	Null	-0,08 (-0.16 to -0.01)
Cheese ≤ 22 g fat/100 g	↑	-0.07 (-0.20 to 0.06)	↑	-0.08 (-0.23 to 0.06)	Null	-0,12 (-0.23 to -0.01)
Butter, margarines, dressing	↓	**-0.54 (-0.67 to -0.40)**[b]	↓	-0.30 (-0.43 to -0.18)	Null	-0,25 (-0.36 to -0.14)
Low-fat butter, margarines, dressing	↑	0.16 (0.05 to 0.27)	↑	0.20 (0.08 to 0.33)	Null	0,03 (-0.06 to 0.11)
High-fat meat	↓	-0.01 (-0.07 to 0.06)	↓	0.06 (-0.02 to 0.13)	Null	-0,01 (-0.07 to 0.05)
Low-fat meat	↑	-0.07 (-0.13 to -0.01)	↑	0.00 (-0.07 to 0.06)	Null	-0,07 (-0.12 to -0.01)
High-fat cooked pork meat	↓	-0.03 (-0.14 to 0.07)	↓	-0.14 (-0.23 to -0.05)	Null	-0,01 (-0.10 to 0.07)
Low-fat cooked pork meat	↑	-0.03 (-0.11 to 0.05)	↑	-0.01 (-0.09 to 0.07)	Null	-0,01 (-0.08 to 0.05)
Low-fat fish and fish products	↑	-0.01 (-0.09 to 0.06)	↑	-0.03 (-0.12 to 0.06)	Null	0.00 (-0.07 to 0.07)
Ready-to-eat meals > 5 g fat/100 g	↓	0.12 (0.05 to 0.19)	↓	0.09 (0.01 to 0.16)	Null	0.09 (0.04 to 0.14)
Ready-to-eat meals ≤ 5 g fat/100 g	↑	0.04 (-0.05 to 0.14)	↑	-0.07 (-0.17 to 0.04)	Null	0.00 (-0.08 to 0.08)
Sugar	Null	0.18 (0.07 to 0.29)	↓	0.12 (0.01 to 0.22)	Null	0.08 (-0.01 to 0.17)
Honey, confectionary	Null	-0.17 (-0.26 to -0.07)	↓	-0.11 (-0.21 to -0.01)	Null	-0.03 (-0.11 to 0.06)
Jams	Null	0.15 (0.02 to 0.28)	↓	0.10 (-0.06 to 0.25)	Null	0.07 (-0.04 to 0.17)
Chocolate, chocolate bars, cakes	↓	-0.26 (-0.36 to -0.16)	↓	-0.21 (-0.31 to -0.11)	Null	-0.13 (-0.21 to -0.05)
Ices	↓	0.13 (0.01 to 0.25)	↓	0.20 (0.08 to 0.32)	Null	0.07 (-0.01 to 0.15)
Carbonated drinks	Null	-0.06 (-0.17 to 0.05)	↓	-0.10 (-0.28 to 0.08)	Null	-0.01 (-0.12 to 0.10)
Waters	Null	-0.06 (-0.17 to 0.04)	↑	0.15 (0.04 to 0.25)	Null	0.07 (-0.01 to 0.14)

Fruit and vegetable juices	Null	-0.05 (-0.13 to 0.02)	↑	-0.06 (-0.14 to 0.03)	Null	-0.06 (-0.13 to 0.01)
High-fat and/or high-sugar breakfast cereals	↓	-0.03 (-0.12 to 0.07)	↓	-0.12 (-0.22 to -0.02)	Null	0.02 (-0.06 to 0.10)
Fruit preparations, fruit purees	Null	-0.03 (-0.15 to 0.09)	↓	-0.12 (-0.27 to 0.03)	Null	-0.02 (-0.11 to 0.08)
Fresh fruits	↑	0.06 (-0.03 to 0.15)	↑	**0.23 (0.13 to 0.34)**[b]	Null	0.03 (-0.05 to 0.11)
French fries, fried potatoes, crisps	↓	-0.03 (-0.12 to 0.05)	↓	-0.07 (-0.15 to 0.01)	Null	0.03 (-0.02 to 0.09)
Rice, couscous, bulgur, pastas	↑	0.02 (-0.04 to 0.08)	↑	0.03 (-0.03 to 0.10)	Null	-0.06 (-0.12 to -0.01)
Potatoes, manioc	↑	-0.09 (-0.17 to -0.01)	↑	-0.10 (-0.21 to 0.01)	Null	-0.05 (-0.12 to 0.03)
All types of breads	↑	**0.14 (0.04 to 0.25)**[b]	↑	**0.20 (0.10 to 0.30)**[b]	Null	-0.07 (-0.15 to 0.01)
High-fat bakery products	↓	-0.06 (-0.19 to 0.06)	↓	0.01 (-0.09 to 0.11)	Null	0.00 (-0.11 to 0.11)
Low-fat bakery products	↑	-0.07 (-0.16 to 0.03)	↑	-0.04 (-0.17 to 0.09)	Null	0.03 (-0.10 to 0.17)
Cooked vegetables > 3 g fat/100 g	↓	-0.01 (-0.22 to 0.19)	↓	0.17 (0.05 to 0.29)	Null	-0.05 (-0.18 to 0.08)
Vegetables ≤ 3 g fat/100 g	↑	-0.21 (-0.31 to -0.11)	↑	-0.10 (-0.20 to 0.00)	Null	-0.13 (-0.21 to -0.04)

* Dietary data include underreporters. [£] Dietary advice was to increase (↑) or decrease (↓) the number of servings per day. [§] For each group, change estimates and 95% confidence intervals (CIs) are different from baseline to end of intervention (final value – initial value). Results for foods consumed by less than 30 subjects are not presented. [¶] Differences between intervention groups and the control group are analyzed using analyses of variance: [a] $P<.05$, [b] $P<.01$.

Table 6. Main changes in number-of-servings per day throughout the intervention (parents)*

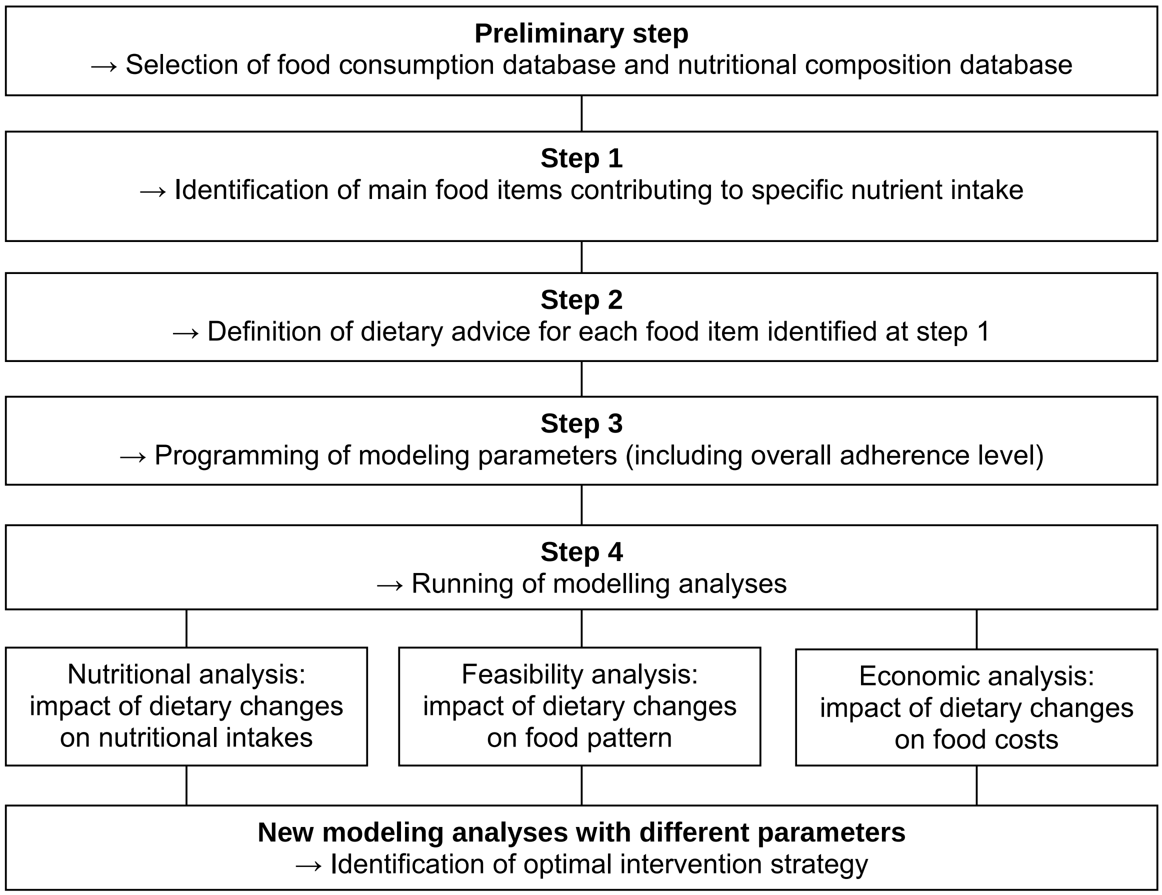
	Group A (n=297)		Group B (n=298)		Control (n=418)	
	Advice[£]	Change (95% CI)[§ ¶]	Advice[£]	Change (95% CI)[§ ¶]	Advice[£]	Change (95% CI)[§ ¶]
Half-skimmed milk and skimmed milk	↑	0.02 (-0.10 to 0.15)	↑	0.16 (0.02 to 0.31)	Null	0.08 (-0.02 to 0.19)
Whole-milk dairy products (> 3.5 g fat/100 g)	↓	0.04 (-0.10 to 0.17)	↓	-0.01 (-0.14 to 0.12)	Null	-0.09 (-0.19 to 0.00)
Low-fat and/or low-sugar dairy products	↑	**0.04 (-0.04 to 0.13)**[a]	↑	**0.05 (-0.04 to 0.15)**[a]	Null	-0.08 (-0.15 to -0.01)
Cheese > 22 g fat/100 g	↓	-0.15 (-0.24 to -0.06)	↓	-0.12 (-0.23 to -0.02)	Null	-0.11 (-0.19 to -0.04)
Cheese ≤ 22 g fat/100 g	↑	-0.01 (-0.12 to 0.10)	↑	-0.05 (-0.18 to 0.08)	Null	-0.13 (-0.22 to -0.05)
Butter, margarines, dressing	↓	-0.36 (-0.49 to -0.23)	↓	-0.31 (-0.44 to -0.19)	Null	-0.20 (-0.32 to -0.09)
Low-fat butter, margarines, dressing	↑	**0.20 (0.07 to 0.33)**[b]	↑	0.15 (0.02 to 0.28)	Null	-0.05 (-0.15 to 0.05)
High-fat meat	↓	0.03 (-0.05 to 0.10)	↓	-0.04 (-0.12 to 0.04)	Null	-0.06 (-0.14 to 0.02)
Low-fat meat	↑	-0.03 (-0.09 to 0.04)	↑	0.00 (-0.06 to 0.06)	Null	-0.03 (-0.08 to 0.02)
High-fat cooked pork meat	↓	0.01 (-0.09 to 0.10)	↓	-0.04 (-0.17 to 0.09)	Null	0.00 (-0.11 to 0.12)
Low-fat cooked pork meat	↑	0.06 (-0.05 to 0.16)	↑	-0.07 (-0.17 to 0.04)	Null	0.03 (-0.04 to 0.10)
Low-fat fish and fish products	↑	-0.01 (-0.10 to 0.08)	↑	-0.03 (-0.11 to 0.06)	Null	-0.07 (-0.15 to 0.00)
Ready-to-eat meals > 5 g fat/100 g	↓	0.06 (-0.01 to 0.14)	↓	**-0.05 (-0.12 to 0.03)**[b]	Null	0.10 (0.04 to 0.16)
Ready-to-eat meals ≤ 5 g fat/100 g	↑	0.03 (-0.05 to 0.11)	↑	0.05 (-0.05 to 0.15)	Null	0.05 (-0.02 to 0.12)
Sugar	Null	0.06 (-0.06 to 0.19)	↓	-0.09 (-0.31 to 0.13)	Null	0.10 (0.00 to 0.21)
Honey, confectionary	Null	-0.08 (-0.22 to 0.07)	↓	-0.03 (-0.18 to 0.13)	Null	-0.11 (-0.24 to 0.03)
Jams	Null	0.06 (-0.05 to 0.17)	↓	0.07 (-0.05 to 0.18)	Null	-0.02 (-0.11 to 0.06)
Chocolate, chocolate bars, cakes	↓	**-0.13 (-0.23 to -0.04)**[a]	↓	**-0.16 (-0.25 to -0.06)**[a]	Null	-0.02 (-0.09 to 0.06)
Ices	↓	-0.05 (-0.18 to 0.08)	↓	-0.07 (-0.25 to 0.12)	Null	0.01 (-0.12 to 0.14)
Sweeteners	Null		↑	0.28 (0.01 to 0.55)	Null	-0.01 (-0.30 to 0.28)
Waters	Null	0.02 (-0.08 to 0.12)	↑	0.09 (0.00 to 0.19)	Null	-0.05 (-0.13 to 0.03)

Fruit and vegetable juices	Null	0.00 (-0.12 to 0.12)	↑	-0.01 (-0.15 to 0.13)	Null	0.02 (-0.06 to 0.10)
Fresh fruits	↑	0.02 (-0.08 to 0.12)	↑	0.07 (-0.04 to 0.17)	Null	-0.03 (-0.11 to 0.05)
French fries, fried potatoes, crisps	↓	-0.01 (-0.11 to 0.10)	↓	**0.12 (0.02 to 0.22)**[b]	Null	-0.03 (-0.09 to 0.04)
Rice, couscous, bulgur, pastas	↑	0.01 (-0.05 to 0.08)	↑	-0.01 (-0.07 to 0.06)	Null	-0.03 (-0.09 to 0.03)
Potatoes, manioc	↑	0.00 (-0.10 to 0.10)	↑	-0.06 (-0.15 to 0.03)	Null	-0.03 (-0.12 to 0.05)
All types of breads	↑	**0.11 (0.01 to 0.21)**[b]	↑	**0.09 (-0.01 to 0.19)**[b]	Null	-0.09 (-0.17 to -0.01)
High-fat bakery products	↓	0.01 (-0.14 to 0.16)	↓	-0.03 (-0.18 to 0.12)	Null	-0.10 (-0.23 to 0.02)
Cooked vegetables > 3 g fat/100 g	↓	0.11 (-0.01 to 0.23)	↓	-0.03 (-0.11 to 0.06)	Null	0.03 (-0.06 to 0.12)
Vegetables ≤ 3 g fat/100 g	↑	-0.09 (-0.21 to 0.03)	↑	-0.08 (-0.19 to 0.04)	Null	-0.16 (-0.25 to -0.07)

* Dietary data include underreporters. [£] Dietary advice was to increase (↑) or decrease (↓) the number of servings per day. [§] For each group, change estimates and 95% confidence intervals (CIs) are different from baseline to end of intervention (final value – initial value). Results for foods consumed by less than 30 subjects are not presented. [¶] Differences between intervention groups and the control group are analyzed using analyses of variance: [a] $P<.05$, [b] $P<.01$.

Figure legends

Figure 1. General methodology for dietary modeling analyses


Preliminary step
→ Selection of food consumption database and nutritional composition database
Step 1
→ Identification of main food items contributing to specific nutrient intake
Step 2
→ Definition of dietary advice for each food item identified at step 1
Step 3
→ Programming of modeling parameters (including overall adherence level)
Step 4
→ Running of modelling analyses
Nutritional analysis: impact of dietary changes on nutritional intakes
Feasibility analysis: impact of dietary changes on food pattern
Economic analysis: impact of dietary changes on food costs
New modeling analyses with different parameters
→ Identification of optimal intervention strategy