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Juan Miguel Fernández Alvira

Nivel socioeconómico y obesidad infantil: hábitos dietéticos en niños europeos

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Socioeconomic level and childhood obesity: dietary habits in European children

Departamento de Fisiatría y Enfermería

Facultad de Ciencias de la Salud

UNIVERSIDAD DE ZARAGOZA

JUAN MIGUEL FERNÁNDEZ ALVIRA

ZARAGOZA, MARZO DE 2017

A mis padres

Prof. Dr. Luis A. MORENO AZNAR

Catedrático de Universidad

Departamento de Fisiatría y Enfermería

Facultad de Ciencias de la Salud

Universidad de Zaragoza, España

LUIS A. MORENO AZNAR, CATEDRÁTICO DE LA UNIVERSIDAD DE ZARAGOZA

CERTIFICA:

Que la Tesis Doctoral titulada "Nivel socioeconómico y obesidad infantil: hábitos dietéticos en niños europeos" que presenta **D. JUAN MIGUEL FERNÁNDEZ ALVIRA** al superior juicio del Tribunal que designe la Universidad de Zaragoza, ha sido realizada bajo mi dirección, siendo expresión de la capacidad técnica e interpretativa de su autor en condiciones tan aventajadas que le hacen merecedor del Título de Doctor, siempre y cuando así los considere el citado Tribunal.

Fdo.: Luis A. Moreno Aznar

En Zaragoza, a 23 de marzo de 2017

Universität Bremen

aequipa

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I HEREBY DECLARE THAT:

The doctoral thesis entitled "Nivel socioeconómico y obesidad infantil: hábitos dietéticos en niños Europeos / Socioeconomic level and childhood obesity: dietary habits in European children", presented by D JUAN MIGUEL FERNÁNDEZ ALVIRA has been carried out under my supervisión, being an expression of the technical and interpretative capacity of the author in conditions that make him deserving the Doctoral Degree, as long as the members of the tribunal consider them.

Karin Bammann

Bremen, 21 march 2017

Lista de publicaciones [List of publications]

La presente Tesis Doctoral es un compendio de trabajos científicos previamente publicados, aceptados para su publicación o sometidos a revisión. Las referencias de los artículos que componen éste documento se detallan a continuación:

I. Bammann K, Gwozdz W, Lanfer A *et al.* (2013) Socioeconomic factors and childhood overweight in Europe: results from the multi-centre IDEFICS study. *Pediatr Obes* **8**, 1-12.

II. 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.

III. 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.

IV. Fernández-Alvira JM, Börnhorst, C, Bamman K et al. (2015) Prospective associations between socioeconomic status and dietary patterns in European children: the IDEFICS study. *Br J Nutr* **113**(3):517-525.

V. Fernández-Alvira JM, Bammann K, Eiben G et al. (2017) Prospective associations between dietary patterns and body composition in European children: the IDEFICS study. *Public Health Nutr (under review)*

Contenidos

Contents

Proyecto de investigación [Research project]

El trabajo que se desarrolla a continuación, incluyendo los artículos que forman parte de esta investigación, están basados en el siguiente proyecto de investigación:

1. **Estudio IDEFICS** (Identification and prevention of dietary- and lifestyle-induced health effects in children and infants). Proyecto financiado por la Comisión Europea: European Union Sixth RTD Framework Programme (Contract FOOD-CT-2006-016181-2).

Página web: www.idefics.eu

Coordinador: Wolfgang Ahrens

Resumen general

La alarmante prevalencia de obesidad infantil a nivel global presenta una distribución desigual en los distintos niveles socioeconómicos de la sociedad. En los países industrializados, los grupos socioeconómicamente más desfavorecidos suelen presentar mayor prevalencia de sobrepeso y obesidad infantil. La evidencia acumulada demuestra que los determinantes de este problema de salud, son complejos e incluyen diversos mecanismos, tales como las condiciones materiales, ocupacionales, psicosociales, conductuales, etc. Dentro de los estilos de vida, la calidad de la dieta también se asocia con el estatus socioeconómico, encontrando habitualmente patrones menos saludables en los grupos más desfavorecidos, predisponiendo a su vez al desarrollo de sobrepeso y obesidad durante el ciclo vital.

A nivel general, los objetivos de la presente Tesis Doctoral son: 1) evaluar la asociación entre distintos indicadores socioeconómicos y la prevalencia de sobrepeso y obesidad infantil en niños europeos, 2) analizar la calidad global de la dieta de los niños según el nivel socioeconómico de las familias y 3) evaluar la asociación entre los patrones dietéticos y los cambios en composición corporal, de manera prospectiva.

Para la consecución de los objetivos, se evaluaron los resultados obtenidos en los participantes en el estudio IDEFICS (Identification and prevention of Dietary- and lyfestyle induced health EFfects In Children and infantS), provenientes de ocho países (Alemania, Bélgica, Chipre, España, Estonia, Hungría, Italia y Suecia). El tamaño de la muestra, en los distintos trabajos presentados, varió entre 8341 y 14426 sujetos, en base al total de participantes con información completa en cada caso.

Los resultados del presente trabajo muestran la existencia de un gradiente socioeconómico inverso en la prevalencia de sobrepeso, en cinco de las ocho regiones investigadas (Alemania, Bélgica, España, Estonia y Chipre), mientras que no se encontró gradiente alguno en las otras tres (Chipre, Hungría e Italia). Las variables que mostraron una mayor fortaleza en la asociación entre el nivel socioeconómico y el sobrepeso, fueron el nivel de desarrollo humano de cada región y el nivel de ingresos medio. En segundo lugar, los participantes de familias de menor nivel socioeconómico mostraron hábitos alimentarios menos saludables que sus compañeros de mayor nivel socioeconómico. Esta asociación fue descrita analizando grupos de alimentos de manera individual, así como patrones dietéticos globales, tanto para el total de la muestra como de manera específica para cada centro de estudio. Los participantes de menor nivel socioeconómico presentaron más frecuentemente perfiles caracterizados por un consumo frecuente de alimentos procesados, ricos en azúcares y grasas, snacks dulces y salados, y refrescos azucarados. Además, dichos perfiles también se caracterizaron por un consumo menos frecuente de frutas, verduras y productos integrales. Por el contrario, los sujetos de mayor nivel socioeconómico mostraron una mayor tendencia a presentar patrones más saludables, con menor frecuencia de consumo de productos de alta densidad energética y mayor frecuencia de consumo de frutas, verduras y productos integrales. Por último, se pudo constatar que los participantes que mostraron patrones dietéticos caracterizados por un consumo frecuente de alimentos procesados, a lo largo del estudio, fueron los que mostraron a su vez cambios antropométricos más desfavorables, con mayor incremento en la masa grasa total y abdominal.

Entre las principales limitaciones de la presente Tesis Doctoral, se encuentran las propias del cuestionario de frecuencia de consumo de alimentos utilizado en el estudio

IDEFICS. Dicho cuestionario no fue diseñado para valorar la ingesta energética total, sino los grupos de alimentos asociados positiva o negativamente con el sobrepeso y obesidad infantil, de manera que no se pudo obtener información precisa acerca del consumo de energía total. Además, el tamaño de las porciones no fue estimado y la información fue aportada por los padres, disminuyendo la precisión, ya que no se consideró la ingesta de alimentos que no tuvo lugar bajo la supervisión de los padres. Por ello, la información obtenida tiene en cuenta solo aquellas comidas realizadas a lo largo del día bajo supervisión de los padres, variando de un país a otro. La deseabilidad social a la hora de facilitar información sobre los estilos de vida, también puede suponer un sesgo, ya que puede afectar de manera diferencial a los sujetos de distinto estatus socioeconómico o perfil antropométrico. Adicionalmente, el análisis transversal realizado en cuatro de los cinco artículos, supone otra de las limitaciones a tener en cuenta, puesto que no permite determinar relaciones causales.

En resumen, los datos obtenidos ponen de manifiesto la mayor vulnerabilidad a la que se encuentran expuestos los niños europeos de bajo nivel socioeconómico, que los lleva a presentar con mayor frecuencia patrones de alimentación desfavorables, que a su vez facilitan el desarrollo de sobrepeso y obesidad. Por tanto, es necesario el desarrollo de estrategias de prevención y promoción de la salud que sean efectivas en dichos subgrupos poblacionales, facilitando el consumo de alimentos saludables, para intentar reducir las desigualdades socioeconómicas en el sobrepeso y obesidad infantil.

General abstract

The alarming global childhood obesity prevalence presents an uneven distribution across socioeconomic segments of the population. In industrialized countries, the most disadvantaged socioeconomic groups present higher rates of obesity. The up-to-date evidence shows a complex interaction between several determinants, such as material and occupational conditions, psychosocial and behavioural factors, etc. Among lifestyle variables, diet quality has been associated with socioeconomic status, with poorer dietary habits in lower socioeconomic groups. This in turn, predispose to overweight development throughout life course.

The general aims of the present Doctoral Thesis are: 1) to evaluate the association between several socioeconomic indicators and overweight prevalence in European children, 2) to analyse the children's diet quality by socioeconomic status and 3) to evaluate the association between dietary patterns and children's body composition changes prospectively.

To full fill these aims, the available data from the IDEFICS (Identification and prevention of Dietary- and lyfestyle induced health EFfects In Children and infantS) study from eight countries (Belgium, Cyprus, Estonia, Italy, Germany, Hungary, Sweden and Spain) were taken into account. The sample size varied throughout the different articles from 8341 to 14426 participants, based on the number of participants with complete information available in each case.

The results of the present work show the existence of an inverse socioeconomic gradient on overweight prevalence in five of the eight investigated regions (in Belgium, Estonia, Germany, Spain and Sweden), while in the other three regions (in Cyprus,

Hungary and Italy) no association was found. The socioeconomic status-overweight association was best explained by the country-specific human development index and the centre-specific mean income. Second, the participants from families with lower socioeconomic status did show unhealthier dietary habits compared to their better-off counterparts. This association was described for single food groups and for global dietary patterns as well, both in country-specific and global analyses. Lower socioeconomic status was associated with dietary profiles characterized by a more frequent consumption of high-fat high-sugar processed foods, sweet and savoury snacks and soft drinks. In addition, these profiles were also characterized by a less frequent consumption of fruits and vegetables and wholemeal products. On the contrary, higher socioeconomic status was associated with healthier profiles, with less frequent consumption of high-energy density products and with more frequent consumption of fruits, vegetables and wholemeal products. Finally, the results showed that participants characterized by persistently showing dietary patterns with frequent consumption of processed foods presented the most unfavourable changes in fat mass and abdominal fat.

The main limitations of the present Doctoral Thesis are the ones related to the food frequency questionnaire applied in the IDEFICS study. This questionnaire was not designed to capture total energy intake or total food intake, but rather to investigate the consumption frequency of food groups positively or negatively associated with obesity. Therefore, no information about total energy intake was obtained. Moreover, portion sizes were not estimated. The information about children's food intake was provided by the parents, and thus limiting the accuracy of the information about the total amount of foods consumed. The presented information takes into account the meal occasions under parental control, which varies from country to country. Social desirability bias cannot be

ruled-out, and can affect the data obtained to a different extent depending on the socioeconomic or anthropometric status of participants. In addition, the cross-sectional design of the first four articles has to be taken into account, as it does not allow drawing causal associations.

In conclusion, the obtained results highlight the vulnerability of European children from families with lower socioeconomic status, presenting more frequently unhealthier dietary patterns, which in turn facilitates the overweight and obesity development. Therefore, prevention and health promotion strategies shown to be effective in low socioeconomic groups need to be developed, in order to facilitate the consumption of healthier foods, and subsequently reducing socioeconomic inequalities in children's overweight and obesity.

1. Introduccción [Introduction]

La actual epidemia de obesidad infantil ha sido descrita como uno de los mayores problemas de salud pública a los que nos enfrentamos a nivel mundial en el inicio de este siglo[1]. Por un lado, la prevalencia de obesidad ha aumentado de manera dramática en las últimas décadas, tanto en países industrializados como en países en desarrollo[2]. A nivel mundial, en los países industrializados, cuando se comparan las cifras registradas en 1980 con las cifras recogidas en 2013, la prevalencia de sobrepeso y obesidad infantil ha pasado de 16.9% a 23.8% en niños y de 16.2% a 22.6% en niñas. En el mismo periodo, en los países en desarrollo, la prevalencia ha pasado de un 8.1% a un 12.9% en niños y de un 8.4% a 13.4% en niñas. En el caso concreto de España, un estudio de 2012 observó una prevalencia de sobrepeso de y obesidad de un 28,6% y 12,9% respectivamente en el caso de los niños, mientras que las niñas presentaron el 23,5% y el 12,3% respectivamente[3]. Por otro lado, el sobrepeso y obesidad en la infancia y adolescencia se asocian con una mayor probabilidad de presentar obesidad en la edad adulta[4] y con una serie de comorbilidades tales como dislipemia, diabetes mellitus de tipo 2, resistencia a la insulina, hipertensión arterial, aterosclerosis, accidentes cerebro-vasculares y mayor morbi-mortalidad cardiovascular[5-7], por lo que su identificación y prevención temprana deben ser una prioridad para evitar las consecuencias a largo plazo[8]. Además de las citadas consecuencias de la obesidad infantil, tanto en el momento de su desarrollo como posteriormente en la edad adulta, podemos observar efectos adversos en la calidad de vida[9], disminución de la autoestima[10,11] y experiencias de discriminación[12].

1.1 Obesidad infantil

La obesidad infantil es un acúmulo excesivo de grasa corporal, producto de una compleja interacción de factores. En niños y adolescentes, la obesidad se diagnostica con frecuencia utilizando el índice de masa corporal (IMC)[13], que es el resultado de dividir el peso en kg por la talla en metros, al cuadrado. Para identificar los niños que presentan sobrepeso u obesidad, existen distintos patrones de referencia, entre los cuales el más utilizado es el del International Obesity Task Force[14,15]. Existen otros métodos que miden de manera más directa la grasa corporal. Algunos de ellos realizan medidas de gran precisión, como la densitometría de rayos X[16,17] o la pletismografía por desplazamiento de aire[18,19], pero solo están disponibles en laboratorios de investigación[20]. Otros métodos menos precisos son sin embargo fáciles de utilizar en estudios epidemiológicos y en la práctica clínica, como son la media de los pliegues cutáneos[21] o la impedancia bioeléctrica[22]. Esta medida de la grasa corporal permite calcular índices relativos a la altura, como son el índice de masa grasa[23].

A nivel fisiológico, la obesidad es el resultado de un balance energético positivo a largo plazo (ingesta energética > gasto energético)[24,25], mientras que a nivel conductual, son muchos los factores que afectan los niveles de actividad física y los hábitos dietéticos de los niños y adolescentes[26,27]. A pesar del efecto de los factores genéticos sobre la predisposición individual a desarrollar obesidad, debido al aumento generalizado en la prevalencia de sobrepeso y obesidad (infantil y en adultos), tanto en países industrializados como en países en desarrollo, se piensa que la epidemia de obesidad se debe en gran medida a cambios sociales y ambientales[28,29]. Según esta perspectiva, el aumento global en la prevalencia de obesidad es resultado de múltiples cambios económicos y sociales, cambios en el procesado, distribución y marketing de alimentos,

aumento del uso de medios de transporte, cambios en el ambiente y planificación urbana, etc. Dichos cambios han producido a su vez adaptaciones conductuales, con un aumento de las actividades sedentarias[30] (tanto ocupacionales como recreacionales), patrones dietéticos menos saludables[31] (con perfiles de mayor densidad energética, mayor contenido en azúcares simples y menor contenido en micronutrientes) y una disminución de los niveles globales de actividad física[32]. El listado de factores asociados con la probabilidad de desarrollar sobrepeso u obesidad en la infancia y adolescencia incluyen además aspectos de la primera infancia[33] (lactancia materna vs leche de formulación, peso al nacer, crecimiento rápido), factores genéticos[34] (IMC de los padres), del ambiente familiar[35] (disponibilidad de ciertos alimentos en el hogar, creencias de salud etc) y ambiente escolar[36] (acceso a fuentes de agua, espacios de recreo, etc).

1.2 Nivel socioeconómico

El nivel socioeconómico, también denominado estatus socioeconómico, es un concepto muy frecuentemente utilizado en la investigación epidemiológica[37-39]. El nivel socioeconómico se refiere a los factores sociales y económicos que influencian la posición que un individuo o grupo ocupa dentro de la estructura de la sociedad en la que vive[40], y se relaciona con muchos factores de riesgo que pueden afectar a la salud. Existen diversos indicadores del nivel socioeconómico[41,42], aunque ninguno de ellos se considera inequívocamente más adecuado que el resto. De hecho, se considera que la elección más adecuada depende de la pregunta de investigación concreta y de los mecanismos propuestos que asocien el nivel socioeconómico con un aspecto particular de la salud. La elección del indicador más apropiado tiene gran importancia; aunque los diversos indicadores suelen estar correlacionados entre sí, las asociaciones descritas pueden

variar drásticamente. Es importante tener en cuenta que, en el caso de la obesidad infantil, el efecto del nivel socioeconómico viene determinado básicamente por las características de los padres[43].

Los indicadores de nivel socioeconómico más utilizados en la literatura, en relación con la obesidad, han sido tradicionalmente en nivel educativo, el nivel de ingresos o renta, y la ocupación profesional:

a) Nivel educativo: uno de los indicadores más utilizados en epidemiología. Utilizado para valorar los conocimientos generales de un individuo. Ya que la educación suele finalizarse al inicio de la edad adulta, está fuertemente asociado con las características de los padres. Suele utilizarse tanto de manera continua (número de años en educación formal) como de manera categórica (nivel educativo máximo alcanzado). Suele considerarse un fuerte determinante del empleo e ingresos posteriores, y su importancia radica en el impacto que la educación formal puede tener en las habilidades cognitivas, haciendo al sujeto más o menos receptivo a los mensajes de salud y a los servicios de salud disponibles[44]. Su mayor ventaja radica en la facilidad de registro, en que suele alcanzar altas tasas de respuesta comparado con otros indicadores, y en que es independiente de la edad o circunstancias laborales actuales.
b) Nivel de ingresos: Se considera el indicador más directo de los recursos materiales del individuo. Al igual que el nivel educativo, muestra asociaciones "dosis-respuesta" con diversos aspectos de la salud. En la mayoría de las ocasiones suele tenerse en cuenta el nivel de ingresos familiares, en lugar de

los ingresos individuales, siendo de especial relevancia en el caso de individuos que no trabajen de manera remunerada. Para poder comparar el nivel de ingresos entre hogares, se puede utilizar el nivel de ingresos ajustado, que tiene en cuenta el número de personas que conforman el hogar. El nivel de ingresos puede afectar a la salud a través de mecanismos como el acceso a comida de mejor o peor calidad, servicios de salud, residencia, acceso a educación, actividades de ocio y nivel de participación social. A pesar de que el nivel de ingresos se considera el mejor indicador de las condiciones materiales de vida, suele presentar problemas a la hora de su obtención en los estudios epidemiológicos, pudiendo llegar a considerarse un tema muy sensible en algunos países. Además, es un indicador que puede variar de manera drástica en el tiempo.

c) Ocupación laboral: se considera como el reflejo del lugar de un individuo en la sociedad en cuanto a sus habilidades específicas y sus ingresos. Al igual que el nivel educativo, puede utilizarse de manera individual o de manera conjunta en el hogar, teniendo en cuenta la ocupación de nivel más alto, especialmente si la información se utiliza en relación a los niños. Se considera que la ocupación está fuertemente asociada a los ingresos, y por tanto también con la salud a través de los recursos materiales. La ocupación también refleja el estatus social y puede estar asociado a la salud a través de privilegios como el acceso a mejor educación, mejores servicios de salud y a entornos más favorecidos en general. Además, la ocupación laboral puede afectar a la red social del individuo, al nivel de estrés y a la autonomía y por tanto a todos aquellos procesos de salud asociados con aspectos psicosociales. Una de sus

mayores desventajas para los estudios epidemiológicos es que dicha información no está disponible para las personas que no trabajen en el momento de ser encuestados, o grupos específicos de la población como las personas jubiladas, personas sin trabajo remunerado que se hagan cargo del hogar, estudiantes o trabajadores sin contrato. Además, el ámbito laboral está cambiando de manera drástica en los últimos años, apareciendo ocupaciones de difícil clasificación.

En los estudios donde se estudian poblaciones infantiles o adolescentes, el estudio del nivel socioeconómico presenta mayores dificultades que en el caso de los adultos[42]. Por ello, en la literatura, también podemos encontrar indicadores compuestos, que tratan de capturar información global de la situación de los menores a estudio, sin necesidad de contar con la información relativa a los progenitores. Uno de los indicadores compuestos más utilizados es el Family Affluence Scale (FAS)[45], que recoge información sobre el acceso a recursos materiales en el hogar (número de televisores, habitación propia, ordenador, internet etc). La dificultad añadida del uso de dicho indicador compuesto es que la información debe ser actualizada a la realidad del momento y del país donde se aplique, y la menor comparabilidad entre estudios.

1.3 Nivel socioeconómico y obesidad infantil

El gradiente socioeconómico en la prevalencia de obesidad infantil fue descrito por primera vez en 1972 en los Estados Unidos[46]. Desde entonces, numerosos estudios elaborados en las últimas décadas han puesto de manifiesto el efecto del nivel socioeconómico en el riesgo de desarrollar obesidad[47]. Se asume que, tanto en países

industrializados como en países en desarrollo, los grupos socioeconómicos con mayor acceso a dietas ricas en energía tienen mayor probabilidad de desarrollar sobrepeso y obesidad, si bien dichos grupos varían en función del país en cuestión. En concreto, los grupos de menor nivel socioeconómico en países industrializados y los grupos de mayor nivel socioeconómico en países en desarrollo, presentan generalmente mayor probabilidad de desarrollar sobrepeso y obesidad[48]. En general, aunque la literatura concluye que la obesidad se asocia al nivel socioeconómico, esta asociación varía según grupos de edad, género y país. De hecho, algunos estudios en Europa han encontrado una mayor prevalencia de sobrepeso en familias menos afluentes en la mayoría de países, a excepción de algunos países del Este, como Croacia, Estonia, Letonia, Lituania, Polonia, Macedonia y Finlandia, donde las familias más afluentes presentaron mayor prevalencia de sobrepeso infantil[49]. A pesar de las diferencias encontradas en la literatura, una revisión sistemática de 2006 pone de manifiesto que la mayor parte de las asociaciones entre nivel socioeconómico y obesidad infantil en los países industrializados se han vuelto predominantemente inversas[50]. Adicionalmente, se está observando un aumento de las desigualdades socioeconómicas en la prevalencia de obesidad infantil en la última década: mientras que en los grupos más favorecidos la tasa de sobrepeso permanece estable o decreciendo, la prevalencia en los grupos más desfavorecidos sigue aumentando[51-53].

1.4 Nivel socioeconómico y hábitos dietéticos

La relación entre el nivel socioeconómico y la calidad de la dieta ha sido estudiada ampliamente, y actualmente se dispone de un gran número de datos epidemiológicos que indican un gradiente socioeconómico en la dieta de la población general[54]. En particular, las dietas con mayor densidad energética y pobres en nutrientes, se asocian con niveles socioeconómicos más desfavorecidos, especialmente con medios económicos limitados[54,55]. La evidencia es especialmente consistente en el caso de los micronutrientes y la calidad de la dieta en general, mientras que no se han observado gradientes claros en cuanto a ingesta energética total o composición de macronutrientes. En el contexto europeo, los grupos de alimentos para los que se ha encontrado mayor gradiente socioeconómico son por una parte aquellos ricos en micronutrientes (frutas, verduras, cereales integrales), habitualmente consumidos en mayor medida o frecuencia por los grupos de alto nivel socioeconómico[56], mientras que por otra parte, aquellos alimentos con menor contenido nutricional (cereales refinados, grasas añadidas, alimentos no básicos, snacks) son consumidos en mayor proporción por los grupos de nivel socioeconómico más desfavorecido. Sin embargo, además de las tendencias globales, una serie de aspectos culturales deben ser tenidos en cuenta. Por ejemplo, el consumo de pan integral es elevado en los países del norte de Europa, mientras que en los países de la cuenca mediterránea, el consumo de pan blanco ha sido tradicionalmente el más extendido. La mayor accesibilidad a frutas y verduras en algunos países productores puede explicar que el gradiente socioeconómico sea menor comparado con países donde dichos alimentos han de ser importados en gran medida, y por tanto de mayor coste.

En la última década se han publicado datos acerca del gradiente socioeconómico en la dieta de los niños y adolescentes, encontrando en gran medida asociaciones

equiparables a las encontradas en adultos: en el entorno de los países industrializados, los niños de menor nivel socioeconómico presentan mayor probabilidad de consumir dietas pobres en frutas y verduras[57], y con mayor ingesta de snacks, comida basura y bebidas azucaradas[58,59].

La asociación entre nivel socioeconómico y hábitos dietéticos descrita en la literatura, puede explicarse por diversos mecanismos[60,61], aunque en cualquier caso se trata de un reto de gran dificultad, puesto que los determinantes de las elecciones dietéticas son complejos y multifactoriales. Dentro de los factores clásicos[50], el nivel educativo ha recibido especial atención. En particular, el nivel educativo materno acumula mayor evidencia. La falta de conocimientos relacionados con la alimentación y la salud puede dificultar las elecciones más saludables. Aspectos culturales más amplios, como el país de origen en el caso de los inmigrantes, puede también determinar en gran medida las elecciones alimentarias. Además de los factores clásicos (educación, nivel de ingresos, ocupación), hace falta contemplar una serie de factores como el acceso a puntos de venta, transporte, seguridad del vecindario, desigualdades en el acceso a alimentos saludables, disponibilidad de tiempo, etc. El precio de los alimentos y de la dieta en su conjunto juega un gran papel en los segmentos de la población más desfavorecidos económicamente[55]. Las dietas más densas energéticamente y pobres en micronutrientes son menos costosas que las dietas ricas en productos frescos de calidad[62], y pueden explicar en parte por qué los segmentos más desfavorecidos tienen a consumirlas en mayor proporción[62]. Por otra parte, el acceso a los alimentos frescos más saludables puede concentrarse en áreas más favorecidas, mientras que áreas más desfavorecidas pueden sufrir carencias importantes, llegando a hablarse de desiertos alimentarios o

"food deserts"[63,64], definidos como áreas con difícil acceso a lugares de venta con alimentos frescos, a precios económicos, usualmente en áreas desfavorecidas.

1.5 Hábitos dietéticos y obesidad infantil

Dado el aumento generalizado en la prevalencia de sobrepeso y obesidad infantil en las últimas décadas, varios investigadores han examinado los cambios seculares en los factores dietéticos[65-68], con el objetivo de describir qué cambios han tenido lugar a nivel global, para posteriormente analizar si dichos cambios se asocian a nivel individual con mayor probabilidad de presentar obesidad. De manera global, podemos afirmar que los patrones dietéticos en niños y adolescentes han sufrido muchos cambios, incluyendo cambios en la ingesta total de energía, en la distribución de macronutrientes, así como el tipo de alimentos y bebidas consumidos[69]. También se han observado cambios en los comportamientos alimentarios, incluyendo aumento del consumo de snacks y de las ocasiones de ingesta fuera del hogar[70].

Más allá de los aspectos generales, el estudio de la asociación de distintos factores de la dieta y el sobrepeso y obesidad infantil no está libre de dificultad y controversia. A pesar de que intuitivamente podemos esperar encontrar asociaciones claras, como una mayor ingesta energética en individuos con sobrepeso en comparación con sus iguales, la literatura muestra que la evidencia no es tan clara como podría esperarse. Por ejemplo, algunos estudios parecen indicar que la ingesta media de calorías no es significativamente diferente entre niños con y sin sobrepeso[69], mientras que otros parecen indicar que sí existen diferencias en grupos de menor edad[71]. Esta conclusión podría reflejar o bien la ausencia de diferencias o bien problemas metodológicos como la infra-declaración de la ingesta, observada en mayor medida en sujetos con obesidad[72], la

dificultad de controlar adecuadamente las variables de confusión (ej. nivel de actividad física), o causalidad inversa (niños con sobrepeso consumirían menos energía con el objetivo de controlar el peso). Por esta razón, otros parámetros dietéticos también han recibido atención en las últimas décadas. De manera destacada, la densidad energética ha recibido atención creciente en relación a la obesidad y distintos desórdenes metabólicos, sugiriéndose que la densidad energética aumentada contribuye al aumento de sobrepeso y obesidad[70,73-75]. Un meta-análisis reciente concluye que los patrones dietéticos caracterizados por tener mayor densidad energética, ricos en energía, alimentos procesados, dulces y snacks pero bajos en fibra, frutas y verduras, se asocian con un exceso de adiposidad[74]. Al respecto, el consumo frecuente de alimentos considerados "comida basura" o "fast-food", de alta densidad energética, ha sido relacionado con la mayor prevalencia de sobrepeso en niños y adolescentes[70].

Debido a que el estudio del efecto del consumo de nutrientes en la obesidad está lleno de limitaciones metodológicas, el análisis del consumo de alimentos y grupos de alimentos ha tomado gran relevancia en las últimas décadas[69]. De manera especial, el estudio de los patrones dietéticos ha ganado popularidad en los últimos años[76]. Los patrones dietéticos, explorados a través de técnicas estadísticas como el análisis de conglomerados o el análisis de componentes principales, permiten obtener valoraciones globales de la calidad de la dieta, más fáciles de entender y con mayor aplicabilidad en el campo de las recomendaciones dietéticas[77,78]. En el caso concreto de la obesidad en niños y adolescentes, una revisión reciente concluye que los patrones dietéticos caracterizados por tener alta densidad energética y que presentan bajo consumo de alimentos ricos en fibra predisponen a presentar sobrepeso y obesidad[79].

2. Objetivos

Los objetivos generales de la presente Tesis Doctoral son estudiar la asociación entre nivel socioeconómico y hábitos dietéticos en niños europeos, así como explorar el papel del nivel socioeconómico y los hábitos dietéticos en la presencia de sobrepeso y obesidad infantil.

Los objetivos específicos de los cinco artículos que componen la Tesis Doctoral son los siguientes:

Artículo I. Valorar la asociación entre diversos indicadores socioeconómicos y el sobrepeso y obesidad infantil en cada uno de los países participantes en el estudio.

Artículo II. Explorar la asociación entre el nivel educativo parental y la frecuencia de consumo de alimentos relacionados con la obesidad, en niños europeos, de manera conjunta y segmentada por país.

Artículo III. Describir patrones dietéticos específicos para cada país, basados en la frecuencia de consumo de alimentos de los niños participantes en el estudio y valorar su asociación con el nivel socioeconómico familiar.

Artículo IV. Valorar la asociación entre nivel socioeconómico y patrones dietéticos persistentes en el tiempo, en niños europeos.

Artículo V. Investigar la asociación entre patrones dietéticos persistentes en el tiempo y cambios en la composición corporal en niños europeos.

2. Objectives

The general objectives of the present Doctoral Thesis are to evaluate the association between socioeconomic level and dietary patterns in European children, and to explore the link between socioeconomic level and dietary patterns and childhood overweight / obesity prevalence.

Specific objectives of each of the five papers included in this Doctoral Thesis are the following:

Paper I. To assess the association between different macro- and micro-level socioeconomic factors and childhood overweight in European children.

Paper II. To explore the relationship between parental education level and the consumption frequency of obesity-related foods in European children globally and country-specifically.

Paper III. To describe country-specific dietary patterns among European children and to assess the association of dietary patterns with household socioeconomic status.

Paper IV. To describe persistent dietary patterns over time and their association with socioeconomic status.

Paper V. To investigate the association between persistent dietary patterns over time and their association with changes in body composition.

3. Material y métodos

La presente Tesis Doctoral se basa en datos procedentes del estudio IDEFICS (Identification and Prevention of Dietary- and Lifestyle-induced Health Effects in Children and Infants).

3.1 Comités de ética

El protocolo del estudio IDEFICS fue desarrollado siguiendo las normas éticas establecidas por la Declaración de Helsinki de 1975 (versión Edimburgo de 2000) y conforme a la normativa española vigente. El protocolo del estudio fue aprobado por los comités éticos locales de cada centro participante en el estudio. En el caso particular de la Universidad de Zaragoza, el estudio fue aprobado por el Comité Ético de Investigación Clínica de Aragón (CEICA). Los padres o tutores legales de los menores participantes en el estudio firmaron un consentimiento informado aceptando la participación en el mismo. De manera adicional, los menores expresaron su consentimiento verbal antes de comenzar las pruebas.

3.2 Muestra y diseño del estudio

El estudio IDEFICS (Identification and Prevention of Dietary- and Lifestyle-induced Health Effects in Children and Infants) es un estudio europeo a gran escala diseñado con el objetivo de investigar los determinantes del sobrepeso infantil y enfermedades relacionadas (incluyendo determinantes sociales, dietéticos y relacionados con los estilos de vida), y llevado a cabo en ocho países europeos (Alemania, Bélgica, Chipre, España, Estonia, Italia, Hungría y Suecia). Se trata de un estudio de

cohortes, prospectivo y multicéntrico. La muestra estudiada se seleccionó en dos áreas por país (control e intervención), comparables socio-demográficamente entre sí. El reclutamiento de participantes fue llevado a cabo a través de centros de educación infantil y primaria, previo acuerdo del equipo directivo de cada centro para formar parte del estudio. La muestra final alcanzada incluyó a 16.224 menores de entre 2 y 9 años de edad al comienzo del estudio, además de la participación de los padres o tutores legales. En los centros de intervención, se implementó un programa de promoción de la salud con el objeto de mejorar los hábitos dietéticos, incrementar el nivel de actividad física y reducir el tiempo sedentario de los menores. Durante el estudio se realizó una medición basal (T0), una medición post-intervención (T1), y una última medición de seguimiento (T2). Para el desarrollo de la presente Tesis Doctoral se han utilizado datos obtenidos durante la medición basal (artículos I a V), llevada a cabo durante el curso académico 2007/2008 y la medición post-intervención (artículos IV y V), llevada a cabo durante el curso académico 2009/2010. Las diferencias en el tamaño de la muestra de cada artículo se deben a la diversa proporción de datos perdidos para las distintas variables a estudio, así como la inclusión de datos procedentes de la medición post-intervención, en los dos últimos artículos. De manera particular, el tamaño de la muestra incluido en cada uno de los artículos de la Tesis Doctoral es el siguiente:

La muestra incluida en el **artículo I** fue de 11.994 niños, incluyendo a todos aquellos participantes con información válida sobre los factores socioeconómicos y sobre la prevalencia de sobrepeso y obesidad.

La muestra incluida en el **artículo II** alcanzó los 14.426 niños con información válida sobre su frecuencia de consumo de alimentos y sobre el nivel educativo de sus padres.

El tamaño de la muestra incluido en el **artículo III** fue de 12.462 niños con información válida sobre la frecuencia de consumo de alimentos y sobre el nivel socioeconómico de la familia, basado en la educación de los padres, la ocupación de los padres y los ingresos familiares.

El tamaño de la muestra en los **artículos IV y V** quedó reducido a 9.301 niños con información válida sobre la frecuencia de consumo de alimentos en la medición basal y la medición post-intervención así como datos validos sobre el nivel socioeconómico de las familias, incluyendo el nivel educativo de los padres, ocupación de los padres, ingresos familiares y origen de los padres (inmigrante versus no inmigrante).

3.3 Métodos de medida

3.3.1 Factores sociodemográficos

La información sociodemográfica fue recogida a través del cuestionario dirigido a los padres. Sobre los factores socioeconómicos clásicos, se obtuvo información acerca del nivel educativo de los padres, la ocupación laboral de los padres y los ingresos del hogar. Las categorías de respuesta fueron específicas para cada país, de manera que fuesen comparables entre sí. Para la clasificación del nivel educativo de los padres se aplicó la Clasificación Internacional Normalizada de la Educación (ISCED) de 1997[80]. Se consideró el nivel educativo de los padres más alto alcanzado por cualquiera de ellos. Para la clasificación de las categorías profesionales se utilizó la clasificación Socioeconómica

Europea (ESeC)[81]. El nivel de ingresos fue codificado a través de la escala de la Organización para la Cooperación Económica y Desarrollo (OECD)[82] y se ajustó en dependencia del número de componentes del hogar. Otros factores socioeconómicos adicionales fueron también analizados, incluyendo el lugar de origen de los padres (considerados de origen inmigrante si uno o ambos progenitores nació en otro país distinto al de residencia), el desempleo (si uno o ambos progenitores se encuentra en situación de desempleo), familias monoparentales (si en el hogar solamente vive uno de los progenitores) y red social pequeña (si la respuesta de los padres a la pregunta "en caso de necesidad, ¿con cuántas personas de confianza además de tu familia puedes contar?" fue una persona o ninguna).

Además de los factores mencionados, una serie de factores a nivel macro fueron incluidos para cada país en los análisis del artículo I, en particular, la media de ingresos familiares netos ajustados según la escala modificada de la OECD, el Coeficiente de Gini, el Índice de Desarrollo Humano, la proporción de niños bajo el umbral de la pobreza, la proporción de niños escolarizados y la tasa de desempleo.

3.3.2 Consumo de alimentos

Para la valoración de los patrones de consumo de alimentos en los niños participantes se utilizó un cuestionario de frecuencia de consumo de alimentos denominado Children's Eating Habits Questionnaire-food frequency section (CEHQ-FFQ)[83-85]. Dicho instrumento fue desarrollado para evaluar la frecuencia de consumo de alimentos asociados negativa o positivamente con el riesgo de sobrepeso y obesidad. El CEHQ-FFQ fue cumplimentado por los padres, reflejando la frecuencia con la que sus hijos consumieron distintos grupos de alimentos durante una semana habitual dentro del mes

anterior. El cuestionario comprende 14 grupos de alimentos: verduras y legumbres, frutas, bebidas, cereales de desayuno, leche, yogur, pescado, huevo, carnes y productos cárnicos, productos a base de soja y/o sustitutivos de la carne, queso, productos para untar (mermelada, miel, mantequilla, etc.), cereales (pan, pasta, arroz, etc.) y aperitivos o snacks (frutos secos, dulces, pasteles, chocolate, palomitas de maíz, ganchitos, etc.). Las categorías de respuesta para cada ítem incluían las siguientes categorías: "nunca/menos de una vez por semana", "1-3 veces por semana", "4-6 veces por semana", "1 vez al día", "2 veces al día", "3 veces al día", "4 o más veces al día" y "no lo sé". Los participantes con más del 50% de valores perdidos fueron excluidos de los análisis. El cuestionario no incluyó estimación del tamaño de las porciones ni tampoco fue diseñado para la estimación de la ingesta calórica total.

3.3.3 Examen físico

Las valoraciones antropométricas fueron obtenidas por personal previamente entrenado conforme al protocolo[86,87]. El peso (Kg, precisión 0.1 kg) fue medido con una báscula electrónica (TANITA BC 420 SMA, TANITA Europe GmbH, Sindelfingen, Alemania) en ropa interior y en ayunas (más de 8 horas desde la última ingesta). La altura (cm, precisión de 0.1 cm) fue medida con un estadiómetro (SECA 225, Seca GmbH & KG, Hamburg, Alemania) con los pies descalzos. El perímetro de la cintura (cm, precisión 0.1 cm) fue medido con una cinta métrica (SECA 200, Seca GmbH & KG, Hamburg, Alemania) en el punto medio entre la cresta iliaca y el borde inferior de la décima costilla, en posición erguida. Los pliegues cutáneos se midieron en el lado derecho del cuerpo en el tríceps (punto medio entre el acromion y el olecranon) y en el área subescapular (2 cm por

debajo de la punta escapular en un ángulo de 45º), por duplicado, mediante un lipómetro (Holtain Ltd., Croswell, UK).

Para cada participante se calculó el IMC y los correspondientes z-scores de acuerdo a estándares de referencia específicos según sexo y edad, propuestos por el International Obesity Task Force[15]. Teniendo en cuenta los valores derivados de los pliegues cutáneos, se calcularon la Masa Grasa Corporal en base a las ecuaciones específicas según sexo y edad de Slaughter[88,89]. Posteriormente se calculó el Índice de Masa Grasa dividiendo la masa grasa corporal por el cuadrado de la altura en metros, y el Índice de Masa Magra dividiendo la masa magra corporal en kilogramos por el cuadrado de la altura en metros. Finalmente se calcularon z-scores del índice de masa grasa y del índice de masa magra, específicos según edad y sexo.

3.4 Análisis estadísticos: consideraciones generales

Las características descriptivas de los participantes se presentan en forma de porcentajes para variables categóricas y como media y desviación estándar para las variables continuas. Las diferencias en variables continuas entre grupos se analizaron mediante *análisis de la varianza (ANOVA)* o *test de muestras independientes (t de Student)*. Las diferencias en variables categóricas se analizaron mediante el test de Chi-cuadrado.

El *análisis de la covarianza (ANCOVA)* junto con el *test de Bonferroni* **(Artículo II)** se usó para describir diferencias en la frecuencia de consumo de alimentos de los niños (veces/semana) según el nivel educativo de los padres, ajustando por una serie de covariables.

El análisis de *regresión logística binaria* se utilizó para analizar el impacto de los diferentes indicadores socioeconómicos en la prevalencia de sobrepeso u obesidad **(Artículo I)** y para examinar el efecto de la educación de los padres en la frecuencia de consumo de alimentos de sus hijos **(Artículo II)**.

Para evaluar el impacto de los diferentes factores socioeconómicos en el gradiente socioeconómico en la obesidad y sobrepeso **(Artículo I)** se calcularon los *coeficientes de correlación de Pearson* de los indicadores socioeconómicos y los coeficientes Beta del indicador socioeconómico agregado sobre la presencia de sobrepeso y obesidad.

El *análisis de componentes principales* se empleó en el **artículo III** para identificar los patrones dietéticos más comunes en los participantes de cada país por separado, basados

en la frecuencia de consumo de 43 grupos de alimentos. En el mismo artículo se empleó el *análisis de regresión lineal* para analizar el impacto del nivel socioeconómico sobre los patrones dietéticos de los niños.

El análisis de conglomerados **(Artículos IV y V)** se utilizó para agrupar a los participantes en base a su frecuencia de consumo de alimentos en dos puntos temporales. El *análisis de regresión logística binaria* también fue aplicado en el **artículo IV** para explorar la probabilidad de pertenecer a cada conglomerado de participantes en ambos puntos temporales según distintos indicadores socioeconómicos.

El *análisis de regresión lineal multinivel* **(Artículo V)** se utilizó para explorar la asociación entre los cambios en distintos marcadores de composición corporal y la pertenencia a los distintos conglomerados basados en la frecuencia de consumo de alimentos en dos puntos temporales, controlando por el efecto del país de origen y de la escuela.

Todos los análisis estadísticos se llevaron a cabo usando el paquete estadístico PASW versión 18. Como norma general, el nivel de significación se estableció en el 5%. En cada uno de los artículos que componen la presente Tesis Doctoral aparece información en detalle acerca de los procesos estadísticos empleados.

4. Resultados

Los resultados y discusión de la presente Tesis Doctoral se muestran en forma de artículos científicos.

4. Results

The results and discussion of this Doctoral Thesis are shown as research manuscripts.

Artículo I [Paper I]:

Socioeconomic factors and childhood overweight in Europe: results from the multi-centre IDEFICS study

Bammann, K., W. Gwozdz, A. Lanfer, G. Barba, S. De Henauw, G. Eiben, J. M. Fernandez-Alvira, E. Kovacs, L. Lissner, L. A. Moreno, M. Tornaritis, T. Veidebaum, I. Pigeot and I. Consortium. (2013)

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Socioeconomic factors and childhood overweight in Europe: results from the multi-centre IDEFICS study

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What is already known about this subject

- Overweight and obesity can be linked to different parental socioeconomic factors already in very young children.
- In Western developed countries, the association of childhood overweight and obesity and parental socioeconomic status shows a negative gradient.
- Ambiguous results have been obtained regarding the association between socioeconomic factors and childhood overweight and obesity in different countries and over time.

What this study adds

- European regions show heterogeneous associations between socioeconomic factors and overweight and obesity in a multi-centre study with highly standardized study protoco.
- The strength of association between SES and overweight and obesity varies across European regions.
- In our study, the SES gradient is correlated with the regional mean income and the country-specific Human development index indicating a strong influence not only of the family but also of region and country on the overweight and obesity prevalence.

Summary

Objective: To assess the association between different macro- and micro-level socioeconomic factors and childhood overweight.

Methods: Data from the IDEFICS baseline survey is used to investigate the cross-sectional association between socioeconomic factors, like socioeconomic status (SES), and the prevalence of childhood overweight. Differences and similarities regarding this relationship in eight European regions (located in Belgium, Cyprus, Estonia, Germany, Hungary, Italy, Spain and Sweden) are explored. 11 994 children (50.9% boys, 49.1% girls) and their parents were included in the analyses.

Results: In five of the eight investigated regions (in Belgium, Estonia, Germany, Spain and Sweden), the prevalence of childhood overweight followed an inverse SES gradient. In the other three regions (in Cyprus, Hungary and Italy), no association between SES and childhood overweight was found. The SES-overweight association in a region was best explained by the country-specific human development index and the centre-specific mean income. For the investigated association between other socioeconomic factors and overweight, no clear pattern could be found in the different regions.

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Conclusion: The association between socioeconomic factors and childhood overweight was shown to be heterogeneous across different European regions. Further research on nationwide European data is needed to confirm the results and to identify target groups for prevention.

Keywords: Child, Europe, overweight, socioeconomic factors.

Introduction

The relationship between socioeconomic status (SES) and obesity is well established in adults. In an exhaustive review, negative associations of SES and obesity were predominantly found in studies conducted in developed countries and positive associations in populations of lesser developed countries (1). For childhood obesity, the situation is less clear. In the landmark review of Sobal and Stunkard (2), results for children in developed countries were found to be ambiguous, and negative as well as positive or no associations were found in the considered studies. It has to be noted that the included studies reached back as far as 1941. The classification whether a country was considered a developed or an undeveloped society, however, was done based on the situation of 1989. This discrepancy might introduce bias to the results. Moreover, the prevalence of childhood obesity changed drastically during the last decades, which also can possibly moderate effects (3). In a review of UK epidemiological studies from 1960 to 2000, Batty and Leon found no evidence for a definite association between SES and obesity during childhood and adolescence (4). In a contemporary review of the literature published between 1990 and 2005 including only Western developed countries, positive associations were no longer found and only negative or no associations were reported (5). This review also revealed that the association between obesity and parental education was more consistently seen than that of obesity and parental income. Apart from the association of SES with the body mass index (BMI) status, Ness *et al*. found also a clear gradient between SES and total body fat as assessed by dual-energy X-ray absorptiometry measurement in children aged 9.9 years of the ALSPAC cohort (6).

Besides from being associated with higher all-cause mortality (7), childhood obesity was shown to lead to a lower educational attainment in later life in men (8). This association remained stable also after adjustment for intelligence level and SES. Moreover, obesity is associated with developmental delays already at a very young age (9).

Social epidemiology offers various possibilities when investigating socioeconomic factors related to health and disease. Measures that are used to define a person's SES are based on household income, educational level and occupational position where children are typically assigned to the same SES as their parents. These traditional SES indicators are complemented by factors used in attainment research (e.g. in sociology and economics) and comprise cultural and ethnic factors (10) and factors leading to social vulnerability such as migration, unemployment or lack of social support (11). Also of interest are macro-level indicators that have the potential to enhance the understanding of the relationship between SES and overweight or obesity (12,13).

The paper aims to investigate (i) the cross-sectional association of different socioeconomic factors (traditional SES indicators and other factors) with the prevalence of childhood overweight and obesity and (ii) to identify and explore differences and similarities regarding this relationship in eight European regions.

Methods

IDEFICS is a multi-centre population-based intervention study on childhood obesity that is carried out in selected regions of eight European countries comprising Belgium, Cyprus, Estonia, Germany, Hungary, Italy, Spain and Sweden. The study was set up in pre- and primary school settings in a control and an intervention region in each of these countries. Two major cross-sectional surveys (baseline and follow-up) were conducted in pre-schools and primary school classes (first and second grades at baseline). The baseline survey (September 2007–May 2008) reached a response proportion of 51% (ranging from 41% to 66% in the single countries) and included 16.220 children aged 2 to 9 years. The general design of the IDEFICS study has been described elsewhere (14,15). The present study only includes children for whom full information on the investigated socioeconomic factors is available. This holds true for 11 994 children (50.9% boys, 49.1% girls). A brief description of the study regions can be found in the appendix of this paper. It should be noted that the study regions are not representative on a national level.

Within the baseline survey, a self-administered questionnaire has been filled in by the parents to gather information on the children's behaviour, parental attitudes and on the social environment of the children. The questionnaire was developed in English, translated to the respective languages and back translated to English to minimize any heterogeneity due to translation problems. Different language versions were available in the centres, and help was offered to those parents who felt they were not able to fill in the questionnaire by themselves.

Anthropometric indicators in the children were assessed in the framework of a physical examination. Weight was determined using a TANITA BC 420 SMA (TANITA Europe GmbH, Sindelfingen, Germany) with the children being in a fasting status and wearing only underwear. Standing height was measured with the children's head in a Frankfort plane using a stadiometer SECA 225 (Seca GmbH & KG, Hamburg, Germany). As in the weight measurement, the children were wearing only underwear, all hair ornaments were removed and all braids undone.

Socioeconomic factors: micro level

Different information on the direct social environment of the children stems from the IDEFICS baseline survey data. The three traditional SES indicators education, occupation and income of the parents were assessed as follows: the *parental educational level* was assessed employing two questions: 'What is the highest level of education you and your spouse/ partner have?' and 'What is the highest level of professional qualification you and your spouse/ partner have?' The country-specific answer categories for these two questions were recoded according to the International Standard Classification of Education (ISCED 1997 (16)).

The *parental level of occupation position* was assessed by the following question: 'In what occupational position are you and your spouse/ partner presently occupied?' which had to be answered by 18 given categories for each parent. Apart from the group of civil servants, the questionnaire categories were the same for all eight countries. For this paper, the five-class version of the European Socioeconomic Classification and a modified Erikson-Goldthorpe-Portocarero Schema was employed on the categories for describing the occupational position (17).

The *household income* was assessed by the question 'What is your monthly household income, i.e. the net income that you (altogether) have after taxes and deductions?' and was accompanied by the explanatory text 'Household includes everyone living in the same residence as the selected child and sharing expenses. Please include also income from rent and lease, pensions, child allowances, alimonies etc'. For answering, nine country-specific categories were given that were built according to a fixed scheme based on the median equivalent income. The categories were transformed such that they can be handled as a continuous variable: in a first step, values were assigned to each category. These values were calculated by the cutoff minus [plus] 20% for the lowest [highest] category and by the mid-points for each of the 8 intermediate categories. The gained amount was equivalized to the number of household members using the Organization for Economic Co-operation and Development (OECD) square root scale (18). All non-Euro currencies (from Cyprus, Hungary and Sweden) were transformed to Euros using the official currency rates of June 2008.

Other socioeconomic factors were investigated to identify vulnerable groups. A *migrant background* was assumed if one or both of the parents were born in another country. *Parental unemployment* was defined if one of the parents was currently unemployed or living on social assistance/welfare. A *one-parent family* was assumed if only one adult person was living in the household. A *small social network* was assessed if the parental answer on the question 'How many persons, including your family, do you know that you can definitely rely on in cases of need?' was either 'Nobody' or '1 person'. Further answer categories were '2 to 3 persons' and 'More than 3 persons'.

Socioeconomic factors: macro level

Additionally, macro-level country-specific indicators from official statistics of 2008 were included in the analyses. The *mean equivalized disposable income* is defined as the household's disposable income equivalized to the household composition using the OECD-modified scale. The *Gini coefficient* is a measure of income inequality ranging from 0 (perfect equality: all incomes are equal) to 100 (perfect inequality: one household receives the complete income). Further technical details can be found in (19).

The *Human Development Index (HDI)* of the United Nations is a composite statistical index that describes the human development of countries (20). The components that went into the calculation of the 2008 index were life expectancy, literacy, school participation and gross domestic product. All countries

participating in the IDEFICS survey belong to the top group denoted 'very high human development countries'.

The proportion of *children below poverty line* is the share of children with an equivalized disposable income below the risk-of-poverty threshold, which is set at 60% of the national median equivalized disposable income (after social transfers).

The proportion of children in *formal child care* is defined as being either in education at pre-schools, child care at centre-based services outside school hours or child care at day care centres. Thus, formal child care includes all kind of care organized by a public or private structure.

The *unemployment rate* represents the proportion of unemployed persons of the economically active population.

Statistical methods

BMI was calculated by dividing body mass in kilograms by squared body height in meters. BMI categories were interpolated for continuous age as proposed by Cole *et al*. (21,22). For this interpolation, cubic splines were used. Two categories were investigated: overweight including obesity (denoted overweight in the following) and obesity alone. Since results were very similar for overweight and obesity, we report mainly the results for overweight.

For income comparisons across countries, purchasing power standards (PPS) were obtained by dividing the original value by the respective country-specific purchasing power parity of 2008.

An additive SES indicator was constructed comprising equivalized household income, parental education and occupational position. For this purpose, all three components were scaled to the interval [1,5] and summed up. The obtained additive SES indicator ranges from 3 (low SES) to 15 (high SES).

To evaluate the impact of a socioeconomic indicator on the prevalence of overweight or obesity, prevalence odds ratios (POR) were calculated. For this, logistic regression models that modeled the age-adjusted probability of being overweight or obese were employed.

To explore the impact of different socioeconomic factors on the SES gradient, we calculated Pearson's correlation coefficients of the indicators and the country-specific beta estimate of the additive SES indicator on overweight and on obesity. This innovative quantitative approach was chosen in order to have a more objective view on the factors influencing the SES gradient across centres than a qualitative evaluation alone would offer.

Pearson's correlation coefficients were calculated using PASW Statistics 18 (SPSS Inc., Chicago, IL, USA). All other statistical analyses were done with SAS 9.2 (SAS Institute, Cary, NC, USA).

Ethical issues

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 eight centres doing the field work. Study children did not undergo any procedure before both they and their parents had given consent for examinations, collection of samples, subsequent analysis and storage of personal data and collected samples. Study subjects and their parents could consent to single components of the study while abstaining from others.

Results

Basic characteristics of the participating countries can be found in Table 1. The IDEFICS sample consists of eight different countries in Europe that are quite heterogeneous. These comprise five long-standing member states from different regions (one Scandinavian country [Sweden]; two from Western Europe [Belgium, Germany]; two Mediterranean countries [taly, Spain] and three countries that entered the European Union in 2004 (Cyprus, Estonia, Hungary). This heterogeneity is reflected by several of the investigated macro-level indicators as, e.g. the mean equivalized disposable income that is in Hungary and Estonia less than 50% of the other countries, the HDI that is, albeit on a high level, lower in the new Member States compared to the older members. The Gini coefficient is moderate (ranging from 24.0 in Sweden to 31.3 in Spain) in all countries. Childhood poverty is highest in the Mediterranean countries and lowest in Sweden. Formal child care is especially low in Germany. The unemployment rate ranges from 3.6% in Cyprus to 11.3% in Spain.

Table 2 shows the investigated socioeconomic factors of the included children and their families.

In comparison with the national income statistics displayed in Table 1, it can be seen that the survey participants from Belgium and Italy and especially from Cyprus and Germany are below the average national level and the survey participants from Spain, Sweden, Hungary and Estonia are above the average national level. This comparably low SES in the German and Italian samples is also reflected in a high proportion of parents with an ISCED level of 2 and lower and also with a low proportion of parents

in a high occupational position. Contrastingly, the participating children from Cyprus and Sweden come from families with the highest educational level and occupational position. The proportion of vulnerable groups highly varies between centres: 4.2% of the children in the Hungarian sample have a migrant background as opposed to 31.3% of the children with migrant background in Germany. Unemployment proportions range from 1.3% in the Estonian sample to 11.4% in the German sample. One-parent families are especially rare in the Italian sample (2.2%), and a small social network is most often reported in Hungary (15.5%), Italy (13.5%) and Spain (16.8%) samples and least often in Sweden (3.2%).

The overweight (including obesity) prevalence ranges from 7.5% in the Belgium sample to 42.0% in the Italian sample (Table 3); the obesity prevalence ranged from 1.9% in Belgium and Sweden to 19.9% in Italy (data not shown). The age-adjusted POR for the traditional SES indicators show two distinct patterns for the different centres for overweight/obesity. In the majority of the centres, an SES gradient for overweight/obesity can be observed for the additive SES indicator and for all or most of the three single components (Belgium, Estonia, Germany, Spain and Sweden). The second group of countries (Cyprus, Hungary and Italy) does not show this SES gradient for overweight/obesity with PORs for SES close to 1.0.

Even more heterogeneity between centres is observed for the association between other micro-level socioeconomic factors and overweight/obesity (Table 3). A migrant background is statistically significantly associated with a higher prevalence of overweight/obesity in Belgium (POR = 2.3, 95% confidence interval [CI] = 1.23–3.70) and Germany (POR = 1.7, 95% CI = 1.31–2.27) shows only weak association in Cyprus and Sweden and no association in the other centres. Unemployment of parents shows an elevated POR for children's overweight/obesity in Belgium (POR = 2.5, 95% CI = 1.15–5.62), Estonia (POR = 1.6, n.s.), Germany (POR = 1.4, n.s.) and Sweden (POR = 2.0, n.s.), a negative association with children's overweight/obesity in Cyprus (POR = 0.3, n.s.) and only weak or no association in Hungary, Italy and Spain. Children from one-parent families have a higher prevalence of overweight/obesity only in Belgium (POR = 1.7, n.s.), Cyprus (POR = 1.4, n.s.), Spain (POR = 1.6, n.s.) and Sweden (POR = 2.1, 95% CI = 1.21–3.56), with no association in the other centres. A small social network is statistically significantly associated with a higher prevalence of overweight/obesity in Germany (POR = 1.9, 95% CI = 1.19–2.98), Belgium (POR 1.7, n.s.) and Sweden (POR = 1.4, n.s.), not associated with the overweight/obesity prevalence in Hungary and Italy and associated with a lower prevalence of overweight/obesity in Cyprus (POR = 0.6, n.s.), Estonia (POR = 0.6, 95% CI = 0.41–0.94) and Spain (POR = 0.6, 95% CI = 0.41–0.94). Similar results were obtained for obesity alone (data not shown).

Table 1 Basic characteristics of included countries (all data of 2008)

	Belgium	Cyprus	Estonia	Germany	Hungary	Italy	Spain	Sweden
Mean equivalized disposable income per year								
Euros	19 986	18 935	6333	21 086	4827	17 734	14 583	21 805
Purchasing power standards (PPS)	18 606	21 555	8635	20 738	7237	17 307	15 707	18 865
Gini coefficient								
	27.5	28.0	30.9	30.2	25.2	31.0	31.3	24.0
Human Development Index (HDI)								
Source: United Nations Development Programme (http://hdr.undp.org)								
	0.865	0.807	0.816	0.885	0.804	0.850	0.861	0.885
Children (less than 16 years) below poverty line								
in %	16.7	13.2	17.1	14.7	19.5	24.6	24.1	12.3
Formal child care (≥30 h)								
<3 years in %	23	18	16	9	5	16	16	31
3 years – minimum compulsory school age in %	74	43	84	36	57	72	45	64
Unemployment								
Unemployment rate 2008	7.0	3.6	5.5	7.5	7.8	6.7	11.3	6.2

Source: Eurostat (http://epp.eurostat.ec.europa.eu) except where stated otherwise.

Table 2 Basic characteristics of included children: family level indicators

Country	Belgium	Cyprus	Estonia	Germany	Hungary	Italy	Spain	Sweden
Sample size	*n* = 1520	*n* = 1049	*n* = 1415	*n* = 1669	*n* = 1758	*n* = 1673	*n* = 1507	*n* = 1619
Age in years: mean (SD)	5.6 (1.6)	6.2 (1.4)	5.9 (2.1)	6.1 (1.8)	6.3 (1.8)	6.2 (1.8)	5.7 (1.8)	5.7 (2.0)
Parental education								
ISCED 0–2 in %	3.2	3.0	1.8	35.4	2.3	19.0	7.8	1.2
ISCED 3–4 in %	49.1	36.0	83.3	48.8	51.4	61.2	38.1	27.7
ISCED 5–6 in %	47.7	61.0	14.9	15.8	46.3	19.8	54.1	71.0
Parental occupation								
Lower technical and routine occupation in %	11.4	12.1	18.2	23.9	22.5	27.8	11.0	11.0
Lower services and sales occupation in %	16.6	11.7	6.6	12.0	21.4	22.4	15.2	8.5
Small employers and self-employed in %	13.4	19.0	10.0	6.2	10.3	21.5	15.7	8.4
Intermediate employee in %	26.8	16.8	23.8	34.8	20.9	20.0	25.0	25.3
Salariat in %	31.0	39.6	41.3	20.9	24.3	7.1	31.7	45.5
Equivalized yearly household income								
In Euros: mean (SD)	19 147 (6898)	13 152 (9381)	8218 (4819)	14 049 (6789)	5378 (2380)	10 170 (4652)	15 689 (6159)	23 145 (7301)
In PPS: mean (SD)	18 685 (6732)	14 972 (10 679)	11 206 (6571)	13 817 (6677)	8063 (3568)	946 (4331)	16 900 (6634)	20 024 (6316)
SES								
Indicator: mean (SD)	10.54 (2.83)	10.92 (2.63)	10.16 (2.84)	9.10 (3.38)	9.94 (3.32)	8.63 (2.97)	10.28 (2.88)	11.04 (2.79)
Vulnerable groups								
Migrant background	5.7	27.7	5.2	31.3	4.2	17.2	10.4	16.7
Unemployment	3.0	2.9	1.3	11.4	7.3	7.0	7.4	2.0
One-parent family	8.6	9.6	9.6	13.7	14.6	2.2	7.3	6.1
Small social network	6.6	9.4	9.2	6.8	15.5	13.5	16.8	3.2

ISCED, International Standard Classification of Education; SD, standard deviation; SES, socioeconomic status.

Table 3 Age-adjusted prevalence odds ratios for being overweight or obese

Country Sample size	Belgium *n* = 1520	Cyprus *n* = 1049	Estonia *n* = 1415	Germany *n* = 1669	Hungary *n* = 1758	Italy *n* = 1673	Spain *n* = 1507	Sweden *n* = 1619
Overweight including obesity in %	7.5	24.6	13.6	15.0	15.2	42.0	19.7	10.3
Equivalized yearly household income								
In Euros/10 000	0.7 (0.54–0.97)	1.0 (0.83–1.13)	0.7 (0.49–0.97)	0.6 (0.50–0.79)	0.8 (0.47–1.43)	1.1 (0.88–1.34)	0.8 (0.64–1.02)	0.8 (0.60–0.95)
In PPS/10 000	0.7 (0.53–0.97)	1.0 (0.85–1.11)	0.8 (0.59–0.98)	0.6 (0.50–0.79)	0.9 (0.60–1.27)	1.1 (0.87–1.37)	0.8 (0.66–1.02)	0.7 (0.55–0.94)
Parental education								
ISCED 0–2	2.1 (0.84–5.20)	1.2 (0.52–2.58)	1.4 (0.44–4.56)	2.5 (1.54–3.93)	1.3 (0.55–3.04)	1.3 (0.95–1.79)	2.2 (1.37–3.60)	2.4 (0.77–7.17)
ISCED 3–4	1.5 (0.99–2.19)	1.1 (0.83–1.42)	1.3 (0.83–2.12)	1.5 (0.94–2.40)	1.2 (0.95–1.63)	1.0 (0.79–1.31)	1.6 (1.18–2.14)	1.2 (0.87–1.75)
ISCED 5–6	1.0 (Ref.)	1.0 (Ref.)	1.0 (Ref.)	1.0 (Ref.)	1.0 (Ref.)	1.0 (Ref.)	1.0 (Ref.)	1.0 (Ref.)
Parental occupation								
Lower technical and routine occupation	1.9 (1.07–3.45)	1.2 (0.73–1.83)	1.7 (1.12–2.58)	1.6 (1.05–2.49)	1.1 (0.78–1.63)	1.0 (0.64–1.47)	1.2 (0.73–1.91)	1.9 (1.14–3.04)
Lower services and sales occupation	1.1 (0.64–2.08)	1.2 (0.76–1.91)	1.0 (0.48–1.90)	2.1 (1.32–3.45)	0.9 (0.58–1.28)	0.8 (0.55–1.27)	1.2 (0.81–1.89)	1.5 (0.86–2.70)
Small employers and self-employed	1.0 (0.54–2.08)	1.3 (0.86–1.84)	0.9 (0.51–1.64)	1.4 (0.71–2.59)	0.8 (0.50–1.37)	0.9 (0.56–1.31)	1.1 (0.72–1.70)	1.7 (0.95–2.90)
Intermediate employee	1.0 (0.60–1.74)	0.8 (0.50–1.19)	1.3 (0.91–2.00)	1.3 (0.89–2.04)	0.9 (0.60–1.32)	0.7 (0.44–1.05)	1.1 (0.75–1.58)	1.2 (0.80–1.83)
Salariat	1.0 (Ref.)	1.0 (Ref.)	1.0 (Ref.)	1.0 (Ref.)	1.0 (Ref.)	1.0 (Ref.)	1.0 (Ref.)	1.0 (Ref.)
SES								
Additive indicator	0.91 (0.85–0.97)	0.99 (0.94–1.04)	0.94 (0.89–0.99)	0.91 (0.88–0.95)	0.99 (0.95–1.03)	0.99 (0.96–1.02)	0.94 (0.90–0.99)	0.92 (0.87–0.97)
Vulnerable groups								
Migrant background	2.3 (1.23–4.27)	1.3 (0.94–1.73)	1.1 (0.58–2.16)	1.7 (1.31–2.27)	1.0 (0.51–1.87)	1.0 (0.76–1.27)	1.0 (0.62–1.52)	1.3 (0.84–1.90)
Unemployed	2.5 (1.15–5.62)	0.3 (0.10–1.13)	1.6 (0.52–5.06)	1.4 (0.97–2.13)	0.7 (0.41–1.27)	1.3 (0.89–1.91)	1.0 (0.59–1.73)	2.0 (0.80–4.86)
One-parent family	1.7 (0.93–2.95)	1.4 (0.86–2.14)	0.9 (0.51–1.51)	0.9 (0.59–1.32)	1.2 (0.81–1.67)	0.9 (0.43–1.73)	1.6 (0.99–2.63)	2.1 (1.21–3.56)
Small social network	1.7 (0.90–3.22)	0.6 (0.36–1.05)	0.6 (0.41–0.94)	1.9 (1.19–2.98)	0.9 (0.62–1.30)	0.9 (0.67–1.20)	0.6 (0.41–0.94)	1.4 (0.61–3.09)

ISCED, International Standard Classification of Education; PPS, purchasing power standards; SES, socioeconomic status.

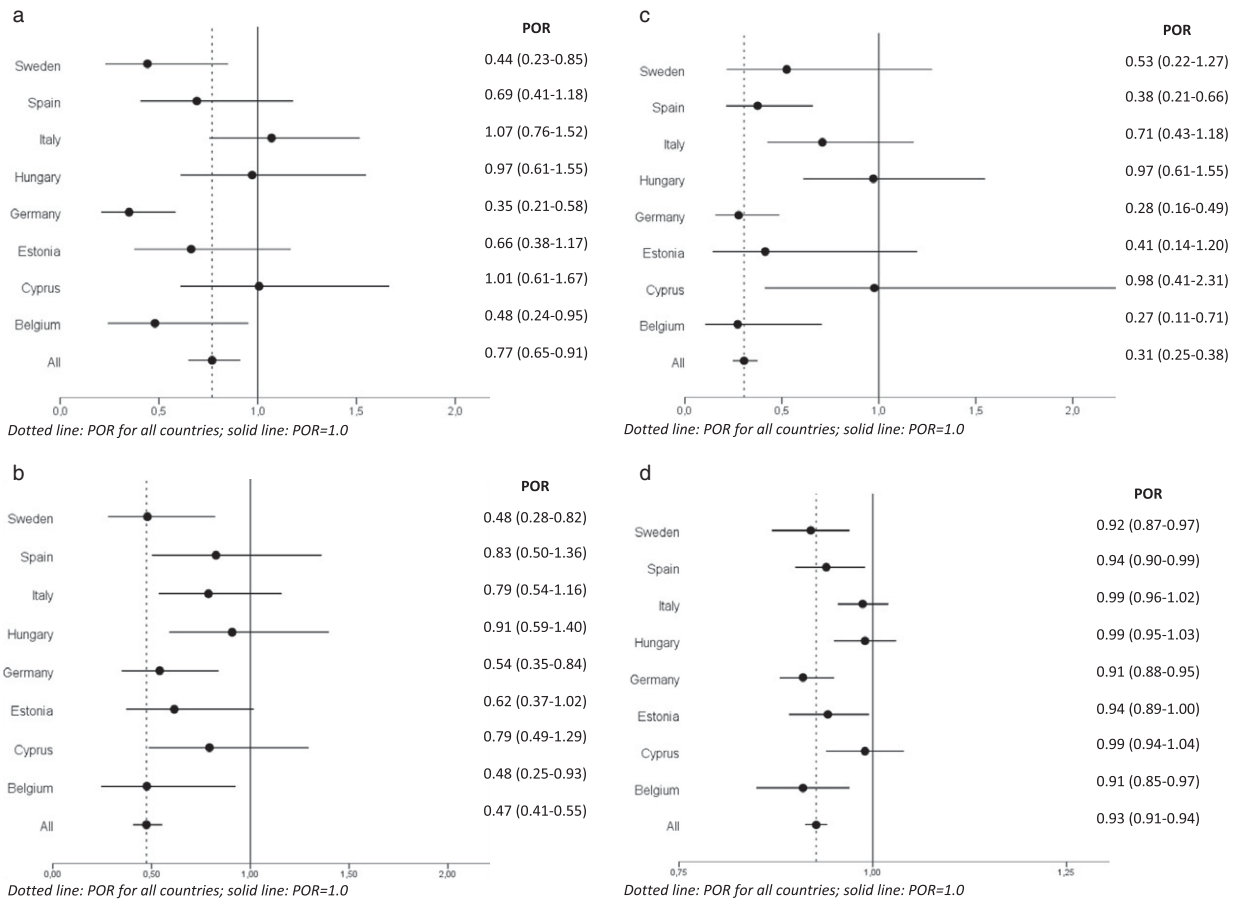

Figure 1 (a) SES indicator component: Household income. Prevalence odds ratios for overweight/obesity with 95% confidence interval. (b) SES indicator component: parental occupational position. Prevalence odds ratios for overweight/obesity with 95% confidence interval. (c) SES indicator component: parental education. Prevalence odds ratios for overweight/obesity with 95% confidence interval. (d) Additive SES indicator. Prevalence odds ratios for overweight/obesity with 95% confidence interval.

Deconstructing the additive SES indicator into its components reveals that overall, all three SES indicators are negatively associated with overweight/obesity and that parental education has the strongest protective influence of all three indicators (see Fig. 1a-d; distance between dotted and solid line). While the centre-specific differences are very similar for household income (POR statistically significant for Sweden, Germany and Belgium: Fig. 1a) and occupational position (POR statistically significant for Sweden, Germany and Belgium: Fig. 1b), a notable exception is educational level (POR statistically significant for Spain, Germany and Belgium; non-significant for Sweden with its low variation in educational level: Fig. 1c). The broader pattern is confirmed by the additive SES indicator showing a protective effect overall, and in Sweden, Spain, Germany, Estonia and Belgium with statistically significant POR (Fig. 1d).

The correlation coefficients of the investigated socioeconomic factors with the SES gradients in the centres are depicted in Table 4. The SES gradients of overweight/obesity are correlated with the country-specific HDI (negative correlation: –0.761, $P = 0.028$). On the centre-specific level, the indicators correlating most with the SES gradient are mean income (negative correlation: –0.678, $P = 0.064$) and proportion of parents with a small social network (positive correlation: 0.623, $P = 0.099$). These results are corroborated by similar results for the SES gradient of obesity: here, the indicators that correlate most are the country-specific HDI (negative correlation: –0.820, $P = 0.013$) and the proportion of formal child care below 3 years (negative correlation: –0.664, $P = 0.072$) and the centre-specific mean income (negative correlation: –0.896, $P = 0.064$).

Table 4 Correlation of social indicators with SES gradient of overweight/obesity in all eight centres

Variable	Pearson's correlation coefficient (p-value)
Country-specific indicators	
Mean equivalized disposable income (PPS)	–0.280 ($P = 0.502$)
Gini coefficient	0.004 ($P = 0.992$)
Human Development Index	–0.761 ($P = 0.028$)
Proportion of children below poverty line	0.369 ($P = 0.369$)
Proportion of formal child care below 3 years	–0.400 ($P = 0.327$)
Proportion of formal child care 3 years – minimum compulsory school age	–0.032 ($P = 0.941$)
Unemployment rate	–0.253 ($P = 0.545$)
Centre-specific indicators	
Mean equivalized net household income (PPS)	–0.678 ($P = 0.064$)
Mean ISCED	0.021 ($P = 0.961$)
Mean ESeC5 class	–0.482 ($P = 0.227$)
Mean SES indicator	–0.332 ($P = 0.422$)
Standard deviation SES indicator	0.112 ($P = 0.791$)
Proportion of children with migrant background	0.010 ($P = 0.982$)
Proportion of unemployed parents	0.020 ($P = 0.962$)
Proportion of one-parent families	–0.098 ($P = 0.818$)
Proportion of parents with small social network	0.623 ($P = 0.099$)

Pearson's correlation coefficients of investigated indicators with beta estimates of SES on overweight/obesity.
ESeC, European Socioeconomic Classification; ISCED, International Standard Classification of Education; PPS, purchasing power standards; SES, socioeconomic status.

Discussion

This paper investigated the association of different socioeconomic factors with the prevalence of childhood overweight and obesity in eight different European regions. Regarding the classical SES indicators, we found an inverse gradient for overweight and for obesity in five of the eight investigated centres (Sweden, Belgium, Spain, Estonia and Germany) and no association in the Cypriot, Hungarian and Italian centre. Within all five centres with an inverse SES gradient, the parental occupational position and parental education contributed more to the gradient than the equivalized household income. The investigated association between other socioeconomic factors and overweight was not consistent. Having a migrant background or being from a one-parent family was linked with a higher prevalence of overweight and obesity only in selected centres and was not associated in other centres. For parental unemployment or a small social network, all kinds of associations (positive, negative and no association) were found in the eight centres and no clear pattern could be found. Furthermore, we investigated factors on a country- and on a centre-specific level that could possibly explain the differences concerning the SES gradient. Highest correlations were found with country-specific HDI and centre-specific mean income for both, the SES gradient of overweight including obesity and that of obesity alone.

The findings from our study confirm the results from the literature (23,24) and extend the study of Sobal and Stunkard (2) and Shrewsbury and Wardle (5) by the finding that the SES gradient is related to the degree of human development even within the group of very highly developed countries. We were able to further substantiate the observation of Shrewsbury and Wardle (5) that among the three single SES indicators, parental education is of particular importance regarding childhood overweight and obesity. However, we found that all three SES indicators contribute to the observed SES gradient. Although the decomposition into the single SES components gives a more detailed picture and is easier to interpret than an artificial construct like the additive SES indicator, the latter gives an appropriate summary and seems to be well suited for, e.g. describing data, integration into more complex models and for comparing single countries. In the case of Estonia, the SES-overweight association might even be better portrayed by the (statistically significant) additive SES indicator than by the three (statistically non-significant) single SES components. However, the appropriateness of an additive SES indicator might be challenged when analyzing data from other continents or even across different continents. Here, the parental education poses probably the most promising alternative.

The association between other socioeconomic factors and childhood obesity has only rarely been the subject of study. Apart from an inverse SES gradient, Singh *et al*. (25) found in a US cohort a higher risk for overweight and obesity for children of unemployed households, with single mothers, with parents with low social capital, of selected ethnicities (Hispanics, non-Hispanic blacks and American Indians) and children of households where English was not the primary language. Bürgi *et al*. (26) found

a small but statistically significant difference of the BMI of migrant of non-migrant parents in Swiss children and Will *et al*. (27) showed for a German pre-school sample a higher point prevalence of obesity in children of migrant parents as opposed to children of non-migrant parents. This might be due to social or genetic causes; the influence of race on childhood obesity was repeatedly shown in US studies.

The current study has several limitations. First, it is a cross-sectional study. Although it can be assumed that parental SES might rather influence the risk of childhood obesity than vice versa no general statements on temporal order or causative associations can be made. Recently, longitudinal data from the ALSPAC study confirmed this assumption by showing that the gradient in childhood obesity by maternal education at birth starts to develop not earlier than around the age of 4 years (28). Further, it has to be kept in mind that the study is not representative of the European population or even of the countries participating in the study. In contrary, some of the investigated regions, like, e.g. in Germany, were rather untypical of the country with respect to the investigated socioeconomic factors. However, this gave opportunity to disentangle the country influence from the regional influence on the SES gradients. All socioeconomic indicators of the study were gathered by parental self-report, and this may or may not have influenced results. Unfortunately, the validity of self-reported socioeconomic indicators is largely understudied.

A particular strength of the study is the fact that the data was gathered in a standardized way in all participating centres. The BMI measurement followed at strictly standardized procedure and was taken with the children being in a fasting status. Quality control procedures like, e.g. central trainings and external site visits, ensured comparability of measurements across centres. Height and weight measurements in the IDEFICS surveys were shown to have an intra- and inter-observer reliability of well above 99% in each of the study centres (29).

The inverse association of SES and childhood overweight and obesity in highly developed countries or regions seems to be more and more well established. In our study, SES was inversely related to childhood overweight in some European regions; in regions with a lesser degree of development, we found no association between SES and childhood overweight. Studying the SES-overweight association in European regions with low socioeconomic development is new and provides a field of research for the future. Moreover, for the identification of target groups for prevention, the inclusion of more and different socioeconomic indicators seems to be desirable (30,31). This paper makes a first attempt for European children in this regard; however, more and, if possible, nationally representative studies are needed for this purpose.

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Conflict of Interest Statement

We certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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Appendix

Table A Description of study regions

	Belgium	Cyprus	Estonia	Germany	Hungary	Italy	Spain	Sweden
Intervention region								
Name	Geraardsbergen	Strovolos	Tartu	Delmenhorst	Pecs	Atripalda/Monteforte I/Volturara I	Zaragoza 1. District	Partille
Province	East-Flanders	Nicosia District	Tartumaa	Lower Saxony	Baranya	Avellino	Zaragoza	Västra Götaland
Size (population)	31 380	100 000	101 965	79 000	156 567	25 309	57 199	33 614
Population density (inh/sqm)	394	na	2538	1195	963	1314/444/129	660 (whole Zaragoza)	585
Citizenship								
Non-nationals in %	na	na	20	7.9	7.4	1.6	2.2	13.4
Control region								
Name	Aalter	Paphos	Tallinn	Wilhelmshaven	Zalaegerszeg	Avellino/Forino/Pratola Serra	Huesca	Alingsas, Mölndal
Province	East-Flanders	Paphos	Harjumaa	Lower Saxony	Zala	Avellino	Huesca	Västra Götaland
Size (population)	18 841	51 000	396 852	81 000	62 158	65 569	49 312	95 805
Population density (inh/sqm)	230	na	2555	759	622	1867/259/453	323	80/415
Citizenship								
Non-nationals in %	na	na	28.9	5.2	4.5	1.4	4.1	11.4
Linear distance in km	46	120	185	68	190	5–22	74	11–33

Source: Data from project partners.

Artículo II [Paper II]:

Parental education and frequency of food consumption in European children: the IDEFICS study

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Parental education and frequency of food consumption in European children: the IDEFICS study

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Abstract

Objective: To assess the relationship between parental education level and the consumption frequency of obesity-related foods in European children.

Design: The analysis was based on data from the cross-sectional baseline survey of a prospective cohort study. The effects of parental education on food consumption were explored using analysis of covariance and logistic regression.

Setting: Primary schools and pre-schools of selected regions in Italy, Estonia, Cyprus, Belgium, Sweden, Hungary, Germany and Spain.

Subjects: Participants (n 14 426) of the IDEFICS baseline cohort study aged 2 to 9 years.

Results: Parental education level affected the intake of obesity-related foods in children. Children in the low and medium parental education level groups had lower odds of more frequently eating low-sugar and low-fat foods (vegetables, fruits, pasta/noodles/rice and wholemeal bread) and higher odds of more frequently eating high-sugar and high-fat foods (fried potatoes, fruits with sugar and nuts, snacks/desserts and sugared beverages; $P < 0{\cdot}001$). The largest odds ratio differences were found in the low category (reference category: high) for vegetables (OR = 0·56; 95 % CI 0·47, 0·65), fruits (OR = 0·56; 95 % CI 0·48, 0·65), fruits with sugar and nuts (OR = 2·23; 95 % CI 1·92, 2·59) and sugared beverages (OR = 2·01; 95 % CI 1·77, 2·37).

Conclusions: Low parental education level was associated with intakes of sugar-rich and fatty foods among children, while high parental education level was associated with intakes of low-sugar and low-fat foods. These findings should be taken into account in public health interventions, with more targeted policies aiming at an improvement of children's diet.

Keywords
Parental education
Children
IDEFICS study
Food consumption

Social inequalities in health determine the risk of morbidity and mortality from childhood through to adult life[1]. Consistent evidence indicates that people of low socio-economic status (SES) have a heavier burden of disease than their better-off counterparts[2]. SES refers to an individual's relative position in the social hierarchy and can be operationalized through diverse indicators including educational attainment, occupation and/or income. It is possible that such indicators affect food consumption in different ways due to different underlying social and psychological processes involving factors like nutritional knowledge, budget constraints or peer group behaviour[3,4]. Diet quality has been shown to follow a socio-economic gradient[5]. Studies examining the impact of SES on adolescents' and children's food intake have suggested high consumption of high-fat and high-sugar foods, and low consumption of fruits and vegetables, in individuals from disadvantaged groups[6–10].

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Family structure and support is one of the most influential aspects of the social environment of children. Parental influences on children's food choices and intake have an effect on individual and family practices, and operate among other mechanisms via availability and accessibility of foods or parental eating behaviour as food modelling[11,12]. Through this link, parental educational level is associated with children's food intake and frequency of consumption, and subsequently with childhood overweight and obesity[13–15]. However, the stability and repeatability of these relationships between countries have been scarcely investigated.

The present study aimed to assess the association between parental education levels and the consumption frequency of obesity-related food groups (e.g. foods that are shown by consistent evidence to be related, either positively or negatively, to overweight and obesity in children) among children aged 2 to 9 years from eight European countries.

Methods

The 'Identification and prevention of Dietary- and lifestyle-induced health EFfects In Children and infantS' (IDEFICS) study is a population-based multicentre study of children aged 2 to 9 years from eight European countries. The two main aims were: (i) to investigate the aetiology of obesity and related disorders; and (ii) to implement a community-based intervention to prevent obesity and related diseases. For the present analysis, children recruited during the cross-sectional baseline survey were considered. Between September 2007 and May 2008, 31 543 children from primary schools and pre-schools of selected regions in Italy (Avellino), Estonia (Tartumaa, Harjumaa), Cyprus (Nicosia District, Paphos), Belgium (East-Flanders), Sweden (Västra Götaland), Hungary (Baranya, Zala), Germany (Lower Saxony) and Spain (Zaragoza, Huesca) were invited to participate in the baseline survey (T0) with a response rate of 53·4 % (*n* 16 864). The lowest response rates were reached in Spain (41 %) and Hungary (44 %), and the highest in Italy (60 %) and Sweden (66 %). In total 16 224 children (51·4 %) fulfilled the study's inclusion criteria (complete information on age, sex, height and weight). Sample size ranged from 1507 in Spain to 2567 in Hungary. An in-depth description of the complete IDEFICS study population is given by Ahrens *et al.*[16]. Of the total sample, 14 426 children (88·9 %) had valid data on SES and food intake, and were included in the current analysis. Further information on the study procedures is available in previous papers[17,18]. Each participating centre obtained ethical approval for the study from its respective responsible authority. All children provided oral consent and their parents provided written informed consent for all examinations and the collection, analysis and storage of personal data and collected samples.

Measurements

Data on personal, social, environmental and behavioural factors were collected by means of two standardized self-administered questionnaires that were filled in by the parents or guardians of the child. Education level of parents taken from the core parental questionnaire was used as a proxy indicator of SES, using categories according to the International Standard Classification of Education (ISCED)[19]. Three levels of education (low, medium, high) were created out of the six ISCED levels of the parental questionnaire: ISCED level 0, 1 or 2 adding up to low education; level 3 or 4 adding up to medium education; and level 5 or 6 adding up to high education. For the purposes of the present analysis, the highest education level of parents (either mother or father) was considered.

Dietary data were obtained by the food frequency section of the Children's Eating Habits Questionnaire–Food Frequency Questionnaire (CEHQ-FFQ)[20] in which the frequency of the child's consumption of selected food items during the preceding four weeks was reported. In order to assess meals under parental control, recall referred to meals outside the school canteen or childcare meal provision settings only[20,21]. The CEHQ-FFQ consisted of forty-three food items clustered into fourteen food groups. It was applied as a screening instrument to investigate the consumption of foods shown to be related, either positively or negatively, to overweight and obesity in children. The CEHQ-FFQ was not designed to provide an estimate of total energy intake or total food intake, but rather to investigate the consumption frequency of obesity-related foods. Those foods less likely to be associated with obesity were not included. Response options displayed were as follows: 'never/less than once a week', '1–3 times a week', '4–6 times a week', '1 time per day', '2 times per day', '3 times per day', '4 or more times per day' and 'I have no idea'. For the analysis, a conversion factor was used to transform the questionnaire answers into actual weekly consumption frequencies. When the proxy reported having 'no idea', consumption frequency could not be calculated and the data were not used in the analysis of the respective food item. No information on portion sizes was obtained.

Anthropometric measurements were carried out by trained staff following a standardized procedure in all centres. Body height (cm) was measured without shoes and all braids undone using a portable stadiometer (SECA 225). Weight (kg) was measured by means of a child-adapted version of an electronic scale (TANITA BC 420 SMA) with the children in a fasting status and wearing only underwear[22]. BMI was calculated and categorized following cut-off points according to the criteria of the International Obesity Taskforce[23,24]. The sample was classified into thinness, normal weight, overweight and obese categories.

Statistical analysis

Descriptive data are shown as proportions, means and standard deviations. Differences in frequency of food consumption (times/week) by classified parental education (low, medium and high) were assessed by analysis of covariance models. Logistic regression analysis was used to examine the effect of parental education on frequency of food consumption. For this purpose, frequencies of food consumption were divided into tertiles (lowest, middle and highest consumption), based on country-specific variable distributions and for each food item separately. Finally, dichotomous variables were created, comparing the highest consumption (high consumers) against the rest of the sample, namely the lowest and middle tertiles (average consumers). High parental education level was set as the reference category. Prevalence of high consumers by parental education was also calculated. Both analyses (analysis of covariance and logistic regression) were adjusted for the following covariates: sex, age, BMI category and country. Statistical significance was set at $P \leq 0{\cdot}05$. All analyses were conducted using the Predictive Analytic Software (PASW) version 18·0 (SPSS Inc., Chicago, IL, USA).

Table 1 Characteristics of the study sample: children (*n* 14 426) aged 2 to 9 years from eight European countries, baseline survey of IDEFICS study, September 2007 to May 2008

	n	%	Mean	SD
Age (years)				
Total	14 426		5·99	1·8
Pre-school	6631	46·6	4·28	0·9
School	7795	54·0	7·44	0·8
Sex				
Girls	7338	50·9	–	–
Boys	7088	49·1	–	–
Parental education level				
Low	1258	8·7	–	–
Medium	7227	50·1	–	–
High	5941	41·2	–	–
BMI category				
Thinness	1592	11·0	–	–
Normal weight	10 068	69·8	–	–
Overweight	1790	12·4	–	–
Obese	976	6·8	–	–
Country				
Belgium	1765	12·2	–	–
Cyprus	1462	10·1	–	–
Estonia	1599	11·1	–	–
Germany	1922	13·3	–	–
Hungary	2480	17·2	–	–
Italy	2189	15·2	–	–
Spain	1272	8·8	–	–
Sweden	1737	12·0	–	–

Results

Study participants excluded from the present study did not differ from those included in terms of sex, age, BMI category or parental education level. Based on the statistically significant interaction between educational level and country (all $P < 0{\cdot}001$), results are provided for the whole sample and by country. Table 1 describes the sociodemographic and anthropometric characteristics of the participating children (*n* 14 426). Mean age was 6·0 (1·8) years, with 46·6 % being of pre-school age (<6 years old) and 50·9 % being girls. Of the children, 69·8 % had normal weight for their height and age, while 12·4 % were classified as overweight and 6·8 % as obese. Some 41·2 % of the participants' parents had a high education level, 50·1 % a medium education and 8·7 % a low education. Sample size as a proportion of the total population varied among countries from 8·8 % in Spain to 17·2 % in Hungary. The following results refer to meals consumed outside the school canteen or childcare meal provision settings. The percentage of meals under parental control differed between countries (Italy 88 %, Estonia 69 %, Cyprus 84 %, Belgium 77 %, Sweden 65 %, Germany 90 %, Hungary 69 % and Spain 84 %).

Table 2 shows the weekly consumption frequencies and odds ratios (95 % confidence intervals) for consumption of low-sugar and low-fat foods by parental education level for the total sample. Significant differences in mean frequency of consumption of the chosen foods between parental education groups were observed. The highest mean frequency of weekly consumption for vegetables, fruits, pasta/noodles/rice, wholemeal bread and water was observed in the highest education level category. The largest differences were found for water (21·6 (SE 0·1) times/week in the high category *v.* 19·5 (SE 0·3) times/week in the low category) and vegetables (9·0 (SE 0·1) times/week in the high category *v.* 7·7 (SE 0·2) times/week in the low category). No significant trend was found for plain unsweetened milk. Taking into account the odds ratio results, children with parents in the low and medium parental education level groups had lower odds of more frequently eating vegetables, fruits, pasta/noodles/rice and wholemeal bread ($P < 0{\cdot}001$). Children with parents from the low parental education level group had also lower odds of more frequently drinking water ($P < 0{\cdot}05$) and plain unsweetened milk ($P < 0{\cdot}001$). The largest odds ratio differences were found in the low category (reference category: high) for vegetables (OR = 0·56; 95 % CI 0·47, 0·65) and fruits (OR = 0·56; 95 % CI 0·48, 0·65).

Table 3 shows the weekly consumption frequencies and odds ratios (95 % confidence intervals) for consumption of high-sugar, refined and high-fat foods by parental education level for the total sample. Significant differences in mean frequency of consumption of the chosen foods between parental education groups were observed. The highest mean frequency of weekly consumption for fried potatoes, fruits with sugar and nuts, fried meat and fish, cold cuts, fast food, white bread, sugared beverages, snacks/desserts and chocolate/nut-based spread was observed in the low educational

Table 2 Weekly consumption frequency (means and their standard errors), prevalence of high consumption, and odds ratios (95 % confidence intervals) for intake of low-sugar and low-fat foods by classified parental education level; children (*n* 14 426) aged 2 to 9 years from eight European countries, baseline survey of IDEFICS study, September 2007 to May 2008

Food group/Parental education	*n*	Mean	SE	p†	OR	95 % CI
Vegetables (raw and cooked)						
Low	1049	7·7[a,b]	0·19	33	0·56***	0·47, 0·65
Medium	6685	8·1[a,c]	0·07	36	0·76***	0·70, 0·82
High	5696	9·0[b,c]	0·08	38		
Fruits						
Low	1021	7·0[a,b]	0·19	27	0·56***	0·48, 0·65
Medium	6598	7·6[a,c]	0·07	35	0·74***	0·69, 0·80
High	5660	8·2[b,c]	0·08	41		
Fresh meat and fish						
Low	1046	3·9[a,b]	0·10	41	1·02	0·88, 1·19
Medium	6685	3·6[a,c]	0·04	36	1·02	0·95, 1·11
High	5726	3·3[b,c]	0·04	35		
Pasta, noodles and rice						
Low	1021	2·8[a,b]	0·08	31	0·61***	0·52, 0·72
Medium	6606	3·0[a,c]	0·03	30	0·85***	0·77, 0·93
High	5669	3·2[b,c]	0·04	32		
Wholemeal bread						
Low	993	3·4[b]	0·15	28	0·76***	0·64, 0·90
Medium	6479	3·5[c]	0·06	32	0·79***	0·72, 0·86
High	5602	3·9[b,c]	0·06	36		
Water						
Low	1001	19·5[a,b]	0·32	60	0·83*	0·71, 0·99
Medium	6563	20·8[a,c]	0·12	51	0·97	0·89, 1·06
High	5637	21·6[b,c]	0·14	50		
Plain unsweetened milk						
Low	973	7·3	0·23	31	0·68***	0·59, 0·80
Medium	6394	7·5	0·09	36	0·92	0·85, 1·00
High	5511	7·4	0·10	33		

Reference group: high education.
Analysis of covariance model adjusted for gender, age and BMI category. Two-sided level of significance ($P < 0·05$): [a]significant difference between low and medium; [b]significant difference between low and high; [c]significant difference between medium and high.
OR and 95 % CI determined by logistic regression models. Variables included in the models were parental education, gender, age and BMI category. Two-sided level of significance: *$P < 0·05$, ***$P < 0·001$.
†p refers to the proportion of participants assigned to the highest consumption category.

level category. Marked differences were observed for sugared beverages (17·5 (SE 0·4) times/week in the low category *v.* 11·4 (SE 0·2) times/week in the high category), snacks/desserts (9·3 (SE 0·2) times/week in the low category *v.* 6·9 (SE 0·1) times/week in the high category) and fruits with sugar and nuts (4·7 (SE 0·2) times/week in the low category *v.* 2·5 (SE 0·1) times/week in the high category). Odds ratio results show that participants in the low and medium parental education level categories had higher odds of more frequently consuming fried potatoes, fruits with sugar and nuts, fried meat and fish, sugared beverages and snacks/desserts ($P < 0·001$). Participants in the low parental education category had also higher odds of more frequently consuming fast food and chocolate/nut-based spread ($P < 0·001$). The largest odds ratio differences were found in the low category (reference category: high) for fruits with sugar and nuts (OR = 2·23; 95 % CI 1·92, 2·59), fried potatoes (OR = 2·00; 95 % CI 1·72, 2·31) and sugared beverages (OR = 2·01; 95 % CI 1·77, 2·37).

Tables 4 and 5 show the weekly consumption frequencies and odds ratio (95 % confidence intervals) for consumption of low-sugar and low-fat foods and high-sugar, refined and high-fat foods, respectively, by parental education level and by participating country. The largest differences by parental education category were observed in Hungary for sugared beverages (22·5 (SE 2·4) times/week in the low category *v.* 14·1 (SE 0·4) times/week in the high category) and for white bread (13·9 (SE 1·4) times/week in the low category *v.* 8·0 (SE 0·2) times/week in the high category); in Belgium for water (9·7 (SE 1·9) times/week in the low category *v.* 17·2 (SE 0·3) times/week in the high category); and in Cyprus for snacks/desserts (11·0 (SE 4·0) times/week in the low category *v.* 6·1 (SE 0·2) times/week in the high category).

In the Hungarian sample, consumption frequencies for the pasta/noodles/rice and wholemeal bread categories followed the opposite trend to that in the whole sample, i.e. higher means in the low parental education level group. Similarly, in the Belgian sample, consumption of chocolate/nut-based spread followed an inverse direction compared with the whole group, i.e. higher frequency in the Belgian high parental education level group.

The largest odds ratio differences for intake of each food item among education level groups were observed in Germany (fruits, fried meat and fish, fast food), Belgium (vegetables, fresh meat and fish, white bread,

Table 3 Weekly consumption frequency (means and their standard errors), prevalence of high consumption, and odds ratios (95 % confidence intervals) for intake of high-sugar, refined and high-fat foods by classified parental education level; children (*n* 14 426) aged 2 to 9 years from eight European countries, baseline survey of IDEFICS study, September 2007 to May 2008

Food group/Parental education	*n*	Mean	SE	P†	OR	95 % CI
Fried potatoes						
Low	1035	1·6[a,b]	0·06	47	2·00***	1·72, 2·31
Medium	6618	1·2[a,c]	0·02	41	1·34***	1·24, 1·45
High	5674	0·9[b,c]	0·02	33		
Fruits with sugar and nuts						
Low	1045	4·7[a,b]	0·15	46	2·23***	1·92, 2·59
Medium	6691	3·2[a,c]	0·06	35	1·23***	1·14, 1·33
High	5742	2·5[b,c]	0·06	36		
Fried meat and fish						
Low	1048	3·9[a,b]	0·09	48	1·36***	1·17, 1·58
Medium	6683	3·4[a,c]	0·04	42	1·10*	1·01, 1·20
High	5717	3·0[b,c]	0·04	41		
Cold cuts						
Low	1025	4·4[a,b]	0·12	36	1·18*	1·00, 1·39
Medium	6574	4·0[a]	0·05	32	1·00	0·92, 1·08
High	5638	3·9[b]	0·05	36		
Fast food						
Low	1015	2·4[a,b]	0·09	30	1·55***	1·30, 1·85
Medium	6622	1·8[a]	0·03	25	0·99	0·89, 1·10
High	5700	1·8[b]	0·04	25		
White bread						
Low	1030	7·8[a,b]	0·19	40	1·14	0·99, 1·33
Medium	6609	7·1[a,c]	0·08	36	1·09*	1·01, 1·18
High	5662	6·6[b,c]	0·09	37		
Sugared beverages‡						
Low	1049	17·5[a,b]	0·35	47	2·01***	1·77, 2·37
Medium	6710	13·5[a,c]	0·14	37	1·27***	1·17, 1·38
High	5744	11·4[b,c]	0·15	33		
Snacks and desserts						
Low	1043	9·3[a,b]	0·21	43	1·61***	1·39, 1·87
Medium	6686	7·6[a,c]	0·08	37	1·22***	1·12, 1·32
High	5738	6·9[b,c]	0·09	39		
Chocolate- or nut-based spread						
Low	1017	2·5[a,b]	0·08	32	1·39***	1·17, 1·66
Medium	6551	1·9[a,c]	0·03	31	1·08	0·96, 1·20
High	5664	1·7[b,c]	0·04	27		

Reference group: high education.
Analysis of covariance model adjusted for gender, age and BMI category. Two-sided level of significance ($P < 0·05$): [a]significant difference between low and medium; [b]significant difference between low and high; [c]significant difference between medium and high.
OR and 95 % CI determined by logistic regression models. Variables included in the models were parental education, gender, age and BMI category. Two-sided level of significance: *$P < 0.05$, ***$P < 0.001$.
†p refers to the proportion of participants assigned to the highest consumption category.
‡Includes soft drinks, fruit juices and sugared milk.

wholemeal bread, water, plain unsweetened milk), Sweden (fried potatoes, chocolate/nut-based spread), Hungary (white bread, snacks/desserts), Spain (fruits with sugar and nuts) and Italy (sugared beverages, pasta/noodles/rice). As an exception, Hungarian and Swedish participants in the low parental education group had higher odds of more frequently consuming pasta/noodles/rice, wholemeal bread (Hungarian) and plain unsweetened milk (Swedish).

Discussion

The present study addressed the relationship between parental education level and the consumption frequency of obesity-related foods in their children. Our findings confirm such an association for a number of the investigated food groups. The intakes of vegetables, fruits, pasta/noodles/rice, wholemeal bread and water increased as education level increased; while intakes of fried potatoes, fruits with sugar and nuts, fried meat and fish, fast food, sugared beverages, snacks/desserts and chocolate/nut-based spread increased as educational level decreased. These trends were observed for the total sample and for most of the participating countries. It is noteworthy to mention that the magnitude of educational differences varied across the selected countries and that some of the observed country-specific differences might reflect cultural food specificities. Country-specific cultural norms on what is considered to be 'healthy eating' and gastronomic heritage may have a major impact on education-related disparities in food habits[25]. For instance, pasta frequency of consumption in Italy was higher in the high parental education group, possibly reflecting the paramount

Table 4a Weekly consumption frequency (means and their standard errors), prevalence of high consumption, and odds ratios (95 % confidence intervals) for intake of low-sugar and low-fat foods by classified parental education level and country; children (*n* 14 426) aged 2 to 9 years from eight European countries, baseline survey of IDEFICS study, September 2007 to May 2008

	Belgium					Estonia					Germany					Sweden				
Food group/Parental education	Mean	SE	p†	OR	95 % CI	Mean	SE	p†	OR	95 % CI	Mean	SE	p†	OR	95 % CI	Mean	SE	p†	OR	95 % CI
Vegetables (raw and cooked)																				
Low	7·2	0·42	19	0·26***	0·11, 0·60	7·1	1·10	27	0·52	0·19, 1·41	8·4[a,b]	0·32	34	0·32***	0·23, 0·46	13·6	2·61	44	1·58	0·58, 4·34
Medium	7·7	0·16	41	0·82	0·66, 1·00	8·8	0·17	36	0·75	0·56, 1·00	10·4[a]	0·20	52	0·80	0·63, 1·02	11·6	0·35	31	0·93	0·73, 1·17
High	7·9	0·11	46			9·6	0·42	44			11·1[b]	0·33	57			12·0	0·19	33		
Fruits																				
Low	5·4	0·61	9	0·48	0·14, 1·61	7·0	1·44	46	0·85	0·31, 2·33	7·1[a,b]	0·36	20	0·42***	0·30, 0·59	11·6	2·11	50	1·89	0·69, 5·16
Medium	5·4[c]	0·18	10	0·55***	0·39, 0·76	7·6	0·17	52	0·72*	0·52, 0·99	8·4[a,c]	0·18	29	0·63***	0·49, 0·82	9·3	0·28	36	1·03	0·82, 1·29
High	7·0[c]	0·15	17			8·3	0·39	58			9·6[b,c]	0·31	39			9·3	0·17	36		
Fresh meat and fish																				
Low	3·1	0·61	38	2·03*	1·02, 4·05	3·8	0·81	33	1·10	0·41, 2·90	4·0[a,b]	0·23	46	1·94***	1·41, 2·66	3·0	0·44	31	0·65	0·22, 1·88
Medium	2·6[c]	0·12	34	1·60***	1·29, 2·03	4·2	0·09	37	1·09	0·81, 1·48	3·0[a,c]	0·09	35	1·25	0·96, 1·62	2·8	0·15	35	0·75*	0·60, 0·94
High	2·0[c]	0·08	24			4·2	0·19	35			2·4[b,c]	0·12	29			2·8	0·06	42		
Pasta, noodles and rice																				
Low	1·8	0·15	3	0·26	0·03, 1·99	3·0	0·51	27	0·64	0·24, 1·73	3·2	0·20	27	0·94	0·67, 1·32	3·5	0·48	6	0·57	0·07, 4·40
Medium	1·8[c]	0·05	5	0·62*	0·40, 0·97	2·8[c]	0·06	25	0·57***	0·42, 0·78	2·9	0·07	30	0·99	0·76, 1·29	4·1	0·12	10	0·90	0·63, 1·29
High	2·1[c]	0·04	8			3·2[c]	0·14	37			2·9	0·09	30			4·2	0·06	11		
Wholemeal bread																				
Low	1·6[a,b]	0·48	8	0·15*	0·05, 0·50	3·7	0·84	35	0·66	0·25, 1·76	4·6[b]	0·29	29	0·56***	0·40, 0·76	4·9	1·22	25	0·81	0·26, 2·56
Medium	3·7[a,c]	0·18	24	0·53***	0·42, 0·67	5·5	0·15	42	0·88	0·66, 1·18	5·2	0·15	37	0·79	0·62, 1·02	4·6	0·19	26	0·86	0·67, 1·10
High	5·4[b,c]	0·15	38			6·3	0·37	45			5·9[b]	0·27	43			4·8	0·12	29		
Water																				
Low	9·7[a,b]	1·87	19	0·14***	0·07, 0·29	21·3	2·36	59	1·18	0·43, 3·25	18·0	0·69	45	0·94	0·68, 1·31	21·1	2·81	56	1·28	0·40, 4·07
Medium	14·3[a,c]	0·45	24	0·46***	0·37, 0·58	18·3	0·29	34	1·08	0·79, 1·48	18·5	0·37	44	1·00	0·77, 1·30	18·4[c]	0·46	34	1·22	0·96, 1·56
High	17·2[b,c]	0·30	25			17·8	0·71	35			17·9	0·60	38			16·6[c]	0·28	24		
Plain unsweetened milk																				
Low	4·0[b]	0·58	5	0·16*	0·04, 0·67	13·2	1·97	50	1·29	0·53, 3·16	7·8	0·40	26	1·06	0·74, 1·50	14·7	2·16	38	3·20*	1·12, 9·10
Medium	5·3[c]	0·26	18	0·60***	0·46, 0·78	10·7	0·22	43	0·98	0·74, 1·33	8·2	0·20	30	1·25	0·95, 1·65	11·4	0·37	21	1·27	0·96, 1·67
High	6·7[b,c]	0·20	27			10·2	0·51	43			7·6	0·30	25			10·6	0·22	17		

Reference group: high education.
Analysis of covariance model adjusted for gender, age and BMI category. Two-sided level of significance ($P < 0·05$): [a]significant difference between low and medium; [b]significant difference between low and high; [c]significant difference between medium and high.
OR and 95 % CI determined by logistic regression models. Variables included in the models were parental education, gender, age and BMI category. Two-sided level of significance: *$P < 0·05$, ***$P < 0·001$.
†p refers to the proportion of participants assigned to the highest consumption category.

Table 4b Weekly consumption frequency (means and their standard errors), prevalence of high consumption, and odds ratios (95 % confidence intervals) for intake of low-sugar and low-fat foods by classified parental education level and country; children (*n* 14 426) aged 2 to 9 years from eight European countries, baseline survey of IDEFICS study, September 2007 to May 2008

	Cyprus					Hungary					Italy					Spain				
Food group/Parental education	Mean	SE	p†	OR	95 % CI	Mean	SE	p†	OR	95 % CI	Mean	SE	p†	OR	95 % CI	Mean	SE	p†	OR	95 % CI
Vegetables (raw and cooked)																				
Low	8·7	1·85	21	0·39*	0·15, 0·96	8·2	0·76	33	1·02	0·57, 1·82	5·5	0·25	33	0·91	0·68, 1·22	7·4	0·74	32	1·07	0·70, 1·63
Medium	7·3	0·30	30	0·62***	0·49, 0·78	7·9[c]	0·16	26	0·71***	0·59, 0·85	5·5	0·15	33	0·92	0·72, 1·17	7·1	0·29	31	1·06	0·81, 1·39
High	8·1	0·23	41			9·0[c]	0·19	34			5·4	0·24	35			7·3	0·21	31		
Fruits																				
Low	8·9	1·86	26	0·61	0·25, 1·47	5·7	0·81	15	0·71	0·32, 1·54	6·4	0·32	21	0·63*	0·46, 0·88	8·9	0·58	39	1·09	0·73, 1·65
Medium	9·0	0·33	33	0·85	0·67, 1·08	6·4	0·15	20	1·01	0·82, 1·24	6·9	0·16	26	0·84	0·65, 1·09	8·1	0·32	29	0·73	0·55, 0·95
High	9·5	0·24	37			6·7	0·15	20			7·4	0·30	29			9·0	0·23	36		
Fresh meat and fish																				
Low	3·1	0·61	14	0·56	0·19, 1·63	3·8	0·52	33	1·07	0·60, 1·90	4·7	0·18	35	0·89	0·67, 1·19	3·9	0·29	29	0·88	0·57, 1·36
Medium	2·6[c]	0·12	24	1·10	0·85, 1·43	3·0[c]	0·09	31	0·98	0·82, 1·18	4·8	0·09	36	0·91	0·72, 1·15	4·4	0·17	31	1·03	0·78, 1·35
High	2·0[c]	0·08	23			2·7[c]	0·07	32			4·6	0·13	38			4·2	0·12	31		
Pasta, noodles and rice																				
Low	3·8	1·27	30	1·20	0·51, 2·80	2·8[b]	0·32	20	2·70*	1·34, 5·45	3·5[a,b]	0·19	31	0·39***	0·29, 0·52	3·0	0·18	29	0·93	0·60, 1·43
Medium	2·7	0·14	24	0·80	0·61, 1·04	2·4[c]	0·06	16	1·91***	1·46, 2·49	4·3[a,c]	0·10	39	0·58***	0·46, 0·73	2·9	0·08	30	0·89	0·68, 1.17
High	2·9	0·10	28			2·0[b,c]	0·04	9			5·6[b,c]	0·19	53			3·0	0·07	32		
Wholemeal bread																				
Low	1·6[a,b]	0·48	53	1·87	0·75, 4·69	4·8[a,b]	0·98	44	1·82*	1·04, 3·19	2·1	0·21	31	0·87	0·64, 1·18	0·6	0·28	9	0·40*	0·21, 0·78
Medium	3·7[a,c]	0·18	31	0·78*	0·60, 0·99	3·2[a]	0·15	28	0·88	0·73, 1·06	1·8	0·11	31	0·91	0·71, 1·16	0·7	0·12	15	0·71*	0·51, 0·99
High	5·4[b,c]	0·15	37			3·1[b]	0·12	31			2·0	0·19	33			0·9	0·10	20		
Water																				
Low	9·7[a,b]	1·87	64	0·51	0·23, 1·13	19·0	1·72	49	0·72	0·40, 1·28	23·4[a,b]	0·49	67	0·49***	0·36, 0·68	27·2	0·64	84	1·07	0·63, 1·84
Medium	14·3[a,c]	0·45	75	0·84	0·64, 1·09	18·8[c]	0·33	44	0·65***	0·54, 0·78	26·1[a]	0·22	78	0·83	0·63, 1·10	27·7	0·31	85	1·26	0·89, 1·77
High	17·2[b,c]	0·30	78			21·5[c]	0·33	52			26·9[b]	0·34	80			27·5	0·22	82		
Plain unsweetened milk																				
Low	4·0[b]	0·58	23	1·66	0·64, 4·30	6·7	1·18	39	0·93	0·52, 1·65	3·8[b]	0·29	32	0·51***	0·37, 0·68	4·3	0·67	32	1·02	0·68, 1·60
Medium	5·3[c]	0·26	19	1·16	0·86, 1·57	5·3	0·18	39	0·99	0·83, 1·18	4·6	0·17	41	0·75*	0·59, 0·95	4·9	0·36	37	1·22	0·93, 1·60
High	6·7[b,c]	0·20	17			4·9	0·17	39			5·2[b]	0·33	48			4·0	0·23	33		

Reference group: high education.
Analysis of covariance model adjusted for gender, age and BMI category. Two-sided level of significance ($P<0·05$): [a]significant difference between low and medium; [b]significant difference between low and high; [c]significant difference between medium and high.
OR and 95 % CI determined by logistic regression models. Variables included in the models were parental education, gender, age and BMI category. Two-sided level of significance: *$P<0·05$, ***$P<0·001$.
†p refers to the proportion of participants assigned to the highest consumption category.

Table 5a Weekly consumption frequency (means and their standard errors), prevalence of high consumption, and odds ratios (95 % confidence intervals) for intake of high-sugar, refined and high-fat foods by classified parental education and country; children (*n* 14 426) aged 2 to 9 years from eight European countries, baseline survey of IDEFICS study, September 2007 to May 2008

	Belgium					Estonia					Germany					Sweden				
Food group/Parental education	Mean	SE	p†	OR	95 % CI	Mean	SE	p†	OR	95 % CI	Mean	SE	p†	OR	95 % CI	Mean	SE	p†	OR	95 % CI
Fried potatoes																				
Low	1·2	0·17	58	1·25	0·63, 2·47	1·4	0·42	50	0·94	0·38, 2·36	1·5^{a,b}	0·15	48	2·23***	1·62, 3·06	1·0	0·26	50	3·45*	1·26, 9·39
Medium	1·3^{c}	0·06	57	1·25*	1·01, 1·55	1·5	0·06	52	1·29	0·96, 1·72	0·9^{a}	0·05	33	1·17	0·90, 1·53	0·5	0·05	21	0·99	0·76, 1·30
High	1·1^{c}	0·04	51			1·2	0·11	46			0·6^{b}	0·06	29			0·5	0·03	21		
Fruits with sugar and nuts																				
Low	1·7	0·45	38	0·78	0·39, 1·55	5·5	1·49	36	1·22	0·48, 3·12	4·2^{a,b}	0·31	37	3·10***	2·20, 4·78	3·1	0·81	69	3·00*	1·02, 8·84
Medium	2·1^{c}	0·13	51	1·36*	1·10, 1·67	5·0	0·15	33	1·10	0·80, 1·50	2·5^{a}	0·14	22	1·47*	1·09, 1·97	2·1	0·15	47	1·14	0·92, 1·41
High	1·6^{c}	0·09	44			4·5	0·36	31			2·1^{b}	0·21	16			1·7	0·09	44		
Fried meat and fish																				
Low	5·2	0·39	43	1·44	0·73, 2·81	2·3	0·60	32	0·81	0·31, 2·12	3·9^{b}	0·20	54	2·07***	1·43, 2·99	5·3	0·39	56	1·99	0·73, 5·45
Medium	4·5	0·12	33	0·97	0·78, 1·21	3·0^{c}	0·09	42	1·46*	1·07, 1·99	3·5	0·08	52	1·58*	1·16, 2·16	4·4	0·13	37	0·96	0·77, 1·21
High	4·5	0·08	33			2·4^{c}	0·15	33			3·2^{b}	0·12	50			4·2	0·06	38		
Cold cuts																				
Low	5·3	0·63	36	1·32	0·66, 2·67	7·5^{a,b}	1·51	38	1·94	0·74, 5·09	6·0	0·27	38	0·90	0·66, 1·23	3·6	0·92	38	1·84	0·65, 5·17
Medium	4·4	0·14	27	0·84	0·66, 1·05	4·3^{a}	0·11	23	0·93	0·66, 1·32	6·6	0·13	43	1·11	0·87, 1·41	2·5	0·15	26	1·11	0·87, 1·43
High	4·5	0·10	30			4·1^{b}	0·24	23			5·7	0·21	41			2·2	0·10	23		
Fast food																				
Low	0·5^{b}	0·30	11	3·77*	1·24, 11·5	3·8	0·90	32	0·77	0·29, 2·04	1·0^{a,b}	0·15	22	4·64***	2·77, 7·78	0·6	0·24	31	1·07	0·37, 3·13
Medium	0·2^{c}	0·04	8	2·51***	1·56, 4·03	4·5	0·11	29	0·78	0·57, 1·07	0·3^{a}	0·03	9	1·52	0·93, 2·47	0·6	0·05	29	0·73	0·73, 1·18
High	0·1^{b,c}	0·02	3			5·0	0·28	35			0·2^{b}	0·05	6			0·6	0·02	31		
White bread																				
Low	7·3^{b}	0·78	56	3·01*	1·53, 5·92	9·4	1·67	36	2·08	0·79, 5·44	8·0^{a,b}	0·35	53	1·92***	1·34, 2·76	3·8	0·87	31	0·79	0·27, 2·34
Medium	5·8^{c}	0·21	43	1·80***	1·45, 2·24	6·8	0·17	23	1·24	0·86, 1·80	6·0^{a}	0·16	42	0·96	0·70, 1·31	3·9^{c}	0·20	42	1·25	0·99, 1·56
High	4·3^{b,c}	0·14	29			6·5	0·40	19			6·2^{b}	0·27	46			3·3^{c}	0·09	37		
Sugared beverages‡																				
Low	15·3^{b}	2·28	34	1·45	0·73, 2·90	12·1	2·11	18	0·47	0·15, 1·48	22·2^{a,b}	0·93	46	2·10***	1·52, 2·90	7·2	1·26	44	1·51	0·55, 4·18
Medium	14·7^{c}	0·50	38	1·77***	1·42, 2·20	12·8	0·27	34	1·20	0·82, 1·53	16·2^{a}	0·44	34	1·14	0·87, 1·49	5·7	0·28	36	1·17	0·93, 1·47
High	10·9^{b,c}	0·29	26			12·7	0·63	32			14·3^{b}	0·65	31			5·1	0·14	32		
Snacks and desserts																				
Low	8·3	0·91	32	0·89	0·44, 1·80	9·6	1·74	48	1·96	0·78, 4·95	10·7^{a,b}	0·49	41	1·34	0·98, 1·86	5·0	0·86	56	0·84	0·27, 2·65
Medium	8·7	0·28	31	0·87	0·70, 1·09	7·9	0·20	33	1·04	0·76, 1·42	9·6^{a}	0·20	36	0·96	0·74, 1·24	5·0	0·16	51	0·88	0·69, 1·12
High	9·3	0·20	35			7·5	0·40	33			9·1^{b}	0·27	36			5·3	0·08	56		
Chocolate- or nut-based spread																				
Low	3·0^{b}	0·36	16	0·43	0·18, 1,06	2·1^{a,b}	0·68	43	4·26*	1·56, 11·6	3·7^{a,b}	0·26	41	1·46*	1·06, 2·00	0·3	0·17	12	6·94*	1·41, 34·2
Medium	3·9^{c}	0·13	26	0·79*	0·62, 0·99	0·9^{a,c}	0·05	25	2·41***	1·56, 3·71	2·8^{a}	0·09	33	1·01	0·78, 1·30	0·1	0·02	4	1·32	0·73, 2·40
High	4·4^{b,c}	0·10	29			0·3^{b,c}	0·06	12			2·8^{b}	0·17	33			0·1	0·02	3		

Reference group: high education.
Analysis of covariance model adjusted for gender, age and BMI category. Two-sided level of significance ($P<0·05$): [a]significant difference between low and medium; [b]significant difference between low and high; [c]significant difference between medium and high.
OR and 95 % CI determined by logistic regression models. Variables included in the models were parental education, gender, age and BMI category. Two-sided level of significance: *$P<0.05$, ***$P<0.001$.
†p refers to the proportion of participants assigned to the highest consumption category.
‡Includes soft drinks, fruit juices and sugared milk.

Table 5b Weekly consumption frequency (means and their standard errors), prevalence of high consumption, and odds ratios (95 % confidence intervals) for intake of high-sugar, refined and high-fat foods by classified parental education and country; children (*n* 14 426) aged 2 to 9 years from eight European countries, baseline survey of IDEFICS study, September 2007 to May 2008

	Cyprus					Hungary					Italy					Spain				
Food group/Parental education	Mean	SE	p†	OR	95 % CI	Mean	SE	p†	OR	95 % CI	Mean	SE	p†	OR	95 % CI	Mean	SE	p†	OR	95 % CI
Fried potatoes																				
Low	3·6^{a,b}	1·12	24	3·21*	1·22, 8·49	1·8^{b}	0·29	62	2·85***	1·60, 5·05	1·2^{a,b}	0·10	42	1·39*	1·04, 1·84	1·5 ^{b}	0·15	60	1·69*	1·13, 2·53
Medium	2·1^{a,c}	0·13	14	1·69***	1·20, 2·39	1·4^{c}	0·05	54	1·99***	1·68, 2·37	0·8^{a}	0·04	33	0·94	0·74, 1·19	1·3	0·08	52	1·21	0·94, 1·55
High	1·5^{b,c}	0·08	9			0·8^{b,c}	0·04	37			0·7^{b}	0·06	34			1·1^{b}	0·05	47		
Fruits with sugar and nuts																				
Low	5·7	2·15	43	1·63	0·77, 3·43	6·3^{a,b}	1·07	46	2·72***	1·56, 4·74	4·7^{a,b}	0·28	45	3·14***	2·30, 4·29	4·4 ^{a,b}	0·44	46	3·24***	2·15, 4·89
Medium	4·5	0·27	36	1·23	0·97, 1·56	3·3^{a,c}	0·14	30	1·41***	1·17, 1·71	3·2^{a,c}	0·14	31	1·73***	1·32, 2·27	3·2 ^{a,c}	0·22	30	1·60***	1·20, 2·12
High	3·8	0·19	31			2·4^{b,c}	0·11	23			2·0^{b,c}	0·17	21			2·1 ^{b,c}	0·11	21		
Fried meat and fish																				
Low	3·2^{b}	1·98	13	1·46	0·70, 3·05	3·7^{b}	0·46	44	1·57	0·90, 2·72	2·8^{a,b}	0·15	36	1·58*	1·18, 2·13	5·3^{a,b}	0·42	39	1·43	0·95, 2·15
Medium	2·1^{c}	0·18	21	1·52***	1·21, 1·90	3·0	0·08	34	1·04	0·87, 1·24	2·4^{a,c}	0·07	34	1·40*	1·08, 1·80	4·0^{a}	0·15	32	1·05	0·81, 1·37
High	1·2^{b,c}	0·07	14			2·8^{b}	0·07	34			2·0^{b,c}	0·10	27			3·9^{b}	0·10	31		
Cold cuts																				
Low	3·5	0·72	48	1·49	0·69, 3·23	6·8^{a,b}	0·87	43	1·72	0·99, 3·02	2·9^{a,b}	0·15	28	1·75*	1·25, 2·46	3·9	0·40	19	0·90	0·55, 1·49
Medium	3·2	0·17	31	0·76*	0·60, 0·96	5·1^{a}	0·12	34	1·22*	1·02, 1·46	2·4^{a}	0·07	20	1·17	0·87, 1·58	3·8	0·15	20	0·91	0·67, 1.24
High	3·1	0·13	37			4·7^{b}	0·12	30			2·1^{b}	0·11	18			4·0	0·11	22		
Fast food																				
Low	5·3	1·15	44	1·53	0·70, 3·35	7·0^{a,b}	1·04	57	2·22*	1·26, 3·91	1·0^{a,b}	0·10	31	1·39*	1·01, 1·90	0·8	0·11	35	1·10	0·73, 1·68
Medium	4·1	0·19	29	0·78*	0·62, 0·99	3·6^{a}	0·11	36	0·95	0·80, 1·14	0·7^{a}	0·04	26	1·11	0·85, 1·45	0·8	0·07	29	0·90	0·68, 1·18
High	4·4	0·13	35			3·5^{b}	0·10	37			0·6^{b}	0·06	24			0·8	0·06	30		
White bread																				
Low	11·4	2·03	44	1·59	0·71, 3·56	13·9^{a,b}	1·36	59	2·89***	1·64, 5·10	6·8	0·30	23	0·88	0·64, 1·21	8·8	0·75	34	0·83	0·55, 1·27
Medium	8·9	0·34	34	1·01	0·80, 1·28	9·7^{a,c}	0·21	42	1·50***	1·26, 1·80	7·2	0·17	26	1·01	0·78, 1·32	7·2	0·36	34	0·81	0·62, 1·06
High	8·8	0·24	34			8·0^{b,c}	0·21	32			7·3	0·31	25			7·0	0·27	39		
Sugared beverages‡																				
Low	15·1	2·18	39	1·74	0·80, 3·77	22·5^{a,b}	2·38	44	2·07*	1·19, 3·60	16·0^{a,b}	0·59	45	2·74***	2·02, 3·71	18·2^{a,b}	1·26	55	2·38***	1·60, 3·54
Medium	13·8^{c}	0·54	34	1·20	0·94, 1·52	16·9^{a,c}	0·39	37	1·53***	1·28, 1·84	12·9^{a,c}	0·29	32	1·52*	1·16, 1·97	14·1^{a,c}	0·47	38	1·24	0·95, 1·60
High	11·8^{c}	0·35	29			14·1^{b,c}	0·37	28			11·2^{b,c}	0·48	23			12·2^{b,c}	0·27	33		
Snacks and desserts																				
Low	11·0^{a,b}	3·99	52	1·34	0·61, 2·95	9·2^{a,b}	0·84	56	3·45***	1·98, 6·03	11·5^{a,b}	0·51	43	2·28***	1·69, 3·08	6·3	0·48	34	1·26	0·83, 1·92
Medium	7·2^{a,c}	0·38	38	1·17	0·92, 1·50	6·4^{a,c}	0·18	38	1·65***	1·38, 1·98	9·3^{a}	0·25	33	1·44*	1·11, 1·85	5·9	0·28	37	1·44*	1·11, 1·88
High	6·1^{b,c}	0·18	38			4·6^{b,c}	0·13	27			8·1^{b}	0·38	25			5·2	0·17	29		
Chocolate- or nut-based spread																				
Low	1·6	0·41	55	3·92*	1·65, 9·32	3·2^{a,b}	0·48	78	4·88***	2·53, 9·42	3·0^{a,b}	0·20	26	1·39	0·99, 1·94	1·5	0·19	55	1·29	0·66, 2·52
Medium	1·2^{c}	0·13	34	1·62***	1·26, 2·09	1·8^{a,c}	0·08	53	1·52***	1·28, 1·81	2·3^{a}	0·08	23	1·20	0·90, 1·59	1·5	0·09	59	1·16	0·74, 1·79
High	0·7^{c}	0·06	24			1·3^{b,c}	0·06	43			1·9^{b}	0·13	20			1·5	0·06	59		

Reference group: high education.
Analysis of covariance model adjusted for gender, age and BMI category. Two-sided level of significance ($P < 0·05$): ^{a}significant difference between low and medium; ^{b}significant difference between low and high; ^{c}significant difference between medium and high.
OR and 95 % CI determined by logistic regression models. Variables included in the models were parental education, gender, age and BMI category. Two-sided level of significance: *$P < 0.05$, ***$P < 0.001$.
†p refers to the proportion of participants assigned to the highest consumption category.
‡Includes soft drinks, fruit juices and sugared milk.

importance of pasta in the traditional Italian gastronomy. The same applies to the case of chocolate in Belgium. Other examples, like bread consumption (e.g. wholemeal bread in the northern countries, white bread in the southern countries) and plain unsweetened milk (e.g. high consumption in Sweden and Estonia), seem also to be affected by traditional consumption.

Similarly to our findings, higher intakes of fruits and vegetables in children and adolescents with high SES have been reported in previous studies[26–30]. Some studies have observed that the impact of SES is particularly strong for healthy foods, such as vegetables and fruits[31]. These findings were reported in several countries with different cultural backgrounds, suggesting that fruit and vegetables are commonly considered as healthy. However, some other socio-economic differences in food intake have not been reported consistently (like for wholemeal bread, pasta, fish or fats), suggesting that these are more culturally dependent.

Previous studies have also focused on the socio-economic situation of parents, especially on maternal education, finding again positive associations between parental education and foods reducing the risk of obesity, like fruits and vegetables[29]. Education could provide an important socio-economic influence on health-related behaviour as it may increase the use of health-related information[32]. Although some other SES indicators, mainly occupational position and income, have been shown to have an impact on food intake[33–37], parental education level, especially maternal education level, has been strongly related to children's dietary habits[14,38,39] and to childhood overweight and obesity[13,40,41].

An important strength of the present study is its large sample size and international multicentric nature, which allowed us to investigate the research question in different cultural settings with a wider variety of food consumption patterns. Another important strength of the study is the strict standardized procedures followed during the data collection of the IDEFICS fieldwork[16,17] and the high quality control procedures carried out during the project, including plausibility checks implemented in the database and performed during data entry.

One of the major limitations of the study is the response rate. The whole survey programme involved complex logistics for participants and required the active involvement of parents, so that time constraints prevented some parents from participating. In addition, a selection bias cannot be ruled out as individuals without health problems or not having concerns about their children's health may be less motivated to take part in such a study. It is also known that participation is lower both in people with lower levels of education and in high-income groups[42]. As we have no systematic information about non-participants, the direction of a possible bias cannot be predicted.

A second limitation of the study design is the fact that the sample selected within the IDEFICS study was not necessarily representative for each specific country and the results obtained by the participating centres cannot be generalized to the whole countries.

Another limitation is related to the use of the frequency of consumption assessment tool, which is based on proxy reports. Proxy reporting might be strongly related to the number of meals under parental control. Subsequently, the accuracy of the consumption frequencies reported by parents could differ between countries, as the number of meals consumed at home did differ between the participating countries. Some previous studies suggest that over-reporting of foods reducing the risk of obesity mainly takes place among individuals with higher levels of education, due to their greater knowledge about healthy diet, and therefore might tend to overstate the actual consumption, the known social desirability bias[33,43]. Although FFQ are not designed to accurately capture intakes, results of food consumption frequencies derived from the food frequency section of the CEHQ-FFQ gave reproducible estimates of the consumption frequency in the IDEFICS children[21].

Conclusions

The present study showed a strong association of parental education level with the frequency of consumption of high-fat, high-sugar foods and products increasing the risk of obesity. These findings suggest that children of parents with a low educational level may be at higher risk of unhealthy eating. Therefore, the socio-economic determinants of food choice within families need to be addressed. It should be noted that the amount of differences, and not only the size of differences, in relation to disease outcome is of interest, and should be addressed in future research. The results of the present study should lead to more accurate targeting of intervention programmes for healthy eating promotion in childhood, in order to overcome social health inequalities. Special focus should be driven to undereducated parents and their children, in order to minimize this social health burden.

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Artículo III [Paper III]:

Country-specific dietary patterns and associations with socioeconomic status in European children: the IDEFICS study

Fernandez-Alvira, J. M., K. Bammann, V. Pala, V. Krogh, G. Barba, G. Eiben, A. Hebestreit, T. Veidebaum, L. Reisch, M. Tornaritis, E. Kovacs, I. Huybrechts and L. A. Moreno (2014)

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ORIGINAL ARTICLE

Country-specific dietary patterns and associations with socioeconomic status in European children: the IDEFICS study

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BACKGROUND/OBJECTIVES: Children from lower socioeconomic status (SES) may be at higher risk of unhealthy eating. We described country-specific dietary patterns among children aged 2–9 years from eight European countries participating in the IDEFICS study and assessed the association of dietary patterns with an additive SES indicator.

SUBJECTS/METHODS: Children aged 2–9 years from eight European countries were recruited in 2007–2008. Principal component analysis was applied to identify dietary country-specific patterns. Linear regression analyses were applied to assess their association with SES.

RESULTS: Two to four dietary patterns were identified in the participating regions. The existence of a 'processed' pattern was found in the eight regions. Also, a 'healthy' pattern was identified in seven of the eight regions. In addition, region-specific patterns were identified, reflecting the existing gastronomic and cultural differences in Europe. The 'processed' pattern was significantly inversely associated with the SES additive indicator in all countries except Sweden, whereas the 'healthy' pattern was positively associated with SES in the Belgian, Estonian, German and Hungarian regions, but was not significant in the Italian, Spanish and Swedish regions.

CONCLUSIONS: A 'processed' pattern and a 'healthy' pattern were found in most of the participating countries in the IDEFICS study, with comparable food item profiles. The results showed a strong inverse association of SES with the 'processed' pattern, suggesting that children of parents with lower SES may be at higher risk of unhealthy eating. Therefore, special focus should be given to parents and their children from lower SES levels when developing healthy eating promotion strategies.

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INTRODUCTION

Social inequalities in health are present from childhood until adult life; socioeconomic status (SES) differences in the risk of morbidity and mortality have been well documented.[1] The burden of disease is heavier among people living under low socioeconomic conditions compared with their better-off counterparts.[2] SES, operationalised through several indicators such as educational attainment, occupation or income, may also affect food consumption and diet quality.[3,4] Studies assessing the impact of parental SES on children's and adolescent's food intake suggest a lower consumption of fruits and vegetables and higher intake of energy-dense foods in individuals from lower SES groups compared with their better-off counterparts,[5–8] leading to a higher risk of developing overweight and obesity during childhood and preadolescence.[9] Therefore, it is of interest to assess the extent to which dietary patterns in school-aged children vary depending on SES.

Food consumption studies traditionally focused on individual foods or nutrients. However, due to the fact that diet is multidimensional and complex, other approaches have been developed in the past years, and research has shifted toward approaches focusing on dietary patterns.[10,11] The study of dietary patterns allows the assessment of many foods and their combinations in a simultaneous way. One of the most used statistical methods for this approach is principal component analysis (PCA).[12] PCA is a data-reduction method that can be used to identify linear combinations of food intakes accounting for the largest variation in diet between individuals, and has been shown to provide a more useful picture of diet in relation to health outcomes rather than individual foods and single nutrients.[13]

Although many studies have applied PCA to describe dietary patterns, the repeatability of the patterns between countries has been scarcely investigated.[14] Therefore, the present study aims first to describe country-specific dietary patterns (based on foods that are shown by consistent evidence to be related, either

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positively or negatively, to overweight and obesity in children) among children aged 2–9 years from eight European countries participating in the IDEFICS study; and second to assess the association of the dietary patterns with an additive SES indicator, comprising information about household income, parental occupation and parental education.

METHODS

Subjects and procedures

The 'Identification and prevention of Dietary- and lifestyle-induced health EFfects In Children and infantS' (IDEFICS) study is a prospective cohort study of children aged 2–9 years from eight European countries. The two main aims of the study were: (1) to investigate the aetiology of obesity and related disorders, and (2) to implement a community-based intervention to prevent obesity and related diseases. Children recruited during the cross-sectional baseline survey were considered for the present analysis. Between September 2007 and May 2008, 31 543 children from primary schools and pre-schools of selected regions in Italy (Avellino), Estonia (Tartumaa, Harjumaa), Cyprus (Nicosia District, Paphos), Belgium (East-Flanders), Sweden (Västra Götaland), Hungary (Baranya, Zala), Germany (Lower Saxony) and Spain (Aragón) were invited to participate in the baseline survey (T0) with a response rate of 53.4% ($n = 16\,864$). The lowest response rates were reached in Spain (41%) and Hungary (44%), and the highest in Italy (60%) and Sweden (66%). In all, 16 224 children fulfilled the study's inclusion criteria (complete information on age, gender, height and weight). Sample size ranged from 1507 in Spain to 2567 in Hungary. The present study only includes children with full information on the examined dietary information and socioeconomic variables, being the included sample of 12 462 children (50.9% boys, 49.1% girls). An in-depth description of the complete IDEFICS study population is given by Ahrens *et al.*[15] Further information on the study procedures is available in previous papers.[16,17] Each participating centre obtained ethical approval from their respective responsible authority. All children provided oral and their parents written informed consent for all examinations and the collection of samples, analysis and storage of personal data and collected samples.

Measurements

The parents filled in a self-administered questionnaire on parental attitudes, children's behaviour and social environment during the baseline survey. Three traditional SES indicators, namely, parental education, occupation and income, were assessed by self-report. Parental education level was categorised according to the International Standard Classification of Education (ISCED97).[18] Parental level of occupation position was assessed via 18 categories for each parent, and transformed into the five-classes version of the European Socioeconomic Classification.[19] Household income was assessed with nine country-specific categories based on the median equivalent income. The gained amount was equalised to the number of household members using the OECD square root scale.[20] All non-Euro currencies were transformed into Euros using the official currency rates of June 2008. For the purposes of the present analysis, an additive SES indicator constructed by Bammann *et al.*[21] was used. It comprises all three components, namely, equalised household income, parental education and occupational position. The additive SES indicator ranges from 3 (low SES) to 15 (high SES). In addition, migrant background was assessed. A migrant background was assumed if one or both of the parents were born in another country.

Dietary data were obtained by the food frequency section of the Children's Eating Habits Questionnaire-Food Frequency Questionnaire (CEHQ-FFQ)[22] in which the frequency of the child's consumption of selected food items during the preceding 4 weeks was reported. In order to assess meals under parental control, recall referred to meals outside the school canteen or childcare meal provision settings only.[22,23] The CEHQ-FFQ consisted of 43 food items clustered into 14 food groups. It was applied as a screening instrument to investigate the consumption of foods shown to be related, either positively or negatively, to overweight and obesity in children. The CEHQ-FFQ was not designed to provide an estimate of total energy intake or total food intake, but rather to investigate the consumption frequency of obesity-related foods.[23] Nevertheless, a previous study showed that it gives reproducible estimates of the consumption frequencies in the participating children.[23] Those foods less likely to be associated with obesity were not included. Response options displayed from left to right were as follows: 'Never/less than once a week', '1–3 times a week', '4–6 times a week', '1 time per day', '2 times per day', '3 times per day', '4 or more times per day' and 'I have no idea'. For the analysis, a conversion factor was used to transform the questionnaire answers into weekly consumption frequencies. When the proxy reported having 'no idea', the weekly consumption frequency could not be calculated and the data were not used in the analysis of the respective food item. Children with more than 50% of missing values were excluded from analyses. No information on portion sizes was obtained.

Analyses

Country-specific dietary patterns were identified by means of PCA. Owing to the different food-related cultural backgrounds and country-specific differences on food-intake frequencies,[5,24] we decided to explore the dietary patterns for each country separately. PCA was performed on the reported weekly frequencies of consumption of 43 food items. This technique produces new variables (principal components), which are independent linear combinations of dietary variables with maximum variance. One of the main concerns about the use of PCA to describe dietary patterns is the influence of subjective decisions taken during the analysis, for example, the number of factors to be extracted, the rotation method, labelling the components and so on.[25,26] To identify the number of components to be retained, two commonly applied criteria[11] were used: (a) the eigenvalue higher than 1 criterion and (b) the interpretability of dietary patterns. Rotation was carried out using varimax (orthogonal) rotation in order to put high loadings (correlations) on few variables and get a better interpretability of the factors. Food items with absolute factor loadings greater than 0.30 were considered to be important contributors to a pattern. A positive factor loading means that the dietary item is positively associated with the specific dietary pattern, whereas a negative factor loading reflects a negative association. Labels were assigned to the components on the basis of foods with higher loadings within the specific component to help in the presentation and discussion of the results.

Each of the retained components was regressed on the additive SES indicator to assess the impact of SES on the children's dietary patterns. The models were adjusted for gender, age and migrant background. All analyses were conducted using the predictive analytic software version 18.0 (SPSS, Chicago, IL, USA).

Table 1. Characteristics of the study sample: children ($n = 14\,233$) aged 2–9 years from eight European countries, baseline survey of Identification and prevention of Dietary- and lifestyle-induced health EFfects In Children and infantS (IDEFICS) study, September 2007 to May 2008

Mean age (s.d.) years	6.0 (1.8)
Girls, *n* (%)	6205 (49)
Overweight, *n* (%)[a]	1874 (13)
Obese, *n* (%)[a]	1011 (7)
Family socioeconomic status, n *(%)*[b]	
Low	1629 (13.9)
Medium	6288 (49.8)
High	4733 (37.4)
Country, n *(%)*	
Belgium	1749 (12)
Cyprus	1411 (10)
Estonia	1636 (11)
Germany	1898 (13)
Hungary	2368 (17)
Italy	2110 (15)
Spain	1421 (10)
Sweden	1729 (12)

[a]Overweight and obesity defined from body mass index *z*-scores in accordance with International Obesity Task Force criteria.[25] [b]Family additive socioeconomic status indicator classified into three categories (3–6, low; 7–11, medium; 12–15, high).

RESULTS

Table 1 shows the characteristics of the children. In all, 13% were classified as overweight and 7% as obese in accordance with International Obesity Task Force criteria.[27] After running PCA on the 43 food items, four dietary patterns in the Belgian and German samples, three dietary patterns in the Italian, Estonian, Hungarian and Spanish samples and two dietary patterns in the Cypriot and Swedish samples were identified (Tables 2a, b and c, and Appendix 1). The percentage of explained food intake variance ranged from 13.4% in Sweden to 26.7% in Germany.

Belgium

The first dietary pattern explained 9.4% of the variance and was called 'processed' due to the high loadings on pizza, hamburger, savoury pastries and crisps. The second pattern labelled as 'health-conscious' presented high loadings on fruits and vegetables and also for diet drinks and fruit juices. The third pattern having high loadings on water, whole-meal bread and fruits, and very low loadings on sweetened and diet drinks and white bread was labelled as 'healthy'. Finally, a fourth component with high loadings on cold cuts, fried meat and sweet products was labelled 'confectionary and meat'.

Cyprus

The first component, also labelled as 'processed', explained 13.5% of the variance and was mainly characterised by high loadings on pizza, crisps, savoury pastries, fried potatoes and ice cream. The second pattern presented high loadings on raw vegetables, hamburger, falafel, kebab, fresh fruits without sugar, plain unsweetened yoghurt, pasta and milled cereals. It was labelled as 'traditional' as it seems to reflect culture-specific dietary features.

Estonia

The first component was also labelled as 'processed' (high loadings on crisps, candy bars, savoury pastries, biscuits and

Table 2a. Country-specific components[a] and factor loadings[b] identified by principal component analysis

Country	*Component*	*Food group*	*Loading coefficient*	*Variance explained (%)*
Belgium ($n = 1749$)	Processed	Pizza as main dish	0.617	9.4
		Hamburger, hot dog, kebab, falafel	0.616	
		Savoury pastries, fritters	0.600	
		Crisps, corn crisps, popcorn	0.483	
		Ice cream, milk or fruit-based bars	0.411	
	Health-conscious	Raw vegetables	0.586	6.4
		Cooked vegetables, beans	0.543	
		Plain unsweetened yoghurt or kefir	0.514	
		Fresh fruits without added sugar	0.443	
		Fried potatoes, potato croquettes	0.407	
	Healthy	Whole-meal bread, dark roll	0.613	4.7
		Water	0.514	
		Fresh fruits without added sugar	0.382	
		Dish of milled cereals	0.345	
		Nuts, seeds, dried fruits	0.345	
	Confectionary and meat	Biscuits, cakes, pastries, puddings	0.570	4.1
		Candies, loose candies, marshmallows	0.544	
		Cold cuts, preserved meat products	0.519	
		Fried meat	0.502	
		Chocolate, candy bars	0.469	
Cyprus ($n = 1411$)	Processed	Savoury pastries, fritters	0.660	13.5
		Crisps, corn crisps, popcorn	0.633	
		Pizza as main dish	0.627	
		Ice cream, milk or fruit-based bars	0.592	
		Ketchup	0.579	
	Traditional	Hamburger, hot dog, kebab, falafel	0.572	6.2
		Fresh fruits without added sugar	0.535	
		Plain unsweetened yoghurt or kefir	0.495	
		Pasta, noodles, rice	0.461	
		Dish of milled cereals	0.460	
Estonia ($n = 1636$)	Processed	Chocolate, candy bars	0.481	10.0
		Biscuits, cakes, pastries, puddings	0.480	
		Savoury pastries, fritters	0.463	
		Ketchup	0.462	
		Chocolate or nut-based spread	0.424	
	Healthy	Cooked vegetables, beans	0.494	6.0
		Fresh fruits without added sugar	0.494	
		Fresh or frozen fish, not fried	0.464	
		Fresh meat, not fried	0.435	
		Fried or scrambled eggs	0.420	
	Sandwich products	Butter, margarine on bread	0.703	4.6
		White bread, white roll	0.696	
		Hamburger, hot dog, kebab, falafel	0.675	
		Whole-meal bread, dark roll	0.531	
		Cold cuts, preserved meat products	0.507	

[a]Dietary components from principal component analysis ordered by proportion of variance explained. [b]Food groups ordered by size of loading coefficient. Only the first five food groups are presented in the table.

Table 2b. Country-specific components[a] and factor loadings[b] identified by principal component analysis

Country	*Component*	*Food group*	*Loading coefficient*	*Variance explained (%)*
Germany ($n=1898$)	Processed	Fried or scrambled eggs	0.556	12.3
		Fresh meat, not fried	0.542	
		Fried meat	0.509	
		Pasta, noodles, rice	0.489	
		Savoury pastries, fritters	0.473	
	Confectionary	Biscuits, cakes, pastries, puddings	0.702	5.6
		Candies, loose candies, marshmallows	0.688	
		Chocolate, candy bars	0.632	
		Ketchup	0.508	
		Ice cream, milk or fruit-based bars	0.480	
	Migrant pattern	Plain unsweetened yoghurt or kefir	0.537	4.7
		Pizza as main dish	0.461	
		Fresh fruit with added sugar	0.460	
		Dish of milled cereals	0.419	
		Nuts, seeds, dried fruits	0.379	
	Healthy	Fresh fruits without added sugar	0.663	4.1
		Raw vegetables	0.617	
		Whole-meal bread, dark roll	0.485	
		Cooked vegetables, beans	0.463	
		Plain unsweetened milk	0.343	
Hungary ($n=2368$)	Processed	Crisps, corn crisps, popcorn	0.669	11.1
		Savoury pastries, fritters	0.521	
		Chocolate or nut-based spread	0.438	
		Chocolate, candy bars	0.431	
		Biscuits, cakes, pastries, puddings	0.424	
	Healthy	Fresh fruits without added sugar	0.572	6.0
		Plain unsweetened yoghurt or kefir	0.555	
		Raw vegetables	0.514	
		Fresh or frozen fish, not fried	0.464	
		Fried fish, fish fingers	0.439	
	Sandwich products	White bread, white roll	0.634	4.4
		Cold cuts, preserved meat products	0.622	
		Butter, margarine on bread	0.589	
		Reduced-fat products on bread	0.472	
		Hamburger, hot dog, kebab, falafel	0.448	

[a]Dietary components from principal component analysis ordered by proportion of variance explained. [b]Food groups ordered by size of loading coefficient. Only the first five food groups are presented in the table.

packaged cakes and sweetened drinks). The second pattern was labelled as 'healthy' due to the high loadings on fruits and vegetables, not fried fish and meat, and nuts, seed and dried fruits. Finally, a third component characterised by high loadings on cold cuts, butter, white bread, whole-meal bread and hamburger was denominated as 'sandwich products'.

Germany

The first component was characterised by high loadings on crisps and savoury pastries, fresh and fried meat, fresh and fried fish, fried and poached eggs and mayonnaise and was named 'processed'. The second pattern 'confectionary' was characterised by high loadings on sweet products (chocolate, candy bars, candies, marshmallows, biscuits and ice cream). The third pattern was named 'migrant pattern' as the highest loadings corresponded to plain yoghurt, fresh fruits, pizza, milled cereals showing also very low loading on cold cuts (mainly corresponding to pork meat) scoring this pattern especially high in the migrant German subsample (mean difference = −0.842 (−0.930, −0.755); *t*-test *P*-value < 0.001). Finally, a 'healthy' pattern characterised by high loadings on fruits and vegetables and whole-meal bread was retained.

Hungary

The first component 'processed' presented high loadings on crisps, savoury pastries, pizza, chocolate, candy bars and biscuits. The second pattern denominated as 'healthy', presented high loadings on plain unsweetened yoghurt, fruits and vegetables, fish and nuts. Finally, a third pattern was labelled as 'sandwich products' because of the high loadings on white bread, cold cuts, butter, reduced-fat products on bread and hamburgers.

Italy

The first component was also labelled as 'processed' because of the high loadings on crisps, savoury pastries, candy bars and sweetened drinks. The second component was called 'healthy' as it showed high loadings on fruits and vegetables and fish. Finally, a third component was found, mainly characterised by butter/margarine and reduced-fat products on bread, jam, honey and chocolate spread.

Spain

The first component was, similar to the rest of the countries, characterised by high loadings on 'processed' products such as crisps, savoury pastries, candies, ice cream and fried potatoes. The second component showed high loadings on cold cuts, fried meat, fruits and vegetables, and therefore was labelled as 'traditional'. Finally, the third component was denominated as 'healthy' due to the high loadings on fresh fish and meat, fruits and vegetables, whole-meal bread and plain unsweetened milk.

Sweden

The first component presented high loadings on fruit and vegetables, fresh fish and whole-meal bread, and therefore was labelled as 'healthy'. The second component showed high

Table 2c. Country-specific components[a] and factor loadings[b] identified by principal component analysis

Country	*Component*	*Food group*	*Loading coefficient*	*Variance explained (%)*
Italy	Processed	Crisps, corn crisps, popcorn	0.632	11.3
($n=2110$)		Ketchup	0.535	
		Chocolate, candy bars	0.533	
		Mayonnaise, mayonnaise-based products	0.532	
		Sweetened drinks	0.521	
	Healthy	Raw vegetables	0.634	4.9
		Cooked vegetables, beans	0.594	
		Fresh fruits without added sugar	0.489	
		Fresh or frozen fish, not fried	0.446	
		Fresh meat, not fried	0.388	
	Spreads	Reduced-fat products on bread	0.797	4.3
		Butter, margarine on bread	0.791	
		Jam, honey	0.549	
		Chocolate or nut-based spread	0.305	
Spain	Processed	Fried potatoes, potato croquettes	0.456	8.4
($n=1421$)		Mayonnaise, mayonnaise-based products	0.432	
		Ketchup	0.403	
		Diet drinks	0.378	
		Fried or scrambled eggs	0.318	
	Traditional	Cold cuts, preserved meat products	0.572	5.5
		Fried meat	0.534	
		Raw vegetables	0.490	
		Cooked vegetables, beans	0.465	
		Sweetened drinks	0.443	
	Healthy	Fresh or frozen fish, not fried	0.529	4.3
		Fresh meat, not fried	0.506	
		Cooked vegetables, beans	0.409	
		Raw vegetables	0.368	
Sweden	Healthy	Raw vegetables	0.639	7.0
($n=1729$)		Fresh fruits without added sugar	0.627	
		Whole-meal bread, dark roll	0.523	
		Fresh or frozen fish, not fried	0.503	
		Cooked vegetables, beans	0.485	
	Processed	Fried potatoes, potato croquettes	0.531	6.4
		Ice cream, milk or fruit-based bars	0.482	
		Hamburger, hot dog, kebab, falafel	0.446	
		Crisps, corn crisps, popcorn	0.421	
		Sweetened drinks	0.412	

[a]Dietary components from principal component analysis ordered by proportion of variance explained. [b]Food groups ordered by size of loading coefficient. Only the first five food groups are presented in the table.

loadings for fried potatoes, sweetened drinks, hamburgers, crisps, chocolate and candy bars and ice cream and was labelled as 'processed'.

Table 3 shows the regression coefficients (95% confidence intervals) and levels of significance for the associations between the country-specific retained dietary patterns and the additive SES indicator. These results show a significantly negative association between the additive SES indicator and the 'processed' food pattern in all countries, except from Sweden. Furthermore, a significantly positive association was found between the SES indicator and the 'healthy' food pattern for Belgium, Estonia, Germany and Hungary. In Hungary also, the sandwich products pattern was significantly negatively associated with the SES indicator, whereas in Germany the confectionary pattern and in Belgium the health-conscious pattern did.

DISCUSSION

This paper assessed the existence of country-specific empirically derived dietary patterns in eight different European regions. Using a standard approach, 2–4 dietary patterns were identified in the participating regions. The identified patterns explained 13.4–26.7% of the total variance in the frequency of consumption of 43 food items, a similar percentage compared with other studies applying factor analysis to a similar number of food frequency variables.[9,28,29]

Our findings show, for the eight investigated regions, the existence of a 'processed' pattern characterised by high intake of foods such as fried potatoes, fried fish fingers, hamburgers, hotdogs, crisps, savoury pastries, sweetened drinks, biscuits, ice cream or chocolates (explaining between 6.4 and 13.5% of the variance). Also, a 'healthy' pattern, characterised by high intake of foods such as raw and cooked vegetables, fruits, plain unsweetened milk, fish, whole-meal bread, nuts, seeds and dried fruits was identified in seven of the eight investigated regions (no healthy pattern in Cyprus). These two dietary patterns were consistent among the countries, suggesting the existence of common dietary practices in children throughout the different participating countries and a narrowing of differences in food choices of European countries.[14]

Several studies identified similar components, usually called 'prudent/healthier pattern' (comparable with our 'healthy' pattern)[30–32] and 'western/processed pattern' (comparable with our 'processed' pattern).[33,34] Nevertheless, the results also show country-specific differences in the common patterns (for example, processed pattern in Germany shows higher loadings for protein products compared with the processed pattern in the rest of the regions). Moreover, our results also describe country-specific dietary patterns, such as 'sandwich products' in the investigated

Table 3. Regression coefficients and standardised regression coefficients for additive socioeconomic status indicator[a]

	β	*Standardised* β	*95% CI for* β	t Statistic	P-*value*
Belgium					
Processed	−0.035	−0.100	−0.053, −0.018	−3.920	<0.001
Health-conscious	−0.030	−0.076	−0.051, −0.010	−2.946	0.003
Healthy	0.122	0.299	0.102. 0.141	12.102	<0.001
Confectionary and meat	0.017	0.041	−0.004, 0.038	1.584	0.113
Cyprus					
Processed	−0.056	−0.176	−0.078, −0.033	−4.789	<0.001
Traditional	−0.025	−0.059	−0.055, 0,006	−1.580	0.114
Estonia					
Processed	−0.037	−0.100	−0.056, −0.019	−4.004	<0.001
Healthy	0.035	0.093	0.017, 0.054	3.696	<0.001
Sandwich products	−0.008	−0.021	−0.026, 0,011	−0.820	0.412
Germany					
Processed	−0.036	−0.129	−0.050, −0.022	−4.905	<0.001
Confectionary	−0.021	−0.068	−0.036, −0.005	−2.546	0.011
Migrant pattern	−0.017	−0.057	−0.032, −0.003	−2.302	0.021
Healthy	0.056	0.180	0.040, 0.073	6.867	<0.001
Hungary					
Processed	−0.069	−0.215	−0.082, −0.055	−10.092	<0.001
Healthy	0.029	0.091	0.016, 0.043	4.196	<0.001
Sandwich products	−0.026	−0.082	-0.040, −0.012	−3.768	<0.001
Italy					
Processed	−0.063	−0.203	−0.077, −0.049	−8.696	<0.001
Healthy	0.006	0.018	−0.010, 0.022	0.755	0.450
Spreads	−0.010	−0.030	−0.025, 0.005	−1.268	0.205
Spain					
Processed	−0.045	−0.123	−0.065, −0.025	−4.357	<0.001
Traditional	−0.020	−0.053	−0.041, 0.001	−1.884	0.060
Healthy	0.001	0.002	−0.020, 0.021	0.071	0.943
Sweden					
Healthy	−0.007	−0.019	−0.026, 0.011	−0.777	0.437
Processed	−0.005	−0.013	−0.024, 0.013	−0.539	0.590

Models adjusted by: age, sex and migrant status. [a]Additive SES indicator includes parental education, parental occupation and household income information, ranging from 3 to 15.

Eastern European regions (from Estonia and Hungary) or 'traditional' in two of the Mediterranean regions (Cyprus and Spain). Although dietary patterns across Europe are becoming more homogeneous in the last decades, there are still large dietary differences between countries that may reflect the existing different cultural food habits and gastronomic heritage.[35,36]

The results pertaining to the second goal—to assess the association between dietary patterns and SES—revealed that the 'processed' pattern was significantly inversely associated with the SES additive indicator in all countries except Sweden (in the case of Sweden, the average amount of meals under parental control was lower compared with the rest of the countries). This finding is in line with previous reports in which more 'unhealthy' patterns, characterised by processed and snack products, have been related to lower SES.[29,30,32] The association of the 'healthy' pattern with SES was significantly positive in the Belgian, Estonian, German and Hungarian regions, but was not significant in the Italian, Spanish and Swedish regions. Previous studies found a positive association between SES and more 'healthy' patterns.[6,30,37] The lack of significant association between the 'healthy' pattern and SES in Italian and Spanish regions may be due to a lack of association of Mediterranean diet and SES gradient. The present results show, however, mixed (positive association or no association) results.

The use of more than one socioeconomic indicator is considered to be desirable.[38] For the present report, we used an additive indicator developed by Bammann *et al.*[21] comprising parental occupation, household income and parental education-related information. Although parental education has been shown as one of the most relevant SES indicators in relation with childhood obesity and lifestyles, the additive indicator showed stronger associations, positive or negative, with the identified dietary patterns compared with parental education level (data not shown) supporting the adequacy of using such an indicator.

One of the main limitations of this study is the response rate. The whole study involved complex logistics for participants and required the active participation of parents. Furthermore, a selection bias cannot be dismissed as individuals without health problems or parents without concerns about their children's health may be less motivated to take part in the study.[39] Unfortunately, the direction of the bias cannot be predicted, as we have no systematic information about non-participants. Social desirability bias may have affected also the dietary reports resulting in an overestimation of healthier food intake and underestimating unhealthier foods intake. Finally, the assessment of frequency of consumption relied on parental reports, and therefore the results may be strongly related to the number of meals under parental control. Previous studies suggest that over

reporting of healthier foods is more frequent in individuals with higher educational levels,[40] which might explain the positive association with SES for this dietary pattern. Furthermore, the study population comprised participants from eight European regions (not necessarily representative for the country), which reveals ecological differences in diet and makes generalisation difficult.

Among the strengths of the present study are the large sample size in an international multicentre design that allowed us to apply country-specific PCA in across-European setting. This is of special interest, as dietary patterns are likely to be strongly affected by culture. The analysis allowed us to find two main common components and several country-specific patterns. Other remarkable strengths are the strict standardised procedures followed during the data collection[14,15] and the high quality-control procedures, including plausibility checks implemented in the database and performed during data entry.

CONCLUSIONS

The present study applied country-specific PCA and identified a 'processed' pattern and a 'healthy' pattern in most of the participating countries in the IDEFICS study, with comparable food item profiles. In addition, region-specific patterns were identified, reflecting the existing gastronomic and cultural differences in Europe. The results showed a strong inverse association of SES with the 'processed' pattern, suggesting that children of parents with lower SES are at higher risk of unhealthy eating. Moreover, previous literature also showed that children from lower SES populations present higher prevalence of overweight and obesity.[21] Therefore, special focus should be given to parents and their children from lower SES levels when developing school-based and community-based healthy eating promotion strategies in order to decrease childhood overweight inequalities.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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APPENDIX

Table A1. Components and factor loadings for Belgium

Food item	*PC1**	*PC2**	*PC3**	*PC4**
Cooked vegetables, beans	−0.140	**0.543**	0.165	0.241
fried potatoes, potato croquettes	**0.308**	**0.407**	−0.112	0.209
Raw vegetables	0.037	**0.586**	0.226	−0.011
Fresh fruits without added sugar	−0.076	**0.443**	**0.382**	0.051
Fresh fruits with added sugar	0.195	**0.416**	−0.081	0.065
Water	−0.103	0.031	**0.514**	0.040
Fruit juices	−0.027	**0.393**	−0.088	0.138
Sweetened drinks	0.087	0.133	**−0.467**	0.293
Diet drinks	0.107	**0.338**	**−0.317**	0.222
Breakfast cereals, muesli, sweetened	0.127	**0.306**	−0.135	0.000
Porridge, oat meal, gruel, cereals, muesli, unsweetened	0.118	0.248	−0.013	−0.197
Plain unsweetened milk	−0.133	0.071	**0.320**	0.017
Sweetened milk	−0.029	0.030	0.011	0.240
Plain unsweetened yoghurt or kefir	0.108	**0.514**	0.154	−0.029
Sweet yoghurt, fermented milk beverages	−0.071	0.244	0.186	0.278
Fresh or frozen fish, not fried	0.205	**0.388**	0.191	−0.103
Fried fish, fish fingers	**0.334**	0.174	0.250	0.139
Cold cuts, preserved, ready-to-cook meat products	0.053	0.186	−0.024	**0.519**
Fresh meat, not fried	0.196	**0.354**	−0.032	−0.078
Fried meat	−0.072	0.116	−0.066	**0.502**
Fried or scrambled eggs	**0.399**	0.247	0.062	0.063
Boiled or poached eggs	**0.407**	0.181	0.162	−0.041
Mayonnaise, mayonnaise-based products	**0.344**	0.130	−0.176	**0.359**
Tofu, tempe, quorn, soy milk	0.069	−0.029	0.292	−0.045
Cheese	0.051	0.092	0.246	0.035
Jam, honey	0.047	0.037	**0.342**	0.110
Chocolate or nut-based spread	0.033	−0.113	0.174	**0.379**
Butter, margarine on bread	0.046	0.067	0.012	0.182
Reduced-fat products on bread	−0.082	−0.053	0.246	0.259
Ketchup	0.267	0.025	−0.100	**0.346**
White bread, white roll, white crispbread	−0.002	0.205	**−0.401**	0.244
Whole-meal bread, dark roll, dark crisp bread	−0.106	−0.053	**0.613**	0.120
Pasta, noodles, rice	**0.402**	0.111	0.225	−0.031
Dish of milled cereals	0.281	0.176	**0.368**	−0.065
Pizza as main dish	**0.617**	−0.110	−0.079	0.018
Hamburger, hot dog, kebab, wrap, falafel	**0.616**	−0.036	−0.078	0.038
Nuts, seeds, dried fruits	0.293	0.166	**0.345**	−0.054
Crisps, corn crisps, popcorn	**0.483**	0.036	−0.252	0.228
Savoury pastries, fritters	**0.600**	0.132	0.030	0.092
Chocolate, candy bars	0.192	0.039	−0.102	**0.469**
Candies, loose candies, marshmallows	0.115	−0.115	−0.012	**0.544**
Biscuits, packaged cakes, pastries, puddings	0.102	−0.266	0.103	**0.570**
Ice cream, milk or fruit-based bars	**0.411**	0.123	−0.147	0.083

Bold entries in the appendix tables are 'factor loadings >0.30', which are considered important contributors to the patterns. *PC1: processed; PC2: health-conscious; PC3: healthy; PC4: confectionary and meat.

Table A2. Components and factor loadings for Cyprus

Food item	*PC1**	*PC2**
Cooked vegetables, beans	−0.088	0.237
fried potatoes, potato croquettes	**0.533**	−0.072
Raw vegetables	0.034	**0.458**
Fresh fruits without added sugar	0.001	**0.535**
Fresh fruits with added sugar	0.277	0.169
Water	−0.049	0.142
Fruit juices	0.201	**0.372**
Sweetened drinks	**0.390**	−0.011
Diet drinks	**0.337**	−0.041
Breakfast cereals, muesli, sweetened	**0.303**	0.202
Porridge, oat meal, gruel, cereals, muesli, unsweetened	0.029	0.246
Plain unsweetened milk	−0.001	0.274
Sweetened milk	0.209	0.042
Plain unsweetened yoghurt or kefir	0.135	**0.495**
Sweet yoghurt, fermented milk beverages	**0.481**	0.226
Fresh or frozen fish, not fried	−0.043	**0.444**
Fried fish, fish fingers	0.251	0.232
Cold cuts, preserved, ready-to-cook meat products	0.140	**0.374**
Fresh meat, not fried	0.159	**0.440**
Fried meat	**0.533**	0.234
Fried or scrambled eggs	**0.354**	**0.331**
Boiled or poached eggs	**0.342**	**0.365**
Mayonnaise, mayonnaise-based products	0.255	0.214
Tofu, tempe, quorn, soy milk	0.035	0.022
Cheese	0.075	**0.303**
Jam, honey	0.123	**0.392**
Chocolate or nut-based spread	**0.559**	−0.058
Butter, margarine on bread	0.231	**0.424**
Reduced-fat products on bread	0.038	0.279
Ketchup	**0.579**	0.051
White bread, white roll, white crispbread	0.227	0.272
Whole-meal bread, dark roll, dark crispbread	−0.074	**0.369**
Pasta, noodles, rice	0.106	**0.461**
Dish of milled cereals	0.067	**0.460**
Pizza as main dish	**0.627**	0.047
Hamburger, hot dog, kebab, wrap, falafel	0.171	**0.572**
Nuts, seeds, dried fruits	0.118	0.158
Crisps, corn crisps, popcorn	**0.633**	0.108
Savoury pastries, fritters	**0.660**	−0.053
Chocolate, candy bars	**0.517**	−0.015
Candies, loose candies, marshmallows	0.284	0.082
Biscuits, packaged cakes, pastries, puddings	**0.496**	0.098
Ice cream, milk or fruit-based bars	**0.592**	0.048

Bold entries in the appendix tables are 'factor loadings >0.30', which are considered important contributors to the patterns. *PC1: Processed; PC2: Traditional.

Table A3. Components and factor loadings for Estonia

Food item	*PC1**	*PC2**	*PC3**
Cooked vegetables, beans	−0.124	**0.494**	0.156
fried potatoes, potato croquettes	**0.350**	0.238	0.046
Raw vegetables	−0.165	**0.553**	0.180
Fresh fruits without added sugar	−0.061	**0.494**	0.213
Fresh fruits with added sugar	0.124	0.281	0.028
Water	−0.149	0.159	0.279
Fruit juices	0.079	**0.302**	0.042
Sweetened drinks	**0.420**	−0.072	0.058
Diet drinks	0.292	0.013	−0.005
Breakfast cereals, muesli, sweetened	0.216	0.072	0.081
Porridge, oat meal, gruel, cereals, muesli, unsweetened	−0.119	**0.301**	0.081
Plain unsweetened milk	−0.028	0.234	0.276
Sweetened milk	0.127	0.141	0.105
Plain unsweetened yoghurt or kefir	−0.033	**0.385**	−0.020
Sweet yoghurt, fermented milk beverages	0.163	**0.335**	0.031
Fresh or frozen fish, not fried	−0.024	**0.464**	−0.114
Fried fish, fish fingers	**0.378**	0.286	−0.042
Cold cuts, preserved, ready-to-cook meat products	0.257	−0.017	**0.507**
Fresh meat, not fried	0.010	**0.435**	0.147
Fried meat	**0.345**	**0.342**	−0.017
Fried or scrambled eggs	0.281	**0.420**	−0.021
Boiled or poached eggs	0.225	**0.337**	0.016
Mayonnaise, mayonnaise-based products	0.262	0.126	0.084
Tofu, tempe, quorn, soy milk	0.073	0.105	−0.038
Cheese	0.064	0.193	0.212
Jam, honey	0.070	**0.374**	0.118
Chocolate or nut-based spread	**0.424**	0.091	0.031
Butter, margarine on bread	0.089	−0.027	**0.703**
Reduced-fat products on bread	0.097	0.079	0.281
Ketchup	**0.462**	−0.003	0.039
White bread, white roll, white crispbread	0.251	−0.064	**0.696**
Whole-meal bread, dark roll, dark crispbread	−0.099	0.302	**0.531**
Pasta, noodles, rice	0.194	0.261	0.091
Dish of milled cereals	0.182	**0.372**	0.045
Pizza as main dish	**0.395**	0.069	−0.059
Hamburger, hot dog, kebab, wrap, falafel	0.099	0.016	**0.675**
Nuts, seeds, dried fruits	0.068	**0.418**	0.017
Crisps, corn crisps, popcorn	**0.635**	−0.050	−0.037
Savoury pastries, fritters	**0.463**	0.153	0.115
Chocolate, candy bars	**0.481**	−0.078	0.029
Candies, loose candies, marshmallows	**0.391**	−0.063	0.144
Biscuits, packaged cakes, pastries, puddings	**0.480**	0.012	0.077
Ice cream, milk or fruit-based bars	**0.393**	0.117	0.095

Bold entries in the appendix tables are 'factor loadings >0.30', which are considered important contributors to the patterns. *PC1: processed; PC2: healthy; PC3: sandwich products.

Table A4. Components and factor loadings for Germany

Food item	*PC1**	*PC2**	*PC3**	*PC4**
Cooked vegetables, beans	0.010	−0.109	−0.038	**0.436**
fried potatoes, potato croquettes	0.206	**0.401**	**0.370**	−0.246
Raw vegetables	−0.096	0.059	0.159	**0.617**
Fresh fruits without added sugar	−0.080	−0.001	0.181	**0.663**
Fresh fruits with added sugar	0.098	0.161	**0.460**	0.160
Water	−0.092	−0.119	0.299	0.293
Fruit juices	0.132	0.134	0.139	0.103
Sweetened drinks	0.227	**0.367**	−0.107	−0.178
Diet drinks	0.032	0.169	−0.262	0.094
Breakfast cereals, muesli, sweetened	−0.030	**0.464**	0.138	0.027
Porridge, oat meal, gruel, cereals, muesli, unsweetened	−0.038	0.137	0.295	0.059
Plain unsweetened milk	0.084	0.127	0.147	**0.343**
Sweetened milk	0.245	0.199	−0.075	0.133
Plain unsweetened yoghurt or kefir	0.139	0.035	**0.537**	0.227
Sweet yoghurt, fermented milk beverages	0.239	0.175	0.005	0.261
Fresh or frozen fish, not fried	**0.330**	−0.102	0.289	0.071
Fried fish, fish fingers	**0.455**	0.033	−0.004	−0.006
Cold cuts, preserved, ready-to-cook meat products	**0.381**	0.079	**−0.446**	0.210
Fresh meat, not fried	**0.542**	−0.053	0.158	0.155
Fried meat	**0.509**	0.060	−0.168	0.133
Fried or scrambled eggs	**0.556**	0.077	0.174	−0.009
Boiled or poached eggs	**0.456**	0.081	0.025	0.090
Mayonnaise, mayonnaise-based products	**0.514**	0.184	0.030	−0.043
Tofu, tempe, quorn, soy milk	0.218	−0.004	−0.029	−0.056
Cheese	0.124	−0.006	−0.077	0.221
Jam, honey	**0.308**	0.041	−0.045	0.290
Chocolate or nut-based spread	0.229	**0.426**	0.014	−0.045
Butter, margarine on bread	0.137	0.151	**−0.319**	0.227
Reduced-fat products on bread	0.036	0.111	−0.114	0.157
Ketchup	**0.317**	**0.508**	0.175	−0.081
White bread, white roll, white crispbread	**0.328**	**0.302**	−0.008	−0.056
Whole-meal bread, dark roll, dark crispbread	0.089	0.028	0.040	**0.485**
Pasta, noodles, rice	**0.489**	0.082	0.113	0.147
Dish of milled cereals	**0.283**	−0.027	**0.419**	0.211
Pizza as main dish	**0.318**	0.208	**0.461**	−0.072
Hamburger, hot dog, kebab, wrap, falafel	0.255	0.280	**0.312**	−0.235
Nuts, seeds, dried fruits	**0.399**	0.048	**0.379**	0.221
Crisps, corn crisps, popcorn	**0.444**	**0.319**	0.191	−0.072
Savoury pastries, fritters	**0.473**	**0.331**	0.193	−0.008
Chocolate, candy bars	−0.001	**0.632**	−0.097	0.095
Candies, loose candies, marshmallows	−0.062	**0.688**	−0.164	0.183
Biscuits, packaged cakes, pastries, puddings	0.070	**0.702**	−0.022	0.159
Ice cream, milk or fruit-based bars	0.062	**0.480**	0.162	0.007

Bold entries in the appendix tables are 'factor loadings >0.30', which are considered important contributors to the patterns. *PC1: processed; PC2: confectionary; PC3: migrant pattern; PC4: healthy.

Table A5. Compoments and factor loadings for Hungary

Food item	*PC1**	*PC2**	*PC3**
Cooked vegetables, beans	−0.070	**0.429**	0.068
fried potatoes, potato croquettes	**0.398**	0.105	0.095
Raw vegetables	−0.192	**0.514**	0.143
Fresh fruits without added sugar	−0.133	**0.572**	0.126
Fresh fruits with added sugar	0.288	**0.343**	0.027
Water	−0.285	0.265	0.138
Fruit juices	0.210	0.176	0.118
Sweetened drinks	**0.305**	−0.109	0.163
Diet drinks	0.114	−0.039	0.109
Breakfast cereals, muesli, sweetened	0.180	0.101	0.119
Porridge, oat meal, gruel, cereals, muesli, unsweetened	−0.007	0.195	0.024
Plain unsweetened milk	−0.080	0.243	0.233
Sweetened milk	0.140	−0.006	0.192
Plain unsweetened yoghurt or kefir	0.015	**0.555**	−0.012
Sweet yoghurt, fermented milk beverages	0.191	0.262	0.208
Fresh or frozen fish, not fried	0.209	**0.464**	−0.227
Fried fish, fish fingers	**0.368**	**0.439**	−0.163
Cold cuts, preserved, ready-to-cook meat products	0.172	0.109	**0.622**
Fresh meat, not fried	0.136	**0.330**	0.218
Fried meat	0.118	0.292	0.155
Fried or scrambled eggs	**0.303**	0.280	0.080
Boiled or poached eggs	0.273	**0.316**	−0.091
Mayonnaise, mayonnaise-based products	**0.399**	0.231	0.045
Tofu, tempe, quorn, soy milk	0.152	0.239	−0.204
Cheese	−0.073	0.241	0.172
Jam, honey	0.013	**0.389**	0.096
Chocolate or nut-based spread	**0.438**	0.090	0.219
Butter, margarine on bread	0.114	0.145	**0.589**
Reduced-fat products on bread	0.115	0.183	**0.472**
Ketchup	**0.333**	0.087	0.256
White bread, white roll, white crispbread	0.190	−0.076	**0.634**
Whole-meal bread, dark roll, dark crispbread	0.011	**0.396**	−0.008
Pasta, noodles, rice	**0.445**	0.260	0.047
Dish of milled cereals	0.117	**0.420**	−0.129
Pizza as main dish	**0.518**	0.005	−0.201
Hamburger, hot dog, kebab, wrap, falafel	**0.326**	0.034	**0.448**
Nuts, seeds, dried fruits	0.253	**0.437**	−0.025
Crisps, corn crisps, popcorn	**0.669**	−0.034	0.000
Savoury pastries, fritters	**0.521**	0.036	0.157
Chocolate, candy bars	**0.431**	−0.086	0.240
Candies, loose candies, marshmallows	**0.362**	−0.027	0.114
Biscuits, packaged cakes, pastries, puddings	**0.424**	0.031	0.068
Ice cream, milk or fruit-based bars	**0.349**	−0.051	0.166

Bold entries in the appendix tables are 'factor loadings >0.30', which are considered important contributors to the patterns. *PC1: processed; PC2: healthy; PC3: sandwich products.

Table A6. Components and factor loadings for Italy

Food item	*PC1**	*PC2**	*PC3**
Cooked vegetables, beans	−0.126	**0.594**	−0.066
fried potatoes, potato croquettes	**0.436**	0.118	0.048
Raw vegetables	−0.063	**0.634**	0.016
Fresh fruits without added sugar	−0.167	**0.489**	0.051
Fresh fruits with added sugar	0.213	**0.317**	0.121
Water	−0.156	0.039	0.008
Fruit juices	**0.329**	0.106	0.252
Sweetened drinks	**0.521**	0.132	0.086
Diet drinks	0.264	0.165	0.134
Breakfast cereals, muesli, sweetened	0.192	**0.349**	0.048
Porridge, oat meal, gruel, cereals, muesli, unsweetened	0.043	0.236	−0.030
Plain unsweetened milk	−0.131	0.117	−0.185
Sweetened milk	0.110	0.029	0.207
Plain unsweetened yoghurt or kefir	0.120	0.204	−0.005
Sweet yoghurt, fermented milk beverages	0.200	**0.333**	0.117
Fresh or frozen fish, not fried	−0.060	**0.446**	−0.025
Fried fish, fish fingers	**0.319**	0.173	0.004
Cold cuts, preserved, ready-to-cook meat products	**0.486**	0.120	0.033
Fresh meat, not fried	0.219	**0.388**	−0.006
Fried meat	**0.502**	0.108	0.011
Fried or scrambled eggs	**0.301**	0.164	0.038
Boiled or poached eggs	0.209	**0.379**	−0.026
Mayonnaise, mayonnaise-based products	**0.532**	0.020	−0.088
Tofu, tempe, quorn, soy milk	0.008	0.030	0.014
Cheese	−0.003	0.202	0.116
Jam, honey	−0.032	0.203	**0.549**
Chocolate or nut-based spread	**0.382**	0.037	**0.305**
Butter, margarine on bread	0.004	−0.053	**0.791**
Reduced-fat products on bread	−0.053	−0.013	**0.797**
Ketchup	**0.535**	0.000	0.003
White bread, white roll, white crispbread	0.100	0.256	0.204
Whole-meal bread, dark roll, dark crispbread	0.033	0.240	0.005
Pasta, noodles, rice	0.078	0.041	−0.011
Dish of milled cereals	0.071	0.153	0.176
Pizza as main dish	0.248	0.187	−0.018
Hamburger, hot dog, kebab, wrap, falafel	**0.478**	0.103	−0.038
Nuts, seeds, dried fruits	**0.408**	0.039	0.080
Crisps, corn crisps, popcorn	**0.632**	0.014	0.120
Savoury pastries, fritters	**0.513**	−0.008	0.112
Chocolate, candy bars	**0.533**	−0.049	0.151
Candies, loose candies, marshmallows	**0.412**	−0.006	0.216
Biscuits, packaged cakes, pastries, puddings	**0.447**	−0.002	0.173
Ice cream, milk or fruit-based bars	**0.436**	0.064	0.070

Bold entries in the appendix tables are 'factor loadings >0.30', which are considered important contributors to the patterns. *PC1: processed; PC2: healthy; PC3: spreads.

Table A7. Components and factor loadings for Spain

Food item	*PC1**	*PC2**	*PC3**
Cooked vegetables, beans	−0.079	**0.465**	**0.409**
fried potatoes, potato croquettes	**0.456**	0.088	0.001
Raw vegetables	−0.103	**0.490**	**0.368**
Fresh fruits without added sugar	−0.222	**0.423**	**0.354**
Fresh fruits with added sugar	0.130	0.142	0.092
Water	−0.173	0.211	−0.079
Fruit juices	0.243	0.261	0.168
Sweetened drinks	**0.301**	**0.443**	−0.027
Diet drinks	**0.378**	0.051	0.106
Breakfast cereals, muesli, sweetened	0.084	0.135	0.099
Porridge, oat meal, gruel, cereals, muesli, unsweetened	−0.016	−0.284	0.162
Plain unsweetened milk	0.025	−0.181	**0.366**
Sweetened milk	0.040	**0.313**	−0.289
Plain unsweetened yoghurt or kefir	0.001	−0.029	**0.343**
Sweet yoghurt, fermented milk beverages	−0.023	**0.425**	−0.085
Fresh or frozen fish, not fried	−0.145	0.078	**0.529**
Fried fish, fish fingers	0.243	0.155	−0.227
Cold cuts, preserved, ready-to-cook meat products	0.131	**0.572**	−0.003
Fresh meat, not fried	0.040	0.091	**0.506**
Fried meat	**0.303**	**0.534**	−0.215
Fried or scrambled eggs	**0.318**	0.098	0.226
Boiled or poached eggs	0.230	0.076	**0.309**
Mayonnaise, mayonnaise-based products	**0.432**	0.148	0.169
Tofu, tempe, quorn, soy milk	0.041	−0.052	0.115
Cheese	0.194	0.186	0.100
Jam, honey	0.051	0.051	0.216
Chocolate or nut-based spread	**0.321**	0.125	−0.131
Butter, margarine on bread	0.196	0.065	0.137
Reduced-fat products on bread	0.175	0.035	0.160
Ketchup	**0.403**	0.111	−0.015
White bread, white roll, white crispbread	0.030	**0.385**	0.010
Whole-meal bread, dark roll, dark crispbread	−0.025	−0.033	**0.361**
Pasta, noodles, rice	0.249	0.262	0.169
Dish of milled cereals	**0.337**	−0.107	0.291
Pizza as main dish	**0.372**	0.081	−0.092
Hamburger, hot dog, kebab, wrap, falafel	**0.315**	0.023	0.145
Nuts, seeds, dried fruits	0.298	0.085	0.193
Crisps, corn crisps, popcorn	**0.516**	0.024	−0.112
Savoury pastries, fritters	**0.516**	−0.036	−0.142
Chocolate, candy bars	**0.402**	−0.137	−0.078
Candies, loose candies, marshmallows	**0.470**	−0.043	−0.001
Biscuits, packaged cakes, pastries, puddings	**0.346**	0.001	−0.034
Ice cream, milk or fruit-based bars	**0.426**	−0.027	0.152

Bold entries in the appendix tables are 'factor loadings >0.30', which are considered important contributors to the patterns. *PC1: processed; PC2: traditional; PC3: healthy.

Table A8. Components and factor loadings for Sweden

Food item	*PC1**	*PC2**
Cooked vegetables, beans	**0.485**	−0.038
fried potatoes, potato croquettes	−0.012	**0.531**
Raw vegetables	**0.639**	−0.101
Fresh fruits without added sugar	**0.627**	−0.030
Fresh fruits with added sugar	0.133	0.271
Water	**0.417**	−0.050
Fruit juices	0.060	**0.336**
Sweetened drinks	−0.077	**0.412**
Diet drinks	−0.040	0.261
Breakfast cereals, muesli, sweetened	−0.096	**0.316**
Porridge, oat meal, gruel, cereals, muesli, unsweetened	0.228	−0.167
Plain unsweetened milk	0.222	−0.038
Sweetened milk	−0.049	**0.326**
Plain unsweetened yoghurt or kefir	**0.423**	−0.070
Sweet yoghurt, fermented milk beverages	−0.078	0.123
Fresh or frozen fish, not fried	**0.503**	−0.031
Fried fish, fish fingers	0.103	0.295
Cold cuts, preserved, ready-to-cook meat products	0.259	0.101
Fresh meat, not fried	**0.332**	0.092
Fried meat	0.129	0.221
Fried or scrambled eggs	0.164	**0.**256
Boiled or poached eggs	0.224	−0.015
Mayonnaise, mayonnaise-based products	−0.020	0.135
Tofu, tempe, quorn, soy milk	0.106	−0.008
Cheese	**0.300**	−0.023
Jam, honey	−0.026	0.211
Chocolate or nut-based spread	−0.060	0.271
Butter, margarine on bread	0.185	0.094
Reduced-fat products on bread	0.156	0.001
Ketchup	0.116	**0.321**
White bread, white roll, white crispbread	−0.025	**0.341**
Whole-meal bread, dark roll, dark crispbread	**0.523**	−0.113
Pasta, noodles, rice	**0.391**	0.218
Dish of milled cereals	**0.308**	−0.033
Pizza as main dish	−0.041	**0.358**
Hamburger, hot dog, kebab, wrap, falafel	−0.060	**0.446**
Nuts, seeds, dried fruits	**0.314**	0.012
Crisps, corn crisps, popcorn	−0.012	**0.421**
Savoury pastries, fritters	0.107	**0.352**
Chocolate, candy bars	−0.066	**0.401**
Candies, loose candies, marshmallows	−0.148	0.286
Biscuits, packaged cakes, pastries, puddings	−0.030	**0.383**
Ice cream, milk or fruit-based bars	0.073	**0.482**

Bold entries in the appendix tables are 'factor loadings >0.30', which are considered important contributors to the patterns. *PC1: healthy; PC2: processed.

Artículo IV [Paper IV]:

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

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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

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Abstract

Exploring changes in children's diet over time and the relationship between these changes and socio-economic status (SES) may help to understand the impact of social inequalities on dietary patterns. The aim of the present study was to describe dietary patterns by applying a cluster analysis to 9301 children participating in the baseline (2–9 years old) and follow-up (4–11 years old) surveys of the Identification and Prevention of Dietary- and Lifestyle-induced Health Effects in Children and Infants Study, and to describe the cluster memberships of these children over time and their association with SES. We applied the *K*-means clustering algorithm based on the similarities between the relative frequencies of consumption of forty-two food items. The following three consistent clusters were obtained at baseline and follow-up: processed (higher frequency of consumption of snacks and fast food); sweet (higher frequency of consumption of sweet foods and sweetened drinks); healthy (higher frequency of consumption of fruits, vegetables and wholemeal products). Children with higher-educated mothers and fathers and the highest household income were more likely to be allocated to the healthy cluster at baseline and follow-up and less likely to be allocated to the sweet cluster. Migrants were more likely to be allocated to the processed cluster at baseline and follow-up. Applying the cluster analysis to derive dietary patterns at the two time points allowed us to identify groups of children from a lower socio-economic background presenting persistently unhealthier dietary profiles. This finding reflects the need for healthy eating interventions specifically targeting children from lower socio-economic backgrounds.

Key words: **Cluster analysis: Dietary behaviour: FFQ: Income: Maternal education: Paternal education**

Abbreviations: CEHQ-FFQ, Children's Eating Habits Questionnaire-FFQ; IDEFICS, Identification and Prevention of Dietary- and Lifestyle-induced Health Effects in Children and Infants; PCA, principal components analysis; SES, socio-economic status; T0, baseline; T1, follow-up after the intervention.

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The influence of socio-economic status (SES) on health has been observed for all age groups. Due to the differences in health-related behaviours, health knowledge, housing conditions, psychosocial stressors, access to health care, etc., people living under lower socio-economic conditions have a heavier burden of disease compared with their better-off counterparts[1,2]. More specifically, diet quality and food consumption have been shown to be associated with several indicators of SES (e.g. income and educational attainment) and to factors leading to social vulnerability (e.g. migration), which, in turn, can affect overall health and increase the predisposition to developing certain disorders such as overweight and obesity[3,4].

Previous studies focusing on the associations between indicators of SES and food intake in children and adolescents reported a lower intake of fruits and vegetables and a higher intake of energy-dense foods in lower-SES groups[5,6]. Other studies have focused on dietary patterns instead and their associations with indicators of SES[7,8]. Indeed, considering diet as a whole is of great relevance for describing groups at a higher risk of developing overweight and obesity, as the overall diet seems to be a more important determinant of weight gain compared with single dietary components[9,10].

Dietary pattern analysis has been increasingly applied in recent years to assess the relationship between overall diet and the risk of chronic diseases[10]. Cluster analysis, a commonly applied method to derive dietary patterns, clusters individuals into non-overlapping groups that reflect relatively homogeneous dietary patterns within groups and distinct dietary patterns between groups. Various studies have applied this method to derive dietary patterns in children and adolescents and explored their associations with indicators of SES[11–13]. Moreover, exploring the changes in children's diet over time and the relationship between these changes and indicators of SES may help to identify the changes in dietary patterns and/or children changing their dietary patterns, thus allowing a better understanding of the impact of social inequalities on diet. Changes in diet over time have been previously explored using the principal components analysis (PCA); however, to the best of our knowledge, there is as yet only one report examining children's dietary patterns over time using cluster analysis[14]. The PCA provides linear combinations of foods instead of referring to identifiable groups of individuals, while cluster analysis identifies relatively homogeneous groups of children based on their food consumption. Applying cluster analysis to describe longitudinal changes in dietary patterns can provide further insight into changes in children's dietary patterns and the identification of groups with persistently unhealthier diets.

Therefore, the primary aim of the present study was to describe dietary patterns by applying cluster analysis to children participating in the baseline and follow-up surveys of the Identification and Prevention of Dietary- and Lifestyle-induced Health Effects in Children and Infants (IDEFICS) Study. The secondary aim was to describe the cluster memberships of children over time and their associations with SES.

Subjects and methods

The IDEFICS Study is a multi-centre, population-based study of children aged 2–9 years upon recruitment in selected regions of eight European countries (Belgium, Cyprus, Estonia, Germany, Hungary, Italy, Spain and Sweden)[15,16]. Each participating country included one intervention region, where the community intervention programme took place, and an equivalent control region[17]. The present study conducted two main surveys (baseline (T0) and follow-up after the intervention (T1)) in pre-schools and primary school classes (first and second grades at baseline). The baseline survey (September 2007 to May 2008) included 16 228 children aged 2–9 years (median age 6·3 (range 7·7) years). The follow-up survey (September 2009 to May 2010) reached an overall response rate of 68 % and included 11 038 children aged 4–11 years. The general design of the IDEFICS Study has been described elsewhere[15,16]. The present study includes only children with <50 % of missing values in FFQ data at T0 and T1 and for whom information on socio-economic variables and anthropometric measures was available (*n* 9301 children; 50·3 % boys; Fig. 1). Each participating centre obtained ethical approval from its health research ethics authority. All children provided oral consent and their parents provided written informed consent for all examinations and for the collection of samples, analysis and storage of personal data and collected samples.

Measurements

Dietary data were obtained at both T0 and T1 using the food frequency section of the Children's Eating Habits Questionnaire-FFQ (CEHQ-FFQ)[18], a validated screening tool in which the frequency of the child's consumption of selected food items during the preceding 4 weeks was reported by the parents. In order to assess meals under parental control, the questionnaire referred to meals outside the school canteen or childcare meal provision settings only[18,19]. The CEHQ-FFQ, which consists of forty-three food items clustered into fourteen food groups, was applied as a screening instrument to investigate the consumption of foods shown to be related, either positively or negatively, to overweight and obesity in children. The CEHQ-FFQ was not designed to provide

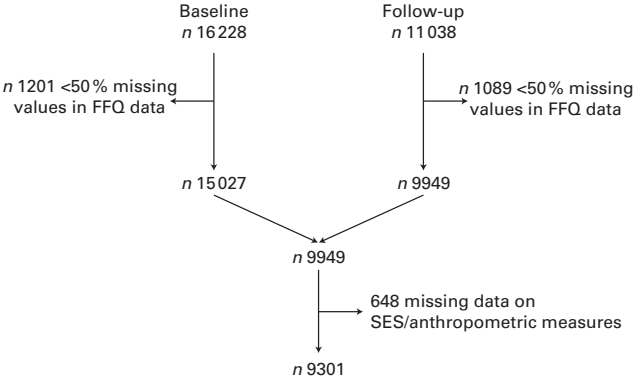

Fig. 1. Selection of the final study sample. SES, socio-economic status.

an estimate of total energy intake or total food intake[19]. Response options displayed from left to right were as follows: never/less than once per week; one to three times per week; four to six times per week; one time per d; two times per d; three times per d; four or more times per d; I have no idea. For the analysis of dietary patterns, a conversion factor was used to transform the answers in the questionnaire into weekly consumption frequencies, represented by a number ranging from 0 to 30. Only children with <50 % of missing values and with valid data on anthropometric measures and socio-economic variables were included in the analyses[20]. Multiple imputation was applied using sex, age, BMI and country as predictors for the remaining missing values (median number of available items 43 (SD 2·55))[21].

During the baseline and follow-up surveys, parents completed a self-administered questionnaire on parental attitudes, children's behaviour and social environment. Parental education and income were self-reported. Parental education level was categorised according to the International Standard Classification of Education-97[22]. Household income was assessed using nine country-specific categories based on the median equivalent income. The gained amount was then equalised to the number of household members using the square root scale provided by the Organisation for Economic Co-operation and Development[23]. Additionally, migrant background was assessed. A migrant background was assumed if one or both of the parents were born in another country.

Trained staff carried out anthropometric measurements at T0 and T1 following a standardised procedure. Body height (cm) was measured without shoes and all plaits undone using a portable stadiometer (SECA 225). Weight (kg) was measured using a child-adapted version of the electronic scale Tanita BC 420 SMA with the children in the fasting state (>8 h since the last meal) and wearing only underwear[24]. BMI and age- and sex-specific BMI *z*-scores were calculated and categorised according to the criteria proposed by the International Obesity Task Force[25].

Statistical analyses

K-means cluster analysis was performed to identify clusters of children with similar dietary patterns[26]. First, all the variables in the FFQ were checked for their suitability in cluster analysis in terms of relevance. The item 'meat replacement products' was not included in the set of variables as more than 95 % of the subjects reported 'never/less than once per week' as the frequency of consumption. Second, correlations between single food items were checked to assess multi-collinearity. The assessment of their correlations showed no redundant variables. Therefore, all the remaining (forty-two) food items were taken into account. The relative frequency of consumption was calculated for each food item by dividing the frequency of consumption of a specific food item by the sum of the consumption frequencies of all the food items reported for each single subject. The *z*-scores of the relative consumption frequency were calculated to standardise the dataset before clustering, as differences in variances of the variables may otherwise affect the resulting clusters[27]. A positive value indicates a higher frequency of consumption and a negative value reflects a lower frequency of consumption. The *K*-means algorithm was applied with a pre-defined maximum of 100 iterations to generate separate cluster solutions for two to six clusters. In order to find a stable clustering pattern, several solutions were obtained with different starting seeds. Iterations were generated until no change in cluster centroids was observed. The stability of the final solution was examined by randomly splitting the database into half and repeating the same clustering procedure, until satisfactory results were observed (a maximum of 327 children in the baseline clustering and 495 children in the follow-up clustering being allocated to different clusters, representing 3·5 and 5·3 % of the total sample, respectively). This procedure was applied for both baseline and follow-up datasets.

The stability of the cluster solutions and the interpretability of the clusters were considered as the criteria for choosing the final number of clusters to be retained. The clusters were labelled based on the *z*-scores of the food items.

Distribution of children in different clusters was calculated, stratified by sex, age, BMI status and country, both at T0 and T1. To assess the changes in dietary patterns over time, the cluster memberships of children at T0 and T1 were cross-tabulated, showing the proportion of children being allocated to the same or different clusters. Based on logistic regression models, OR for being allocated to the same cluster at T0 and T1 (i.e. healthy, sweet or processed at both time points; three models) or for changing the cluster (processed/sweet to healthy or vice versa; two models) were calculated, where the alternative category consisted of all the remaining combinations of cluster memberships in each model. Sex, age group, BMI status, migrant status, maternal and paternal education level, household income, country, and a dummy variable indicating intervention *v.* control region were assessed at both time points and included as covariates in all the models. The significance level was set at $P \leq 0{\cdot}05$. The analyses were performed using the Statistical Package for the Social Sciences (version 20.0; SPSS, Inc.).

Results

Based on the forty-two food items and their relative frequency of consumption, the three cluster solutions were considered the most interpretable and stable for both baseline and follow-up datasets and therefore were retained. The following labels were assigned to the three clusters: processed (*n* 4427 at T0, *n* 2554 at T1); sweet (*n* 1910 at T0, *n* 1939 at T1); healthy (*n* 2964 at T0, *n* 4808 at T1). Tables 1 and 2 present the mean *z*-scores and standard deviations of all the food items in the three clusters at T0 and T1. Dietary data for both surveys were more likely to be available for children with lower-educated parents and lower household income and for children with lower BMI compared with the complete IDEFICS Study samples (data not shown). The cluster solutions obtained were similar in terms of interpretability at both time points. The mean values of the majority of the food items differed markedly between the three clusters (Tables 1 and 2).

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Table 1. *z*-Scores of relative consumption frequencies in the three clusters at baseline
(Mean values and standard deviations)

	Processed (*n* 4427)		Sweet (*n* 1910)		Healthy (*n* 2964)	
Food items	Mean	SD	Mean	SD	Mean	SD
Cooked vegetables, potatoes, beans	−0·36^{c*}	0·74	0·42^{a}†	1·06	0·27^{b}	1·10
Fried potatoes, potato croquettes	0·21^{a}†	1·13	0·08^{b}	0·95	−0·37^{c*}	0·67
Raw vegetables	−0·32^{b}	0·72	−0·35^{b*}	0·73	0·70^{a}†	1·15
Fresh fruits without added sugar	−0·24^{b}	0·88	−0·24^{b*}	0·81	0·51^{a}†	1·09
Fresh fruits with added sugar	0·23^{a}†	1·19	−0·17^{b}	0·73	−0·24^{b*}	0·73
Water	0·21^{a}†	0·98	−0·49^{c*}	0·99	0·00^{b}	0·92
Fruit juices	0·08^{b}	1·02	0·21^{a}†	1·15	−0·26^{c*}	0·79
Sweetened drinks	−0·10^{b}	0·76	0·58^{a}†	1·64	−0·22^{c*}	0·50
Diet drinks	−0·14^{b}	0·45	0·59^{a}†	1·95	−0·17^{b*}	0·33
Breakfast cereals, muesli, sweetened	0·15^{a}†	1·09	0·10^{a}	1·01	−0·29^{b*}	0·76
Porridge, oat meal, gruel, cereals, muesli, unsweetened	−0·21^{b}	0·72	−0·40^{c*}	0·49	0·57^{a}†	1·31
Plain unsweetened milk	−0·22^{b}	0·90	−0·23^{b*}	0·83	0·48^{a}†	1·07
Sweetened milk	0·29^{a}†	1·13	−0·02^{b}	0·94	−0·42^{c*}	0·60
Plain unsweetened yogurt or kefir	−0·08^{b}	0·85	−0·29^{c*}	0·66	0·31^{a}†	1·27
Sweet yogurt, fermented milk beverages	−0·01^{b}	1·02	0·16^{a}†	1·02	−0·09^{c*}	0·94
Fresh or frozen fish, not fried	0·02^{b}	1·00	−0·33^{c}	0·80	0·19^{a}†	1·07
Fried fish, fish fingers	0·03^{a}†	1·02	−0·06^{b}	0·94	−0·01^{a}	1·00
Cold cuts, preserved, ready-to-cook meat products	−0·04^{b}	0·87	0·60^{a}†	1·19	−0·32^{c*}	0·86
Fresh meat, not fried	0·21^{a}†	1·01	−0·30^{c*}	0·96	−0·12^{b}	0·95
Fried meat	−0·15^{c*}	0·96	0·35^{a}†	1·09	0·00^{b}	0·95
Fried or scrambled eggs	0·25^{a}†	1·09	−0·26^{b*}	0·82	−0·21^{b}	0·85
Boiled or poached eggs	0·07^{a}†	1·27	−0·14^{c*}	0·72	−0·02^{b}	0·62
Mayonnaise, mayonnaise-based products	−0·04^{b}	0·86	0·52^{a}†	1·53	−0·28^{c}	0·52
Cheese	0·07^{a}†	1·05	−0·17^{c*}	0·90	0·00^{b}	0·98
Jam, honey	−0·08^{b*}	0·90	0·29^{a}†	1·24	−0·07^{b}	0·94
Chocolate- or nut-based spreads	−0·11^{b}	0·72	0·95^{a}†	1·44	−0·44^{c*}	0·48
Butter, margarine on bread	−0·08^{b*}	0·88	0·03^{a}	1·09	0·10^{a}†	1·09
Reduced-fat products on bread	−0·28^{c*}	0·58	0·13^{b}	1·12	0·34^{a}†	1·26
Ketchup	−0·07^{c*}	1·00	0·11^{a}†	1·04	0·03^{b}	0·97
White bread, white roll, white crispbread	0·31^{a}†	1·06	−0·08^{b}	0·96	−0·42^{c*}	0·74
Wholemeal bread, dark roll, dark crispbread	−0·36^{c*}	0·73	0·27^{b}	1·17	0·37^{a}†	1·04
Pasta, noodles, rice	−0·03^{b}	1·04	−0·27^{c*}	0·72	0·22^{a}†	1·04
Dish of milled cereals	0·03^{b}	1·06	−0·22^{c*}	0·55	0·10^{a}†	1·10
Pizza as main dish	0·23^{a}†	1·22	−0·12^{b}	0·81	−0·27^{c*}	0·58
Hamburgers, hot dogs, kebabs, wraps, falafel	0·32^{a}†	1·16	−0·48^{c*}	0·52	−0·17^{b}	0·79
Nuts, seeds, dried fruits	0·01^{b}	0·95	−0·27^{c*}	0·69	0·16^{a}†	1·19
Crisps, maize (corn) crisps, popcorn	0·20^{a}†	1·13	−0·04b	0·92	−0·26^{c*}	0·74
Savoury pastries, fritters	0·37^{a}†	1·20	−0·38^{b*}	0·55	−0·31^{b}	0·62
Chocolate, candy bars	0·19^{a}†	1·10	0·13^{a}	1·10	−0·37^{b*}	0·60
Candies, loose candies, marshmallows	−0·17^{b}	0·78	0·72^{a}†	1·48	−0·20^{b*}	0·63
Biscuits, packaged cakes, pastries, puddings	−0·15^{b}	0·86	0·70^{a}†	1·30	−0·24^{c*}	0·73
Ice cream, milk- or fruit-based bars	0·12^{a}†	1·14	−0·16^{c*}	0·92	−0·07^{b}	0·78

^{a,b,c} Mean values within a row with unlike superscript letters were significantly different ($P<0·05$).
* The lowest mean value within a row.
† The highest mean value within a row.

Compared with the other clusters, the processed cluster presented at both time points had higher relative frequencies of consumption of takeaway and high-fat foods, such as savoury pastries and fritters; pizza as main dish; fried potatoes; hamburgers, hot dogs, kebabs and wraps; and crisps, maize (corn) crisps and popcorn. Products such as wholemeal bread, cooked vegetables, raw vegetables, and fresh fruits without added sugar scored lowest. At both time points, the sweet cluster had higher values for sugar-rich products, such as chocolate- or nut-based spreads; sweetened drinks; fruit juices; diet drinks; candies, loose candies and marshmallows; and biscuits, packaged cakes, pastries and puddings, and had the lowest scores for water; porridge, oat meal, gruel, cereals and muesli, unsweetened; raw vegetables; plain unsweetened milk; and plain unsweetened yogurt and kefir. The healthy cluster had at both time points higher values for low-fat foods, foods rich in vitamins and whole-grain foods, e.g. raw vegetables; fresh fruits without added sugar; porridge, oat meal, gruel, cereals and muesli, unsweetened; and plain unsweetened milk, and lower values for high-fat and high-sugar products, such as fried potatoes; sweetened drinks; sweetened milk; mayonnaise and mayonnaise-based products; chocolate- or nut-based spreads; crisps, maize (corn) crisps and popcorn; and biscuits, packaged cakes, pastries and puddings.

Table 3 summarises the distribution of age, sex, BMI status and country in the three clusters at T0 and T1. The percentage of girls in the healthy cluster was slightly higher than that in the other two clusters, while a higher percentage of boys were allocated to the processed and sweet clusters. Older children represented a higher percentage in the processed and sweet clusters

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Table 2. *z*-Scores of relative consumption frequencies in the three clusters at follow-up
(Mean values and standard deviations)

	Processed (*n* 2554)		Sweet (*n* 1939)		Healthy (*n* 4808)	
Food items	Mean	SD	Mean	SD	Mean	SD
Cooked vegetables, potatoes, beans	−0·45^{c*}	0·64	0·31^{a}†	1·12	0·11^{b}	1·02
Fried potatoes, potato croquettes	0·42^{a}†	1·22	0·16^{b}	1·01	−0·29^{c*}	0·74
Raw vegetables	−0·40^{b*}	0·71	−0·41^{b}	0·66	0·37^{a}†	1·10
Fresh fruits without added sugar	−0·46^{c*}	0·74	−0·25^{b}	0·81	0·35^{a}†	1·06
Fresh fruits with added sugar	0·27^{a}†	1·13	−0·13^{b*}	0·79	−0·09^{b}	0·98
Water	0·06^{a}	0·99	−0·46^{b*}	0·96	0·15^{a}†	0·97
Fruit juices	0·15^{a}†	1·05	0·11^{a}	1·15	−0·12^{b*}	0·89
Sweetened drinks	−0·05^{b}	0·73	0·68^{a}†	1·71	−0·25^{c*}	0·47
Diet drinks	−0·11^{b}	0·51	0·55^{a}†	1·92	−0·16^{b*}	0·40
Breakfast cereals, muesli, sweetened	0·31^{a}†	1·21	−0·02^{b}	0·87	−0·16^{c*}	0·88
Porridge, oat meal, gruel, cereals, muesli, unsweetened	−0·19^{b}	0·77	−0·40^{c*}	0·54	0·26^{a}†	1·16
Plain unsweetened milk	−0·22^{b}	0·85	−0·26^{c*}	0·86	0·22^{a}†	1·07
Sweetened milk	0·28^{a}†	1·12	−0·05^{b}	0·95	−0·13^{c*}	0·92
Plain unsweetened yogurt or kefir	0·04^{b}	0·94	−0·35^{c*}	0·61	0·12^{a}†	1·12
Sweet yogurt, fermented milk beverages	−0·13^{c*}	0·91	0·14^{a}†	1·04	0·01^{b}	1·02
Fresh or frozen fish, not fried	0·00^{b}	0·96	−0·39^{c*}	0·82	0·16^{a}†	1·04
Fried fish, fish fingers	0·08^{a}†	1·04	−0·04^{b*}	0·89	−0·02^{b}	1·02
Cold cuts, preserved, ready-to-cook meat products	−0·16^{c*}	0·81	0·48^{a}†	1·18	−0·11^{b}	0·95
Fresh meat, not fried	0·17^{a}†	0·94	−0·23^{c*}	1·08	0·00^{b}	0·98
Fried meat	−0·28^{c*}	0·74	0·59^{a}†	1·23	−0·09^{b}	0·92
Fried or scrambled eggs	0·30^{a}†	1·50	−0·14^{b*}	0·69	−0·10^{b}	0·70
Boiled or poached eggs	0·10^{a}†	1·13	−0·23^{b*}	0·82	0·04^{a}	0·98
Mayonnaise, mayonnaise-based products	0·09^{b}	1·07	0·50^{a}†	1·42	−0·25^{c*}	0·59
Cheese	0·01^{b}	0·95	−0·23^{c*}	0·96	0·09^{a}†	1·03
Jam, honey	−0·09^{b*}	0·86	0·13^{a}†	1·10	−0·01^{b}	1·02
Chocolate- or nut-based spreads	0·10^{b}	0·89	0·84^{a}†	1·38	−0·39^{c*}	0·55
Butter, margarine on bread	−0·16^{c*}	0·76	−0·05^{b}	1·03	0·11^{a}†	1·08
Reduced-fat products on bread	−0·23^{c*}	0·59	0·05^{b}	1·04	0·10^{a}†	1·13
Ketchup	0·37^{a}†	1·44	0·04^{b}	0·85	−0·21^{c*}	0·65
White bread, white roll, white crispbread	0·06^{a}†	1·00	0·04^{a}	1·01	−0·05^{b*}	0·99
Wholemeal bread, dark roll, dark crispbread	−0·35^{b*}	0·68	0·15^{a}†	1·13	0·12^{a}	1·04
Pasta, noodles, rice	0·00^{a}	1·05	−0·21^{b*}	0·81	0·09^{a}†	1·03
Dish of milled cereals	0·17^{a}†	1·29	−0·23^{c*}	0·55	0·01^{b}	0·95
Pizza as main dish	0·63^{a}†	1·49	−0·16^{b}	0·68	−0·27^{c*}	0·53
Hamburgers, hot dogs, kebabs, wraps, falafel	0·31^{a}†	1·15	−0·36^{c*}	0·70	−0·02^{b}	0·97
Nuts, seeds, dried fruits	0·16^{a}†	1·13	−0·28^{c*}	0·65	0·03^{b}	1·02
Crisps, maize (corn) crisps, popcorn	0·42^{a}†	1·23	0·17^{b}	1·06	−0·29^{c*}	0·70
Savoury pastries, fritters	0·78^{a}†	1·41	−0·31^{b*}	0·54	−0·29^{b}	0·56
Chocolate, candy bars	0·24^{a}	1·12	0·36^{a}†	1·25	−0·27^{b*}	0·69
Candies, loose candies, marshmallows	−0·13^{b}	0·78	0·78^{a}†	1·48	−0·25^{c*}	0·64
Biscuits, packaged cakes, pastries, puddings	−0·07^{b}	0·79	0·83^{a}†	1·44	−0·30^{c*}	0·63
Ice cream, milk- or fruit-based bars	0·30^{a}†	1·26	−0·08^{b}	0·95	−0·12^{b*}	0·81

^{a,b,c} Mean values within a row with unlike superscript letters were significantly different ($P<0·05$).
* The lowest mean value within a row.
† The highest mean value within a row.

compared with younger children. The processed cluster included a lower percentage of normal-weight children and a higher percentage of obese children compared with the other two clusters. The biggest differences were observed between the countries, i.e. certain countries represented up to 46 % of one cluster. Thus, the sweet cluster was mainly represented by Belgian and German children, the processed cluster by Italian, Cypriot, Estonian and Spanish children, while the healthy cluster included a high percentage of Swedish children.

Table 4 summarises the percentage of children being allocated to the same cluster at T0 and T1 and those being allocated to different clusters (see online supplementary Table S1 for the same proportions taking into account only subjects with complete information). With 85 % of the children being allocated to the healthy cluster at both T0 and T1, this cluster was the one with the greatest stability. Only 46 % of the children in the processed cluster at T0 remained in this cluster at T1, while 43 % switched to the healthy cluster at T1. Also, 382 children (20 %) allocated to the sweet cluster at T0 changed to the healthy cluster at T1. No differences in the percentage of children allocated to the same or different clusters at T0 and T1 were found between the interventions and the control regions (data not shown).

Table 5 presents OR and 95 % CI for the associations between the identified dietary patterns and socio-economic characteristics. Girls (OR 0·88, 95 % CI 0·79, 0·98) and children with higher-educated fathers (OR 0·73, 95 % CI 0·59, 0·91) were less likely to be included in the processed cluster at T0 and T1, while the OR were higher for older children (OR 1·23, 95 % CI 1·10, 1·38) and migrants (OR 1·24, 95 % CI

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Table 3. Description of the included study population, stratified by cluster membership, at baseline (T0) and follow-up (T1)
(Number of participants and percentages)

	Processed				Sweet				Healthy					
	T0		T1		T0		T1		T0		T1		Total	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Total	4427		2554		1910		1939		2964		4808		9301	
Sex														
Boys	2240	51	1342	53	999	52	1037	54	1444	49	2304	48	4683	51
Girls	2187	49	1212	47	911	48	902	46	1520	51	2504	52	4618	49
Age														
< 6 years	1858	42	1042	41	895	47	903	47	1497	51	2305	48	4250	46
≥ 6 years	2569	58	1512	59	1015	53	1036	53	1467	49	2503	52	5051	54
BMI status														
Underweight	435	10	269	10	251	13	261	14	317	10	473	9	1003	11
Normal weight	2997	68	1751	69	1417	74	1443	74	2180	74	3400	71	6594	71
Overweight	626	14	338	13	166	9	170	9	320	11	604	13	1112	12
Obese	369	8	196	8	166	4	65	3	320	5	331	7	592	6
Country														
Italy	1032	23	579	23	181	10	221	11	261	9	674	14	1474	16
Estonia	749	17	393	15	100	5	110	6	397	13	743	16	1246	13
Cyprus	795	18	680	27	6	1	8	1	235	8	348	7	1036	11
Belgium	72	2	43	2	877	46	867	45	141	5	180	4	1090	12
Sweden	64	1	35	1	34	2	53	3	1257	42	1267	26	1355	15
Germany	161	4	98	4	558	29	464	24	259	9	416	9	978	10
Hungary	680	15	328	13	99	5	148	8	207	7	510	11	986	11
Spain	874	20	398	16	55	3	68	4	207	7	670	14	1136	12

1·05, 1·46) than for younger children and non-migrants. Girls (OR 0·78, 95% CI 0·66, 0·92), migrants (OR 0·40, 95% CI 0·31, 0·52), and children with the highest educated mothers (OR 0·65, 95% CI 0·47, 0·89) and fathers (OR 0·73, 95% CI 0·54, 0·99) and highest household income (OR 0·77, 95% CI 0·61, 0·97) were less lik ely to be allocated to the sweet cluster at T0 and T1. Obese children (OR 1·37, 95% CI 1·08, 1·74) and children with higher-educated mothers (OR 1·61, 95% CI 1·28, 2·04) and fathers (OR 1·51, 95% CI 1·20, 1·90) were more likely to be allocated to the healthy cluster at both time points. Girls (OR 1·16, 95% CI 1·04, 1·31) and children with the highest household income (OR 1·31, 95% CI 1·12, 1·53) were also more likely to be allocated to the healthy cluster at T0 and T1. Older children (OR 0·65, 95% CI 0·58, 0·73) were less likely to be allocated to the healthy cluster. Girls (OR 1·18, 95% CI 1·07, 1·31), obese children (OR 1·41, 95% CI 1·12, 1·78) and children with higher-educated fathers (OR 1·24, 95% CI 1·02, 1·50) were more likely to change from the processed/sweet cluster at T0 to the healthy cluster at T1. Finally, obese children (OR 0·54, 95% CI 0·35, 0·85) were less likely to change from the healthy cluster at T0 to the processed/sweet cluster at T1.

Discussion

The present study derived dietary patterns based on a cluster analysis performed at two different time points in 2- to 9-year-old children participating in the IDEFICS Study. Overall, three consistent dietary patterns were identified at T0 and T1: a processed cluster, showing higher frequencies of consumption of snacks and fast food and lower frequencies of vegetables and wholemeal products; a sweet cluster, showing higher frequencies of consumption of biscuits and sweet products, candies, and sweetened drinks; a healthy cluster, showing higher frequencies of consumption of fruits, vegetables and wholemeal products, and lower frequencies of consumption of processed food products. These three patterns presented similar profiles of relative frequencies of food consumption at each time point, allowing us to assess which children remained in the same patterns and who changed their dietary patterns between T0 and T1. The cluster membership was additionally found to be associated with a number of socio-economic indicators, namely paternal and maternal education levels, household income and migrant status.

Although dietary patterns are dependent on the population considered and therefore not completely comparable between studies, previous reports extracting dietary patterns of children using cluster analysis found similar results. A British study in children aged 1–4 years has also identified three clusters that were labelled as healthy diet, convenience diet and traditional diet[11]. Another recent British study in 7-year-old children has singled out processed, plant-based and traditional

Table 4. Cross-tabulation between the cluster memberships of children at baseline (T0) and follow-up (T1)
(Number of participants and percentages)

Cluster membership at T1	Cluster membership at T0						
	Processed		Sweet		Healthy		Total
	n	%	*n*	%	*n*	%	*n*
Processed	2046	46	228	12	280	9	2554
Sweet	474	11	1300	68	165	6	1939
Healthy	1907	43	382	20	2519	85	4808
Total	4427		1910		2964		9301

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Table 5. Associations between the cluster memberships over time (each group compared with all the other combinations of cluster memberships) and socio-economic characteristics*

(Odds ratios and 95 % confidence intervals)

	Processed cluster at two time points (*n* 2046)		Sweet cluster at two time points (*n* 1300)		Healthy cluster at two time points (*n* 2519)		Processed/sweet cluster at T0, healthy cluster at T1 (*n* 2289)		Healthy cluster at T0, processed/ sweet cluster at T1 (*n* 445)	
	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI
Sex										
Boys (*n* 4683)	1·00		1·00		1·00		1·00		1·00	
Girls (*n* 4618)	0·88	0·79, 0·98	0·78	0·66, 0·92	1·16	1·04, 1·31	1·18	1·07, 1·31	1·01	0·83, 1·22
Age group										
< 6 years (*n* 4250)	1·00		1·00		1·00		1·00		1·00	
> 6 years (*n* 5051)	1·23	1·10, 1·38	1·14	0·97, 1·35	0·65	0·58, 0·73	1·00	0·90, 1·11	1·07	0·88, 1·30
BMI status										
Normal weight (*n* 6462)	1·00		1·00		1·00		1·00		1·00	
Overweight (*n* 1098)	0·96	0·80, 1·15	0·79	0·62, 1·02	1·02	0·85, 1·23	1·25	1·04, 1·51	0·96	0·71, 1·28
Obese (*n* 598)	0·81	0·65, 1·03	0·81	0·57, 1·16	1·37	1·08, 1·74	1·41	1·12, 1·78	0·54	0·35, 0·85
Missing (*n* 1045)	0·73	0·56, 0·95	0·49	0·30, 0·81	1·52	1·15, 2·03	1·64	1·27, 2·13	0·60	0·35, 1·02
Migrant status										
Non-migrant (*n* 7951)	1·00		1·00		1·00		1·00		1·00	
Migrant (*n* 1252)	1·24	1·05, 1·46	0·40	0·31, 0·52	0·98	0·82, 1·18	1·06	0·90, 1·23	0·88	0·66, 1·18
Maternal ISCED level										
Low (*n* 1406)	1·00		1·00		1·00		1·00		1·00	
Medium (*n* 4610)	1·15	0·96, 1·38	0·80	0·63, 1·01	1·31	1·07, 1·60	0·98	0·84, 1·15	1·00	0·71, 1·40
High (*n* 2848)	1·07	0·86, 1·33	0·65	0·47, 0·89	1·61	1·28, 2·04	0·92	0·76, 1·12	1·03	0·69, 1·52
Missing (*n* 339)	1·82	1·23, 2,68	0·83	0·56, 1·24	0·83	0·56, 1·22	0·95	0·68, 1·32	1·07	0·59, 1·97
Paternal ISCED level										
Low (*n* 1247)	1·00		1·00		1·00		1·00		1·00	
Medium (*n* 4814)	0·84	0·71, 0·99	0·81	0·63, 1·04	1·22	1·00, 1·48	1·27	1·09, 1·49	1·08	0·77, 1·40
High (*n* 2472)	0·73	0·59, 0·91	0·73	0·54, 0·99	1·51	1·20, 1·90	1·24	1·02, 1·50	1·15	0·78, 1·70
Missing (670)	0·96	0·72, 1·29	0·65	0·46, 0·92	1·15	0·85, 1·56	1·17	0·91, 1·52	1·07	0·65, 1·77
Household income										
Low (*n* 2993)	1·00		1·00		1·00		1·00		1·00	
Medium (*n* 2297)	0·98	0·84, 1·13	0·86	0·68, 1·08	1·07	0·91, 1·26	1·06	0·92, 1·21	0·79	0·61, 1·03
High (*n* 2934)	0·90	0·78, 1·04	0·77	0·61, 0·97	1·31	1·12, 1·53	1·11	0·97, 1·27	0·75	0·57, 0·97
Missing (*n* 979)	0·85	0·70, 1·03	0·71	0·52, 0·98	1·24	0·99, 1·54	1·19	0·99, 1·43	0·82	0·59, 1·14

T0, baseline; T1, follow-up after the intervention; ISCED, International Standard Classification of Education.
* All the models were adjusted for country and study region (intervention *v.* control) and for all the other factors presented in the table.

British clusters[13]. A study among Chinese children aged 6–13 years has also found three clusters: a healthy pattern; a transitive pattern; a Western pattern[28]. However, also different numbers of dietary patterns have been described, ranging from two to seven clusters[12,14,29,30–33]. The heterogeneity of the reference populations from different countries and continents, the different dietary assessment methods (FFQ *v.* dietary records), the different number and types of food items included and the use of different clustering algorithms (e.g. *K*-means and Ward's method) are likely explanations for the different results. Nevertheless, similar variations in certain patterns have been repeatedly reported across different populations. This is especially true for the patterns labelled as healthy or health-conscious[26].

A previous study has derived four dietary patterns from the IDEFICS baseline data by applying the PCA[20]. The first pattern was labelled 'snacking', with the highest loadings for hamburgers, hot dogs, butter, savoury pastries and white bread. The sweet and fat pattern showed the highest loadings for sweet products such as chocolate- or nut-based spreads, cakes, puddings and cookies. The third pattern was labelled 'vegetables and wholemeal', with the highest loadings for vegetables, fruits and wholemeal bread. Finally, the protein and water pattern presented the highest loadings for fish, water, eggs and meat. Our cluster solution presents groupings that are similar to the PCA solution. Nevertheless, it also reflects different aspects and detects a different number of factors/clusters. Other studies exist that have compared dietary patterns obtained by applying the PCA and cluster analysis to the same samples[13,34,35]. The results showed a general correlation between the methods, although the two methods describe diet in a different way.

Although it was not the focus of the study, we found a higher percentage of overweight/obese children allocated to the healthy cluster than those allocated to the sweet pattern. The results also showed that obese children were more likely to be allocated to the healthy cluster at both time points. The parents of overweight/obese children might be more prone to under-reporting or providing socially acceptable answers than those of normal-weight children, which is also the case among obese adults. Another plausible explanation is that our dietary instrument, similar to most instruments assessing children's diet, reflects the information provided by proxy reporters (parents) and therefore only

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includes meals under parental control. As a result, this questionnaire might not have been able to adequately capture the consumption of certain high-fat, high-sugar foods, potentially beyond parental control[20].

The present study found that children's membership in a specific cluster was associated with parental education. Specifically, children with higher-educated mothers and fathers were more likely to remain in the healthy cluster at the two time points or to change from the processed/sweet cluster to the healthy one. Notably, the association was found to be stronger for paternal education. Most of the findings in the literature have shown a stronger association with maternal education. Nevertheless, few studies have also described a strong paternal influence on children's dietary intake[36,37], suggesting that higher-educated fathers might communicate beneficial roles and healthy behaviour more clearly than lower-educated fathers. The lack of studies showing paternal influence on children's dietary intake underlines the importance of our findings and the need for further evidence. Previous results from the IDEFICS Study also pointed out the association between parental education and children's food consumption[38]. A recent publication describing four clusters (processed, healthy, traditional and packed lunch) at three different time points in a sample of British children has also found an association between a child's cluster membership over time and maternal education level[14]. In particular, children with lower-educated mothers were more likely to be allocated to the processed cluster at all time points, while children with higher-educated mothers were more likely to remain in the healthy cluster. The present study also found this association in the case of paternal education. Although similar associations have been reported previously using dietary patterns derived from the PCA[39], the use of cluster analysis to describe dietary patterns over time makes it possible to track which children remain in a specific cluster, thus providing more insight into specific subgroups that consistently show unhealthy dietary patterns.

The present study is subject to a number of limitations. First, the IDEFICS Study was not designed to be nationally representative. Participation in the IDEFICS Study was voluntary, which means that some population groups, e.g. lower-educated or high-income individuals, may have been less willing to take part in the study. The direction of a possible bias cannot be predicted because no systematic information on non-participants is available. Moreover, the direction of the bias usually points in opposite directions for lower and higher SES. A further limitation is the fact that 43 % of the initial baseline cohort did not participate at follow-up and/or did not provide complete data, precluding their inclusion in the present study. Excluded participants showed a higher prevalence of overweight/obesity and a higher percentage of lower-educated parents (see online supplementary Table S2). Consequently, a selection bias cannot be ruled out. Additionally, participants without valid information on maternal education were more likely to be allocated to the processed cluster at both time points, which is another reason why a selection bias cannot be ruled out. The CEHQ-FFQ was not designed to reflect total food intake, but rather to capture information on parent-supervised meals. The number of meals under parental control varied between countries. Sweden, for example, had a higher number of meals and a higher percentage of children eating at school. This might partially explain the differences observed in dietary patterns between countries. However, it was still possible to describe socio-economic differences in dietary patterns, as mainly family socio-economic characteristics influence meals under parental control, as opposed to meals at school.

To the best of our knowledge, this is the first multi-centre European study assessing dietary patterns over time using cluster analysis. The large sample size, the wide variety of dietary habits and cultural backgrounds across eight European countries, and the use of a validated dietary instrument shown to provide reproducible estimates of consumption frequencies are the main strengths of the present study. The use of cluster analysis for deriving dietary patterns at two time points allowed us to identify groups of children with persistently unhealthier dietary profiles and to characterise them according to socio-economic indicators. Healthy eating interventions may benefit from the results of the present study, taking the results into consideration to specifically address groups presenting persistently unhealthier dietary patterns.

Supplementary material

To view supplementary material for this article, please visit http://dx.doi.org/10.1017/S0007114514003663

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The authors' contributions are as follows: J. M. F.-A. carried out the statistical analyses with the help of C. B. and I. P. and drafted the manuscript; K. B. supervised the quality-control study protocol; K. B., W. G., V. K., L. R. and I. P. developed the measurement instruments; A. H., G. B., G. E., I. I., T. V., Y. A. K., E. K., I. H. and L. A. M. supervised the national data collection procedures. All authors read and critically reviewed the manuscript.

None of the authors has any conflicts of interest to declare.

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Artículo V [Paper V]:

Prospective associations between dietary patterns and body composition changes in European children: the IDEFICS study

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Abstract

Objective: To describe dietary patterns by applying cluster analysis and to describe the cluster memberships of European children over time and their association with body composition changes.

Design: The analyses included K-means clustering based on the similarities between the relative frequencies of consumption of 43 food items and regression models were fitted to assess the association between dietary patterns and body composition changes.

Setting: Primary schools and pre-schools of selected regions in Italy, Estonia, Cyprus, Belgium, Sweden, Hungary, Germany and Spain.

Subjects: Participants (n=8341) in the baseline (2 to 9 years old) and follow-up (4 to 11 years old) surveys of the IDEFICS Study.

Results: Three persistent clusters were obtained at baseline and follow-up. Children consistently allocated to the "processed" cluster (higher frequency of consumption of snacks and fast food) presented increased body mass index, increased waist circumference and increased fat mass gain over time compared to children allocated to a dietary pattern rich in fruits, vegetables and wholemeal products ("healthy"). Being in the "sweet" pattern (higher frequency of consumption of sweet foods and sweetened drinks) was also linked to increased body mass index, increased waist circumference and increased fat mass gain over time compared to the "healthy" pattern.

Conclusions: Children consistently showing a processed dietary pattern or changing from a processed pattern to a sweet pattern presented the most unfavourable changes in fat mass and abdominal fat. These findings support the need of promoting overall healthy dietary habits in obesity prevention and health promotion programs targeting children.

Introduction

Childhood overweight and obesity are associated with a high prevalence of a number of comorbidities and psychosocial disadvantages, representing one of the major public health concerns worldwide [1]. While obesity prevalence seems to be levelling off in some countries [2; 3], developing countries are experiencing concurrent rapid shifts in diet and activity levels and rising overweight prevalence [4]. In addition, population groups with lower education and income levels present a higher obesity burden [5]. As childhood overweight and obesity track into adulthood, the increasing prevalence will entail future community health consequences further increasing the risk of developing non-communicable diseases at younger ages [6; 7].

The childhood overweight epidemic is largely determined by global changes in lifestyle behaviours leading to an imbalance between energy intake (dietary habits) and energy expenditure (basal metabolic rate and physical activity). Previous research described the most relevant energy balance-related behaviours in children and adolescents, showing that among them, poor dietary habits are linked to worse body composition indicators, especially for specific items such as sugared drinks [8] and fast food [9]. However, examining multiple dietary factors in the context of dietary patterns may better explain the risk of developing overweight and obesity than examining single foods or nutrients.

Dietary pattern analysis has been increasingly applied to assess the relationship between overall diet and the risk of chronic diseases, including obesity [10; 11]. It allows to evaluate the impact of the whole diet, given that foods are consumed in combination. In a previous study, we analysed the prospective associations between socioeconomic status and dietary patterns in the IDEFICS Study, applying cluster analysis at two points

in time [12]. Cluster analysis, one of the most commonly applied methods to derive dietary patterns, clusters individuals into non-overlapping groups that reflect relatively homogeneous dietary patterns within groups and distinct dietary patterns between groups. Moreover, exploring changes in children's diet over time may help to identify changes in dietary patterns and/or children changing their dietary patterns, thus allowing a better understanding of the impact of diet on body composition. Changes in diet over time and the associations with overweight markers have been previously explored using principal components analysis (PCA) [13; 14; 15; 16] and reduced rank regression (RRR) [17; 18], but to the best of our knowledge, few studies examined children's dietary patterns over time using cluster analysis [12; 19] and none of them explored the association with changes in body composition. PCA provides linear combinations of foods instead of referring to identifiable groups of individuals. Applying cluster analysis to describe dietary patterns throughout time allows identifying groups of children with consistently healthy/unhealthy diets providing further insight into dietary impact on body composition changes.

Although body mass index (BMI) has been widely reported as an indicator of overweight and obesity due to its simplicity, it is not a perfect indicator of excess body fat [20; 21]. Therefore, other body composition indicators, such as waist circumference (WC) for assessing abdominal fat and the fat mass index (FMI) and fat free mass index (FFMI) as indicators of overall fat/lean tissue in relation to total mass, might help to complement BMI when assessing dietary impact on body composition.

The present study aims to investigate the association between dietary patterns obtained by applying cluster analysis to children participating in the baseline and follow-up surveys of the IDEFICS Study (Identification and prevention of Dietary- and lifestyle

induced health EFfects In Children and infantS), and changes in body composition including BMI, WC, FMI and FFMI.

Subjects and methods

The IDEFICS Study is a large multi-centre population-based study of children aged 2 to 9 years in selected regions of eight European countries (Belgium, Cyprus, Estonia, Germany, Hungary, Italy, Spain and Sweden) including an embedded intervention [22; 23]. Two main surveys (baseline (T0) and follow-up (T1)) were conducted in pre-schools and primary school classes (first and second grades at baseline). The baseline survey (September 2007 – May 2008) included 16,228 children aged 2 to 9 years (median=6.3). The follow-up survey (September 2009 – May 2010) reached a 68% overall response and included 11,038 children aged 4 to 11 years. The follow-up survey was synchronized with the baseline to account for seasonal variation. Details of the general design, instruments and survey characteristics can be found elsewhere [22; 23]. The present study includes only children with less than 50% of missing values in the food frequency data at baseline and follow-up and for whom complete anthropometric information was available (n=8,341 children; 49.9% boys). Excluded participants presented a slightly higher proportion of overweight/obesity and higher percentage of lower educated parents (see appendix table 2). The study was conducted according to the declaration of Helsinki. Each participating centre obtained ethical approval from its health research ethics authority. All children provided oral consent and their parents provided written informed consent for all examinations and for the collection of samples, subsequent analysis and storage of personal data and collected samples.

Measurements

Dietary data

Dietary data were obtained at baseline and follow-up surveys applying the food frequency section of the Children's Eating Habits Questionnaire-Food Frequency Questionnaire (CEHQ-FFQ) [24], a validated screening tool in which the parents report the frequency of the child's consumption of selected food items during the preceding four weeks. The questionnaire referred to meals outside the school canteen or childcare meal provision settings only (under parental control) [24; 25]. The CEHQ-FFQ, includes 43 food items from food groups, and was designed as a screening instrument to investigate the consumption of foods shown to be related, either positively or negatively, to overweight and obesity in children, but not to provide an estimate of total energy intake or total food intake [25]. Response options displayed from left to right were as follows: Never/less than once a week; 1-3 times a week; 4-6 times a week; 1 time per day; 2 times per day; 3 times per day; 4 or more times per day; I have no idea. For deriving dietary patterns, K-means cluster analysis was performed to identify clusters of children with similar dietary patterns. This procedure was applied for both baseline and follow-up data sets. The complete procedure and the derived dietary patterns have been previously described in a previous paper [12] and will be taken into account for the purposes of the present study.

Anthropometric measurements

Trained staff carried out anthropometric measurements at baseline and follow-up following a standardised procedure. Body height was measured without shoes and all plaits undone using a portable stadiometer (model: telescopic height measuring instrument SECA 225) to the nearest 0.1 cm. Weight was measured by means of a child-

adapted version of the electronic scale Tanita BC 420 SMA with the children in fasting status (more than eight hours since last meal) and wearing only underwear [26] to the nearest 0.1 kg. For each child, BMI, BMI categories and z-scores of BMI and of BMI change over the 2-year follow-up were determined according to age- and gender-specific BMI reference standards according to the criteria proposed by the International Obesity Task Force [27].

WC was measured using a non-elastic tape (Seca 200) at the midpoint between the iliac crest and the lower border of the tenth rib in a standing position to the nearest 0.1 cm. For each child, z-scores of WC and of WC change over the 2-year follow up were also determined according to age- and gender specific reference standards according to Cole [27].

Skinfold measurements were taken on the right side of the body at the triceps (halfway between the acromion and the olecranon process at the back of the arm) and the subscapular site (about 2 cm below the tip of the scapula at an angle of 45º to the lateral side of the body) with a skinfold calliper (Holtain, range 0-40 mm) to the nearest 0.2 mm. For each child, body fat mass (BFM) was calculated using the gender-specific Slaughter's equations. Fat mass index (FMI) was calculated by dividing BFM by the square of height in metres. Fat free mass index (FFMI) was calculated by dividing lean mass in kg by the square of height in metres. Finally, FMI and FFMI age- and gender specific z-scores were derived.

Parental questionnaire variables

During the baseline and follow-up surveys, parents completed a self-administered questionnaire on parental attitudes, children's behaviour and social environment.

Parental education and income were self-reported. Parental education level was categorised according to the International Standard Classification of Education (ISCED-97) [28]. Household income was assessed using nine country-specific categories based on the median equivalent income. The gained amount was then equalised to the number of household members using the Organisation for Economic Co-operation and Development (OECD) square root scale [29]. Additionally, a migrant background was assumed if one or both of the parents were born in another country. For the purposes of the present analysis, an additive socioeconomic status (SES) indicator constructed by Bammann et al. [30] was used.

In order to assess physical activity, parents reported how many hours (h) and minutes (m) their child spent playing outdoors on a typical weekday and weekend day during the previous month. In addition, parents reported how many hours and minutes per week the child spent doing sport in a sports club. Finally, total physical activity time was calculated and expressed as hours per week.

Statistical methods

In a previous IDEFICS report, K-means cluster analysis was performed to identify clusters of children with similar dietary patterns at baseline and follow-up. These results have been previously published elsewhere [12]. Briefly, the authors described three persistent dietary patterns in children: processed (higher frequency of take away and high-fat foods, such as savoury pastries, fritters, pizza as main dish, fried potatoes, hamburger, hot dog, kebab and wraps, and lowest scores for products such as whole meal bread, cooked vegetables, raw vegetables, and fresh fruits without added sugar), sweet (higher frequency of consumption of sugar-rich products, like chocolate- or nut-based

spread, sweetened drinks, fruit juices, diet drinks, candies, loose candies, marshmallows, and biscuits, packaged cakes, pastries, puddings, with the lowest scores for water, porridge, oat meal, gruel, unsweetened cereals, muesli, raw vegetables, plain unsweetened milk and plain unsweetened yoghurt) and healthy (higher frequency of consumption of low-fat foods, foods rich in vitamins and whole grain foods, e.g. raw vegetables, fresh fruits without added sugar, porridge, oat meal, gruel, unsweetened cereals, muesli and plain unsweetened milk, and the lowest values for high-fat, high-sugar products, such as fried potatoes, sweetened drinks, sweetened milk, mayonnaise and mayonnaise-based products, chocolate- or nut-based spread, crisps, corn crisps, popcorn and biscuits, packaged cakes, pastries and puddings). To assess the changes in dietary patterns over time, children's cluster memberships at baseline and follow-up were cross-tabulated, showing the proportion of children being allocated to the same or to different clusters.

The associations between body composition changes with dietary patterns at baseline (T0) and follow up (T1) were estimated based on mixed models with random effects for country and setting (school) to account for the clustered study design. Dietary patterns at baseline and follow-up as predictor variables and gender, age, intervention vs control, SES score, physical activity and baseline predictor levels as covariates. Analogous models were applied for estimating body composition changes according to different dietary patterns combinations (i.e. healthy, sweet or processed both times; processed/healthy, sweet/processed, etc). The statistically significance level was set at $p \leq 0.05$. The analyses were performed using the Statistical Package for the Social Sciences (SPSS) (Version 20.0, SPSS Inc., Chicago, IL).

Results

Table 1 shows the characteristics of the study sample. 6.5 % of the sample was classified as obese and 12.3% as overweight, while 10.4% was classified as underweight. Based on the 42 food items and their relative frequency of consumption, the most prevalent dietary pattern was the "processed" cluster at baseline (n=4,076 in T0, n=2,360 in T1) while the "healthy" cluster was the most prevalent at follow up (n=2,558 in T0, n=4,256 in T1). The "sweet" cluster showed similar numbers at baseline and follow up (n=1,707 in T0, n=1,725 in T1). Table 2 present the mean and standard deviations of all body composition indicators in the three clusters at baseline and follow-up. The highest BMI z-score and WC z-score means were found in the processed cluster both at baseline and follow up. Likewise, the highest FFMI z-score and FMI z-score means were found in the processed cluster. The lowest values in all 4 indicators were found in the sweet cluster.

Table 3 shows the associations between body composition changes at follow up with dietary patterns at baseline and follow up. Taking the healthy cluster as reference, being allocated to the processed cluster at baseline was associated with larger WC z-score change (β=0.079; 95% confidence interval (CI): 0.022, 0.135) at follow up. Being allocated to the processed cluster at follow up was also associated with larger BMI z-score change (β=0.039; CI: 0.006, 0.071) and larger FMI z-score change (β= 0.045; CI: 0.016, 0.073) at follow up. Taking again the healthy cluster as reference, being allocated to the sweet cluster at baseline was associated with larger WC z-score gain (β=0.078; CI: 0.006, 0.151) at follow up, while being allocated to the sweet cluster at follow up was associated with larger BMI z-score gain (β=0.053; CI: 0.014, 0.091), larger WC z-score gain (β=0.098; CI: 0.034, 0.161) and larger FMI z-score gain (β=0.041; CI: 0.006, 0.075) at follow up.

Figure 1 displays the estimated associations between body composition changes and the different prospective cluster combinations (see also supplementary table 1). Taking into account the healthy-healthy combination as reference, children allocated to the processed-processed combination presented a larger increase in BMI z-score (β= 0.050; CI: 0.006, 0.093), larger WC z-score gain (β=0.071; CI: 0.001, 0.141) and larger FMI z-score increase (β=0.052; CI: 0.014, 0.090) at follow up. Being allocated to the processed-sweet combination was also associated with larger BMI z-score increase (β=0.079; CI: 0.015, 0.143), larger WC z-score increase (β=0.172 (0.069, 0.275) and larger FMI z-score gain (β=0.076; CI: 0.019, 0.133) at follow up. Finally, children allocated to the sweet-sweet combination presented also a larger WC z-score gain (β=0.127; CI: 0.038, 0.216) at follow up.

Discussion

The present study describes associations between dietary patterns and body composition changes in European children applying cross-sectional and prospective models. A dietary pattern characterized by higher frequency of consumption of snacks and fast food (processed) was associated with increased BMI, increased WC and fat mass gain compared to a dietary pattern rich in fruits, vegetables and wholemeal products (healthy). The sweet pattern (higher frequency of consumption of sweet foods and sweetened drinks) was also linked to increased BMI, WC and fat mass gain compared to the healthy pattern. All the described associations were observed accounting for country, setting (school), gender, age, intervention vs control groups, SES, physical activity level and baseline predictor levels.

This paper is based on dietary patterns derived by cluster analysis at two different points in time in 2 to 9-year-old children participating in the IDEFICS Study. These patterns presented similar profiles of relative frequencies of food consumption at each point in time, allowing us to describe changes in body composition in those children consistently presenting unhealthier dietary patterns, and to compare their body composition changes to the changes in children consistently showing healthier dietary profiles. Among all combinations, the persistent processed pattern (children allocated to the processed cluster at baseline and follow-up) and the processed-sweet pattern showed the largest differences in body composition compared to the persistent healthy pattern, with larger increases in body mass and fat gain indicators.

Even if dietary patterns are dependent on the population studied and/or the technique applied (cluster analysis, PCA, RRR) and thus not fully comparable between cohorts, previous studies found similar results. Briefly, several reports described "processed" and "healthy" dietary patterns in children across different studies. Moreover, some studies explored diet longitudinally and found evidence of tracking of the dietary patterns over time, especially the "healthy" and "processed" patterns [19; 31; 32; 33].

Concerning the associations of dietary patterns and later body composition, on the one hand, some studies found associations between "energy-dense, high-fat, high-sugar" or "snacking" dietary patterns and increased BMI [15] and adiposity measured using the FMI [17; 18] over time. On the other hand, a "health-aware" pattern at age 10 years, characterized by higher consumption of fruits and vegetables and whole-grain products and lower consumption of processed foods and soft drinks, was linked to lower fat mass at age 11 years [34]. In Norway, a "varied Norwegian" pattern rich in vegetables, fruits, unrefined cereal products and fish was related to lower risk of

remaining overweight over time from middle childhood (9 to 10 years old) to early adolescence (12 to 13 years old) [16].

The results of the present study add value to the main conclusion of a recent review by Ambrosini [11], where the balance of evidence shows that *aposteriori* dietary patterns defined as high in energy-dense, high-fat and low-fibre foods predispose children and adolescents to later overweight and obesity. Our results replicate previous findings applying an alternative technique (cluster analyses vs PCA / RRR) and taking into account several body composition indices.

This study is subject to a number of limitations. First, the IDEFICS Study was not designed to be representative at national level. The participation in the study was voluntary, thus some population groups, e.g. lower educated families or individuals presenting worse body composition, may have been less willing to take part in the study [35]. As no systematic information on non-participants was available, the direction of a possible bias cannot be predicted. In addition, 43% of the initial baseline cohort did not participate at follow-up and/or did not provide complete data. Excluded participants showed a higher prevalence of overweight/obesity and a higher proportion of lower educated parents (see appendix table 2). Consequently, a selection bias cannot be ruled out. Concerning the dietary information, the CEHQ-FFQ was designed for capturing information on parent-supervised meals but not for recording total food intake. Nevertheless, the data allowed us to describe prospective body composition differences in relation to dietary patterns, as the main inter-individual variation in dietary patterns takes place in the family setting, rather than at school.

To the best of our knowledge, this is the first multi-centre European study assessing dietary patterns over time in relation to prospective body composition changes

in children. Another strength is the large sample size, including a wide variety of dietary habits and cultural backgrounds across eight European countries. The use of a validated dietary instrument shown to provide reproducible estimates of consumption frequencies is also one of the main strengths of the study. Deriving dietary patterns by applying cluster analyses at two points in time allowed us to identify children with consistently healthier or unhealthier dietary profiles and to relate them to prospective body composition changes.

Children consistently showing a processed dietary pattern or changing from a processed pattern to a sweet pattern presented the most unfavourable changes in fat mass and abdominal fat. These results support the need of promoting overall healthier dietary patterns in children in order to prevent overweight and obesity later in life.

Table 1. Characteristics of the study sample: children (n = 8 341) aged 2–9 years from eight European countries, baseline survey of Identification and prevention of Dietary- and lifestyle-induced health EFfects In Children and infantS (IDEFICS) study, September 2007 to May 2008

	total		boys (n=4165)		girls (n=4176)	
	n	**%**	**n**	**%**	**n**	**%**
BMI category						
thinness	865	10.4	433	10.4	432	10.4
Normal weight	5906	70.8	3019	72.5	2887	69.1
overweight	1025	12.3	445	10.7	580	13.9
obesity	545	6.5	268	6.4	277	6.6
Country						
Italy	1352	16.2	690	16.6	662	15.9
Estonia	1063	12.7	511	12.3	552	13.2
Cyprus	962	11.5	503	12.1	459	11.0
Belgium	931	11.2	469	11.3	462	11.1
Sweden	1110	13.3	530	12.7	580	13.9
Germany	915	11.0	457	11.0	458	11.0
Hungary	950	11.4	472	11.3	478	11.4
Spain	1058	12.7	533	12.8	525	12.6
Family socio-economic status						
low	290	3.5	140	3.4	150	3.6
medium	3199	38.4	1620	38.9	1579	37.8
high	3747	44.9	1858	44.6	1889	45.2
dietary pattern baseline (T0)						
processed	4076	48.9	2074	49.8	2002	47.9
sweet	1707	20.5	886	21.3	821	19.7
healthy	2558	30.7	1205	28.9	1353	32.4
dietary pattern follow-up (T1)						
processed	2360	28.3	1239	29.7	1121	26.8
sweet	1725	20.7	914	21.9	811	19.4
healthy	4256	51	2012	48.3	2244	53.7
	mean	**SD**	**mean**	**SD**	**mean**	**SD**
Age, years	6.15	1.68	6.10	1.67	6.20	1.68
Physical Activity, hours/week	17.66	10.62	17.87	10.74	17.46	10.50

Table 2. Body composition indicators by dietary patterns at baseline (T0) and follow-up (T1)

Baseline (T0)				**Follow-up (T1)**			
	Mean	**SD**	**pvalue**		**Mean**	**SD**	**pvalue**
BMI z-score T0				**BMI z-score T1**			
processed (4076)	0.457	1.197	<0.001	*processed (2360)*	0.566	1.361	<0.001
sweet (1707)	0.125	1.070		*sweet (1725)*	0.175	1.275	
healthy (2558)	0.269	1.105		*healthy (4256)*	0.456	1.331	
WC z-score T0				**WC z-score T1**			
processed (4076)	0.383	1.529	<0.001	*processed (2360)*	0.704	1.348	<0.001
sweet (1707)	-0.049	1.255		*sweet (1725)*	0.409	1.231	
healthy (2558)	0.187	1.301		*healthy (4256)*	0.553	1.337	
FFMI z-score T0				**FFMI z-score T1**			
processed (4076)	0.061	1.024	<0.001	*processed (2360)*	0.597	1.027	<0.001
sweet (1707)	-0.154	0.973		*sweet (1725)*	-0.174	0.946	
healthy (2558)	0.008	0.970		*healthy (4256)*	0.038	0.999	
FMI z-score T0				**FMI z-score T1**			
processed (4076)	0.097	1.067	<0.001	*processed (2360)*	0.089	1.062	<0.001
sweet (1707)	-0.169	0.872		*sweet (1725)*	-0.169	0.910	
healthy (2558)	-0.038	0.954		*healthy (4256)*	0.021	0.993	

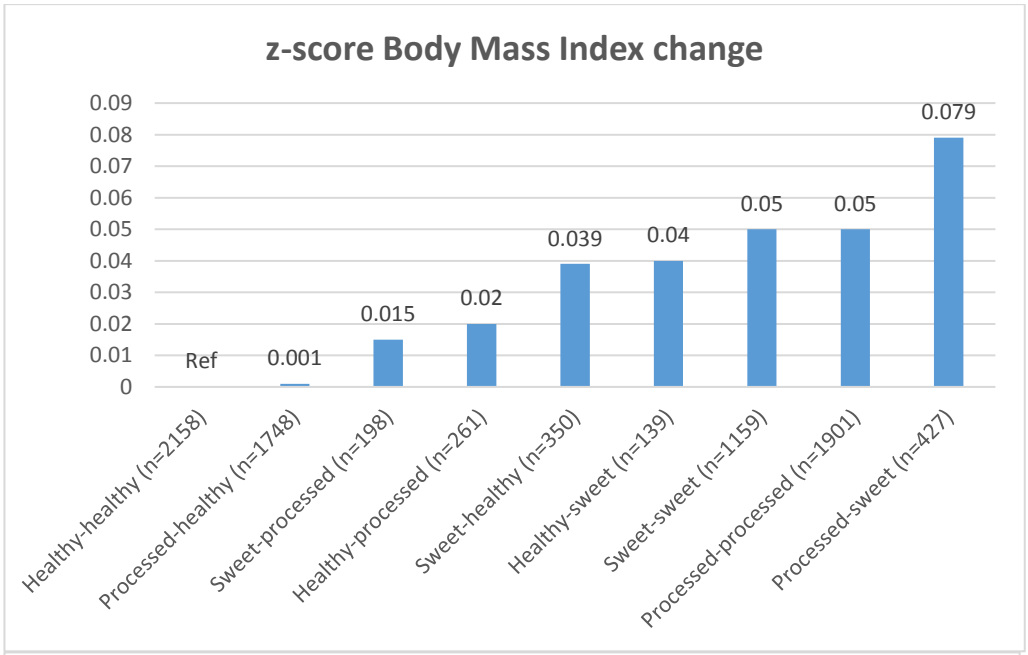
BMI: Body Mass Index; WC: Waist Circumference; FFMI: Fat Free Mass Index; FMI: Fat Mass Index. P-value from analysis of variance (ANOVA).

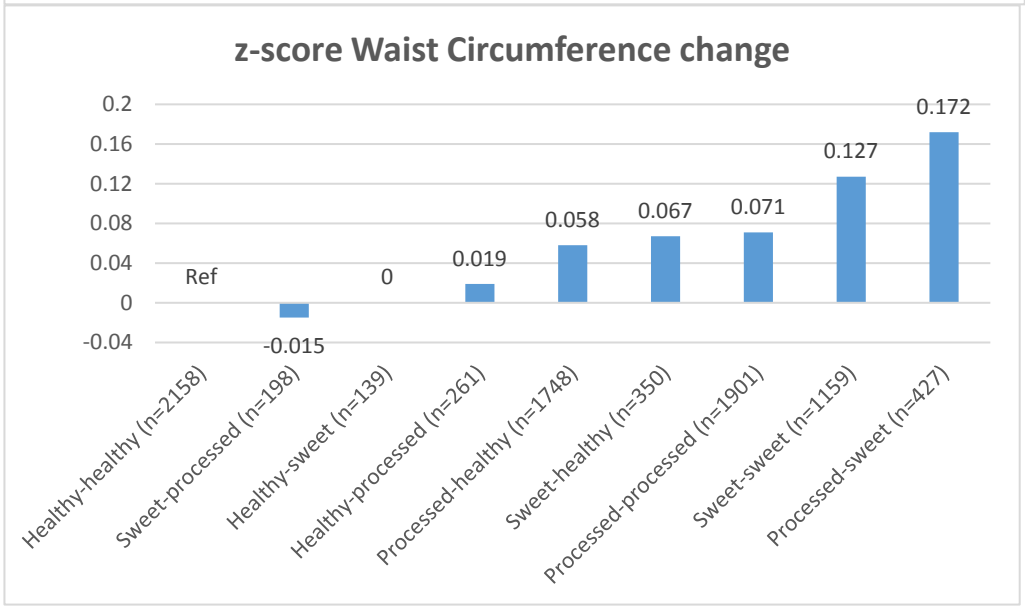
Table 3. Body composition change estimates by dietary patterns at baseline (T0) and follow up (T1)

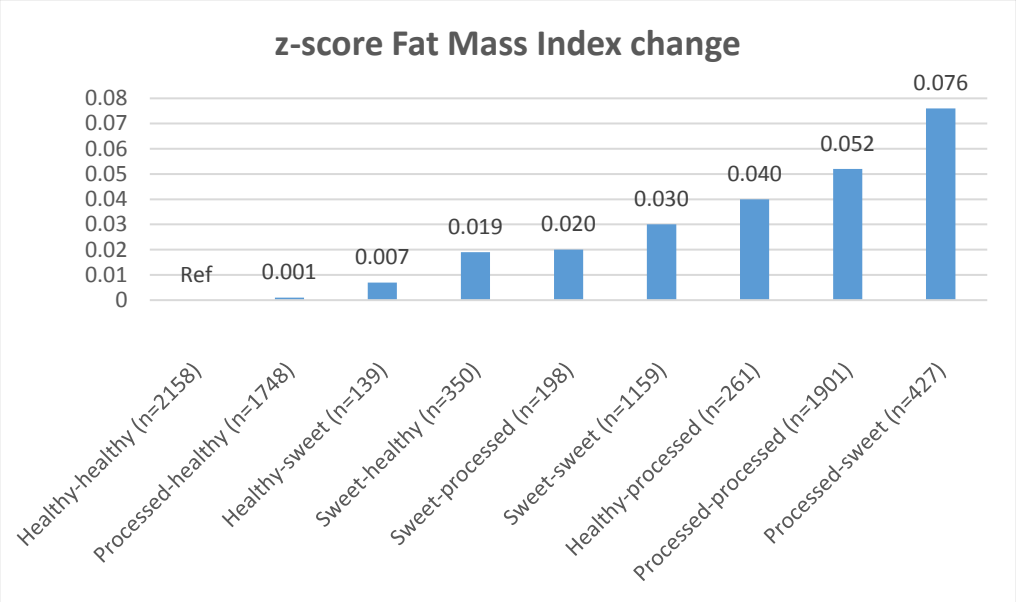
Parameter	Estimate	95% CI		t	p-value
Z-Score BMI (Cole) change					
processed cluster T0 (4076)	0.027	-0.008	0.061	1.506	0.132
sweet cluster T0 (1707)	0.033	-0.011	0.077	1.453	0.147
healthy cluster T0 (2558)	*ref*	.	.	.	.
processed cluster T1 (2360)	0.039	0.006	0.071	2.344	0.019
sweet cluster T1 (1725)	0.053	0.014	0.091	2.657	0.008
healthy cluster T1 (4256)	*ref*	.	.	.	.
Z-score WC (Cole) change					
processed cluster T0 (4076)	0.079	0.022	0.135	2.737	0.006
sweet cluster T0 (1707)	0.078	0.006	0.151	2.116	0.034
healthy cluster T0 (2558)	*ref*	.	.	.	.
processed cluster T1 (2360)	0.019	-0.034	0.071	0.707	0.480
sweet cluster T1 (1725)	0.098	0.034	0.161	3.022	0.003
healthy cluster T1 (4256)	*ref*	.	.	.	.
Z-score FMI change					
processed cluster T0 (4076)	0.026	-0.004	0.057	1.649	0.099
sweet cluster T0 (1707)	0.019	-0.021	0.058	0.921	0.357
healthy cluster T0 (2558)	*ref*	.	.	.	.
processed cluster T1 (2360)	0.045	0.016	0.073	3.025	0.002
sweet cluster T1 (1725)	0.041	0.006	0.075	2.322	0.020
healthy cluster T1 (4256)	*ref*	.	.	.	.
Z-scores FFMI change					
processed cluster T0 (4076)	-0.004	-0.065	0.056	-0.134	0.893
sweet cluster T0 (1707)	0.013	-0.066	0.091	0.316	0.752
healthy cluster T0 (2558)	*ref*	.	.	.	.
processed cluster T1 (2360)	-0.048	-0.105	0.009	-1.641	0.101
sweet cluster T1 (1725)	-0.014	-0.083	0.054	-0.405	0.685
healthy cluster T1 (4256)	*ref*	.	.	.	.

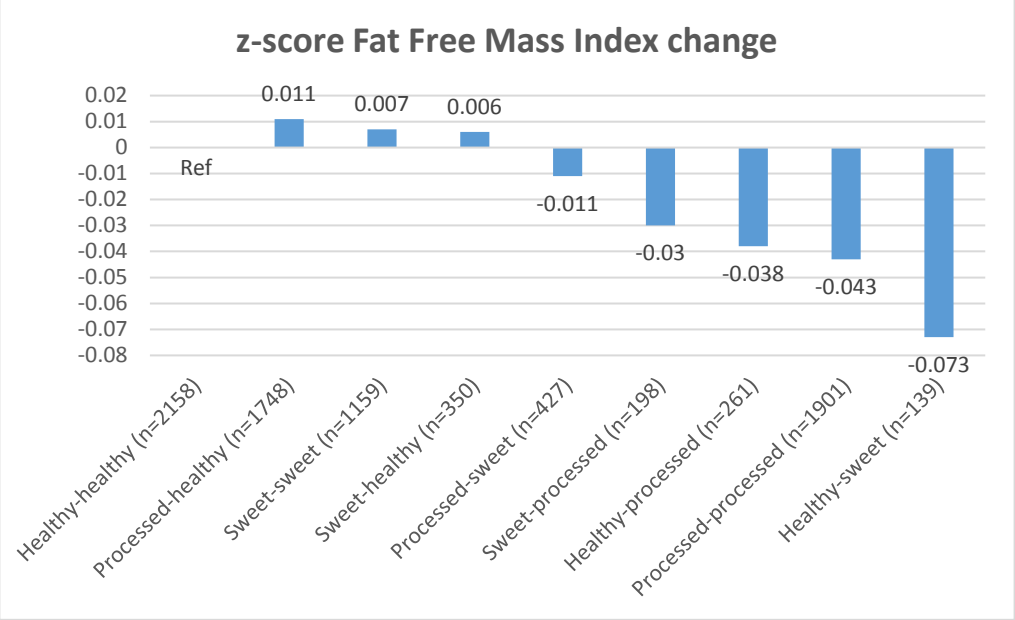
mixed models with body composition parameters as the outcome with random effects for country and setting, dietary pattern in T0, T1 or both as predictor variables and gender, age, intervention vs control, SES, physical activity level and baseline predictor levels as covariates. BMI: Body Mass Index; WC: Waist Circumference; FFMI: Fat Free Mass Index; FMI: Fat Mass Index.

Figure 1. Mixed models with body composition parameters as the outcome, dietary patterns combination sin T0 and T1 as predictor variables, random effects for country and setting and gender, age, intervention vs control, SES, physical activity level and baseline predictor levels as covariates. (A) BMI z-score change estimates by prospective dietary patterns combinations; (B) Waist circumference z-score change estimates by prospective dietary patterns combinations; (C) Fat mass index change by prospective dietary patterns combinations; (D) Fat free mass index change by prospective dietary patterns combinations. *p<0.05; † p<0.001






z-score Fat Mass Index change
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Ref
0.001
0.007
0.019
0.020
0.030
0.040
0.052
0.076
Healthy-healthy (n=2158)
Processed-healthy (n=1748)
Healthy-sweet (n=139)
Sweet-healthy (n=350)
Sweet-processed (n=198)
Sweet-sweet (n=1159)
Healthy-processed (n=261)
Processed-processed (n=1901)
Processed-sweet (n=427)


z-score Fat Free Mass Index change
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
-0.08
Ref
0.011
0.007
0.006
-0.011
-0.03
-0.038
-0.043
-0.073
Healthy-healthy (n=2158)
Processed-healthy (n=1748)
Sweet-sweet (n=1159)
Sweet-healthy (n=350)
Processed-sweet (n=427)
Sweet-processed (n=198)
Healthy-processed (n=261)
Processed-processed (n=1901)
Healthy-sweet (n=139)

Appendix table 1. Body composition change estimates by prospective dietary patterns combinations

Parameter	Estimate	95% CI		t	p-value
Z-Score BMI (Cole) change					
processed-processed (1901)	0.050	0.006	0.093	2.255	0.024
sweet-processed (198)	0.015	-0.075	0.105	0.330	0.741
healthy-processed (261)	0.020	-0.062	0.102	0.483	0.629
processed-sweet (427)	0.079	0.015	0.143	2.413	0.016
sweet-sweet (1159)	0.050	-0.004	0.103	1.822	0.069
healthy-sweet (139)	0.040	-0.058	0.139	0.805	0.421
processed-healthy (1748)	0.001	-0.042	0.043	0.032	0.975
sweet-healthy (350)	0.039	-0.030	0.109	1.109	0.268
healthy-healthy (2158)	*ref*	.	.	.	.
Z-score Waist (Cole) change					
processed-processed (1901)	0.071	0.001	0.141	1.999	0.046
sweet-processed (198)	-0.015	-0.159	0.129	-0.200	0.842
healthy-processed (261)	0.019	-0.113	0.151	0.287	0.774
processed-sweet (427)	0.172	0.069	0.275	3.268	0.001
sweet-sweet (1159)	0.127	0.038	0.216	2.808	0.005
healthy-sweet (139)	0.000	-0.158	0.158	0.003	0.998
processed-healthy (1748)	0.058	-0.011	0.126	1.644	0.100
sweet-healthy (350)	0.067	-0.045	0.179	1.166	0.244
healthy-healthy (2158)	*ref*	.	.	.	.
Z-score FMI change					
processed-processed (1901)	0.052	0.014	0.090	2.681	0.007
sweet-processed (198)	0.020	-0.058	0.099	0.507	0.612
healthy-processed (261)	0.040	-0.033	0.113	1.079	0.281
processed-sweet (427)	0.076	0.019	0.133	2.626	0.009
sweet-sweet (1159)	0.030	-0.017	0.078	1.246	0.213
healthy-sweet (139)	0.007	-0.077	0.092	0.171	0.864
processed-healthy (1748)	0.001	-0.037	0.038	0.023	0.982
sweet-healthy (350)	0.019	-0.004	0.081	0.615	0.539
healthy-healthy (2158)	*ref*	.	.	.	.
Z-score FFMI change					
processed-processed (1901)	-0.043	-0.119	0.032	-1.122	0.262
sweet-processed (198)	-0.030	-0.184	0.125	-0.375	0.707
healthy-processed (261)	-0.038	-0.181	0.105	-0.522	0.601
processed-sweet (427)	-0.011	-0.123	0.100	-0.202	0.840
sweet-sweet (1159)	0.007	-0.089	0.104	0.149	0.882
healthy-sweet (139)	-0.073	-0.240	0.093	-0.869	0.385
processed-healthy (1748)	0.011	-0.064	0.085	0.279	0.780
sweet-healthy (350)	0.006	-0.115	0.128	0.101	0.919
healthy-healthy (2158)	*ref*	.	.	.	.

mixed models with body composition parameters as the outcome with random effects for country and setting, dietary pattern in T0, T1 or both as predictor variables and gender, age, intervention vs control, SES, physical activity level and baseline predictor levels as covariates

Appendix table 2. Description of the included and excluded subjects participating in the IDEFICS baseline study (T0).

	Included n	%	Excluded n	%	p-value
Total	8341		7383		
Gender					
Boys	4133	50	3818	52	0.007
Girls	4208	50	3565	48	
Age					
<6 years	3901	47	3417	46	0.536
≥6 years	4440	53	3966	54	
BMI categories					
Underweight	958	12	860	12	<0.001
Normal weight	5859	70	4972	67	
Overweight	997	12	972	13	
Obese	528	6	579	8	
Parental Education					
Low	561	7	693	10	<0.001
Medium	4255	52	3538	53	
High	3400	41	2474	40	

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5. Discusión [Discussion]

5.1 Nivel socioeconómico, sobrepeso y obesidad infantil

La asociación entre el nivel socioeconómico y la prevalencia de sobrepeso y obesidad infantil ha sido explorada por diversos autores[48,50]. Los datos aportados en la última década, indican que la mayor parte de las asociaciones entre nivel socioeconómico y sobrepeso y obesidad infantil en países industrializados son inversas, y que las asociaciones positivas o directas han desaparecido.

En la presente Tesis Doctoral se presentan los resultados derivados del estudio IDEFICS (Artículo I), encontrando un gradiente inverso entre los indicadores socioeconómicos clásicos y la prevalencia de sobrepeso y obesidad, en cinco de las ocho regiones participantes (situadas en Alemania, Bélgica, España, Estonia y Suecia). En las tres regiones restantes (situadas en Chipre, Italia y Hungría), no se encontró asociación alguna. En aquellos centros donde se encontró asociación, el nivel educativo de los padres y la ocupación laboral fueron los indicadores que más contribuyeron a la asociación. Además, también se investigaron indicadores macroeconómicos que pudiesen explicar el gradiente socioeconómico existente. De todos ellos, el Índice de Desarrollo Humano propio de cada país y los ingresos medios de cada centro participante, mostraron la mayor asociación con el gradiente socioeconómico en cuanto a la prevalencia de sobrepeso y obesidad infantil.

El impacto del nivel de desarrollo humano de cada país en la asociación entre nivel socioeconómico y obesidad ya había sido observado anteriormente[47,50,90]. Dicho impacto explica la diversidad encontrada habitualmente en la fuerza y dirección de las asociaciones arriba descritas, incluso en los países de mayor desarrollo. Los resultados

del estudio IDEFICS muestran que los tres indicadores clásicos utilizados en la literatura (educación, ocupación, ingresos) contribuyeron al gradiente socioeconómico en el sobrepeso y obesidad infantil, aunque de especial importancia resultó el nivel educativo de los padres. Además de los indicadores individuales, fáciles de comprender y de utilizar, se valoró el uso de un indicador aditivo, a modo de constructo recopilatorio de las principales variables. Si bien dicho indicador puede no ser tan intuitivo como los indicadores individuales, su uso resulta de utilidad para la descripción de datos y para su inclusión en modelos estadísticos más complejos, o para su uso como variable de ajuste. En el caso particular de Estonia, dicho indicador aditivo reflejó en mayor medida el gradiente en sobrepeso y obesidad comparado con los tres indicadores individuales. En el artículo III, dicho indicador fue utilizado de nuevo, ya que mostró mayor asociación con los patrones dietéticos que en el caso del nivel educativo de los padres.

Además de los factores clásicos, algunos indicadores adicionales de vulnerabilidad social han recibido atención creciente en la literatura[91-93]. Algunos de los factores recientemente estudiados incluyen la pertenencia a minorías étnicas[94] o de inmigrantes[95], pertenecer a familias monoparentales[96], situaciones de precariedad laboral y desempleo[97], etc. La presente Tesis Doctoral muestra de manera sucinta las asociaciones con algunos de dichos factores. Pertenecer a familias monoparentales o de inmigrantes se asoció con mayor prevalencia de sobrepeso y obesidad en algunos de los centros, pero no en otros. En cuanto al desempleo y el tamaño de la red social, no se observó un patrón claro en los resultados, encontrándose tanto asociaciones positivas como negativas e incluso no asociación. La heterogeneidad entre los centros acerca del porcentaje de participantes incluidos dentro de alguna de las categorías anteriores puede explicar parcialmente la falta de resultados concluyentes al respecto.

5.2 Nivel socioeconómico y hábitos dietéticos

La mayor parte de la presente Tesis Doctoral explora la asociación entre el nivel socioeconómico familiar y los hábitos dietéticos de los niños participantes. El artículo II describe las diferencias socioeconómicas en la frecuencia de consumo de los principales grupos de alimentos explorados en el estudio IDEFICS. De manera global, en los niños con padres de menor nivel educativo se observó un consumo menos frecuente de frutas, verduras, agua y pan integral, y un consumo más frecuente de patatas fritas, fruta con azúcar añadido, carne y pescado fritos, comida rápida, refrescos, snacks, postres y productos dulces para untar, comparado con los hijos de padres de alto nivel educativo. Si bien dichas diferencias en la frecuencia de consumo se encontraron a nivel global, el análisis por separado para cada país mostró diferencias culturales en algunos de ellos, reflejo de la cultura gastronómica de la región y de las diferencias culturales sobre la percepción de los alimentos en cuanto a la salud. Por ejemplo, en Italia la frecuencia en el consumo de pasta fue mayor en el grupo de niños con padres de alto nivel educativo. En el caso del pan, la frecuencia de consumo de pan integral de manera global es mayor en los países del norte, independientemente del nivel educativo, mientras que el consumo de pan blanco es más prevalente en los países del sur.

Más allá del consumo de ciertos grupos de alimentos evaluados de manera individual, para el conjunto de la cohorte IDEFICS, y para cada uno de los centros participantes, el artículo III explora patrones dietéticos específicos para cada país, derivados del uso del análisis de componentes principales, una de las herramientas estadísticas más utilizadas en el análisis de patrones dietéticos en estudios epidemiológicos[98,99]. Dicha técnica recoge la información de todos los ítems incluidos en el cuestionario de frecuencia de consumo de alimentos, y crea nuevas variables (o componentes principales) que son

combinaciones lineares independientes de las variables que explican la mayor varianza posible. En este caso, se decidió aplicar la técnica de manera independiente para cada país en base a 1) los resultados obtenidos en el artículo II, donde se observaron diferencias específicas en las frecuencias de consumo ligadas a las particularidades de cada centro, y 2) a modo de complemento sobre un artículo previo donde se describieron los patrones dietéticos generales en la cohorte IDEFICS[100]. El resultado principal del artículo III es la existencia de un patrón "procesado" en las ocho regiones investigadas, con características muy similares entre sí, que se basan en una alta frecuencia de consumo de alimentos procesados como patatas fritas, hamburguesas, perritos calientes, patatas chips, bebidas azucaradas, galletas, helados y chocolates. En segundo lugar, también se encontró un patrón denominado "saludable" en todas las regiones salvo en Chipre, caracterizado por un consumo más frecuente de frutas y verduras crudas y cocinadas, leche sin azucarar, pescado, pan integral, frutos secos y semillas. Ambos patrones fueron muy similares en todos los centros, lo que indica que más allá de las diferencias culturales específicas de cada país, existen prácticas dietéticas comunes y prevalentes, que sugieren una disminución de las diferencias en el consumo de alimentos en los distintos países europeos. No obstante, también se describieron algunos patrones dietéticos específicos de algunas de las regiones. En particular, se describió un patrón "tradicional" en las regiones situadas en España y Chipre, caracterizado en cada caso por altas frecuencias de consumo de grupos de alimentos propios de la cultura gastronómica del país.

En línea con los resultados del artículo II, el artículo III muestra que el patrón "procesado" se asoció inversamente con el nivel socioeconómico (salvo en Suecia, donde el número de comidas bajo control parental fue menor que en el resto de centros). En cuanto al patrón "saludable" se encontró asociación directa en el caso de los centros

situados en Bélgica, Estonia, Alemana y Hungría, mientras que en el caso de Italia, España y Suecia no se encontró asociación. Dichos resultados, especialmente en los centros en Italia y España podrían reflejar la discrepancia observada en una reciente revisión sistemática acerca de la asociación de la dieta mediterránea con el gradiente socioeconómico[101].

Diversos estudios anteriores han descrito asociaciones entre niveles socioeconómicos más bajos y patrones dietéticos ricos en productos procesados y snacks[102-104], así como asociaciones entre niveles socioeconómicos más altos y dietas más saludables[59,102,105]. En este sentido, los resultados obtenidos en el artículo III coinciden con las investigaciones previas en el gradiente socioeconómico y la calidad global de la dieta en niños y adolescentes.

Tras valorar, de manera transversal, los patrones dietéticos principales en los distintos centros participantes, se consideró importante explorar la estabilidad de los patrones dietéticos a lo largo del tiempo y su asociación con el nivel socioeconómico, especialmente en aquellos casos en los que los patrones se mostrasen persistentes a lo largo del tiempo. Para ello, se optó por aplicar la técnica del análisis de conglomerados en aquellos participantes con información válida tanto para el estudio transversal como para el seguimiento. Dicha técnica[106] agrupa a los sujetos en distintos grupos en base a sus frecuencias de consumo de alimentos, creando grupos de participantes con patrones dietéticos relativamente homogéneos entre sí, y distintos de los del resto de participantes. De esta manera, se pudo detectar a aquellos participantes que mostraron patrones persistentes en ambos momentos temporales, y caracterizarlos en base a sus características socioeconómicas. Los análisis, efectuados para el conjunto de la muestra, agruparon a los sujetos en tres patrones dietéticos consistentes en ambos momentos

temporales. El primer patrón denominado “procesado” se caracterizó por mayor frecuencia de consumo de snacks y comida rápida y menor frecuencia de verduras y productos integrales; el segundo patrón denominado “dulce” se caracterizó por mayor consumo de galletas y productos dulces, caramelos y bebidas azucaradas. Por último, el patrón denominado “saludable” se caracterizó por mayores frecuencias de consumo de frutas, verduras y productos integrales y menores frecuencias de consumo de alimentos procesados. Los tres patrones mostraron frecuencias de consumo similares en ambos momentos temporales y por ello se consideraron equiparables. De esta manera, la muestra pudo agruparse en base a la clasificación en T0, T1 y la combinación de ambos momentos. La clasificación en grupos se asoció con un número de indicadores socioeconómicos, incluyendo el nivel educativo materno y paterno, el nivel de ingresos del hogar y el pertenecer al grupo inmigrante. Fundamentalmente, los participantes con madres y padres de alto nivel educativo y de mayores ingresos familiares tuvieron mayores probabilidades de ser agrupados en el patrón “saludable” y menores probabilidades de ser agrupados en el patrón “dulce” en ambos puntos temporales comparado con los hijos de padres con menor nivel educativo. Los participantes hijos de inmigrantes mostraron a su vez mayores probabilidades de permanecer en el patrón “procesado” en ambos grupos temporales comparado con los hijos de no inmigrantes.

El análisis de conglomerados permitió describir a la muestra en base a los patrones dietéticos principales derivados considerando las frecuencias de consumo de alimentos. Comparando los resultados con los obtenidos en un estudio previo en la misma cohorte, que aplicó el análisis de componentes principales[100], se observan patrones muy similares en el caso de los denominados “procesado” y “dulce”. Dicho estudio[100] describió un tercer patrón caracterizado por alta frecuencia de consumo de vegetales, frutas y productos

integrales, y un cuarto patrón denominado "proteína y agua", con alta frecuencia de consumo de proteínas animales (carne, pescado y huevos) y agua, a diferencia del tercer patrón aquí descrito, denominado "saludable", hasta cierto punto equiparable, pero con diferencias evidentes. Una posible explicación para las diferencias encontradas es que el análisis de conglomerados es dependiente de la muestra estudiada[107], y por tanto los resultados obtenidos no son completamente comparables a los de la publicación previa. En nuestro caso, la muestra se redujo a aquellos sujetos con información válida en ambos puntos temporales (n=9301), mientras que en el estudio anterior la muestra alcanzó un tamaño mayor (n=14989).

A pesar de que los resultados de diferentes cohortes no son completamente comparables, otros estudios han encontrado resultados similares en población infantil y adolescente. Un estudio llevado a cabo en niños británicos de 7 años de edad describió un patrón "procesado", otro "basado en vegetales" y otro "tradicional"[108]. Otro estudio en China describió un patrón "saludable", un patrón "de transición" y un patrón "occidental" en niños de 6 a 13 años de edad[109]. Sin embargo, también hemos encontrado estudios con resultados diversos, describiendo un número variable de patrones (desde 2 hasta 7) y con diferentes características[110-117]. Tal heterogeneidad en los resultados puede deberse a distintos factores, incluyendo las poblaciones de referencia (distintas culturas gastronómicas), diferentes métodos de valoración de la dieta (cuestionarios de frecuencia de consumo de alimentos, recuerdos de 24-horas, historia dietética)[118], diferente tipo y número de alimentos a estudio y las distintas decisiones estadísticas para la obtención de patrones dietéticos derivados mediante el análisis de conglomerados (métodos jerárquicos vs métodos no jerárquicos). Aún con las limitaciones y consideraciones descritas, los patrones que más se repiten en la literatura son los

denominados “procesados / occidentales” y los “saludables”. Los artículos III y IV por tanto, muestran datos en concordancia con la mayoría de la literatura.

5.3 Patrones dietéticos y cambios en composición corporal

Una vez descritos los patrones dietéticos principales en la muestra a estudio, el último artículo incluido en la presente Tesis Doctoral fue el estudio de la asociación entre los patrones dietéticos y distintos parámetros de composición corporal, tanto de manera transversal (T0 o T1) como de manera prospectiva (cambio entre T0 y T1). Los resultados del artículo V mostraron que los participantes agrupados en ambos puntos temporales en el patrón denominado “procesado” (con mayor frecuencia de consumo de snacks y comida rápida) mostraron mayor incremento entre T0 y T1 en IMC, circunferencia de cintura e índice de masa grasa, comparado con los participantes agrupados en el patrón “saludable” (caracterizado por mayor frecuencia de consumo de frutas, verduras y productos integrales). Además, los sujetos agrupados en el patrón “dulce” (mayor frecuencia de consumo de productos dulces y bebidas azucaradas) en ambos puntos temporales también mostraron mayor incremento en IMC, circunferencia de cintura e índice de masa grasa, comparado con los participantes agrupados en el patrón “saludable”.

Los resultados mostraron que, comparado con el patrón “saludable”, el mayor incremento en marcadores de masa grasa y de IMC entre T0 y T1 tuvo lugar en los grupos de participantes que permanecieron a lo largo del tiempo en el patrón “procesado” o en el patrón “dulce”.

Anteriormente, en la literatura ya se describieron patrones dietéticos “procesados” y “saludables” en niños y adolescentes en diversos estudios. Algunos de dichos estudios

exploraron los patrones dietéticos de manera longitudinal, encontrando que gran parte de los sujetos estudiados mostraban patrones dietéticos persistentes a lo largo del tiempo[119], especialmente en el caso de los sujetos agrupados en patrones "saludables" y "procesados"[112,120]. En cuanto a la asociación de los distintos patrones dietéticos con la composición corporal al cabo del tiempo, la literatura ofrece por una parte asociaciones entre patrones de alta densidad energética, ricos en grasa y azúcares y mayores incrementos en IMC[121] y adiposidad general[122,123], mientras que por otra parte, patrones dietéticos caracterizados por mayor consumo de frutas y verduras, productos integrales y menor consumo de refrescos y alimentos procesados se han asociado con menor masa grasa en niños de 11 años de edad[113], y con menor riesgo de mantener sobrepeso en el paso de la infancia tardía a la adolescencia[124].

Una revisión reciente de la literatura[79] concluye que los patrones derivados a posteriori (análisis de componentes principales, RRR), que se caracterizan por tener alta densidad energética, ricos en grasa y bajos en fibra predisponen a los niños y adolescentes a desarrollar sobrepeso y obesidad. En este sentido, los datos del artículo V añaden evidencia al replicar dichos resultados mediante el uso de una técnica alternativa para la descripción de patrones dietéticos (análisis de conglomerados) y teniendo en cuenta diversos índices de composición corporal. Por tanto, los resultados obtenidos evidencian la necesidad de promover patrones alimentarios saludables en niños, con el objetivo de dificultar cambios antropométricos desfavorables y prevenir el desarrollo de sobrepeso y obesidad en el futuro.

5.4 Implicaciones para la salud pública

La Organización Mundial de la salud define como dieta saludable aquella que permite mantener el balance energético, limitando la ingesta de grasas totales, azúcares simples y sal y con alto consumo de frutas, verduras, legumbres, frutos secos y cereales integrales[125]. Los resultados obtenidos en la presente Tesis Doctoral ponen de manifiesto el gradiente socioeconómico existente en a) la prevalencia de sobrepeso en cinco de las ocho regiones estudiadas y b) en los hábitos dietéticos de los participantes a estudio, observando mayor probabilidad de llevar dietas poco saludables en los grupos socioeconómicamente más desfavorecidos. Además, los resultados del artículo V indican que los niños con patrones dietéticos menos saludables presentan mayor incremento en su masa grasa al cabo del tiempo. Por tanto, estos resultados destacan la importancia de promover desde edades tempranas una alimentación saludable para la prevención del desarrollo de sobrepeso durante la infancia y adolescencia y más tarde en el ciclo vital, ya que los hábitos establecidos en edades tempranas tienden a persistir en la edad adulta.

Además, los resultados arriba expuestos indican que la promoción de hábitos saludables debe ir especialmente dirigida a los grupos socioeconómicamente más vulnerables, ya que acumulan mayor prevalencia de sobrepeso y tienden a presentar estilos de alimentación más desfavorables. A pesar de la sencillez del mensaje, la puesta en práctica de estrategias de promoción de una alimentación saludable en los grupos socioeconómicamente más desfavorecidos no está exenta de dificultades. La literatura muestra que si bien algunas iniciativas llevadas a cabo en edades tempranas, especialmente aquellas dirigidas a modificar las condiciones ambientales, presentan el potencial para limitar o disminuir las desigualdades socioeconómicas en los comportamientos relacionados con la salud[126], otros tipos de intervención,

especialmente las dirigidas a modificar los comportamientos a nivel individual, tienden a aumentar la desigualdad socioeconómica[127,128]. En este sentido, los centros escolares se consideran un entorno idóneo para la implementación de estrategias de promoción de la salud, ya que presentan el potencial de llegar a todos los alumnos, independientemente de su estatus socioeconómico[129].

A pesar del relativamente extenso número de intervenciones que se han llevado a cabo en el entorno escolar para promover una alimentación saludable, evaluar el impacto diferencial en distintos niveles socioeconómicos no siempre ha sido posible. Hasta el momento, algunas iniciativas se han mostrado eficaces por igual en todos los niveles, como por ejemplo incrementar el acceso a frutas o proporcionar desayunos en la escuela sin incrementar el coste para las familias, o proporcionar contenido curricular adicional acerca de los beneficios de frutas y verduras[130,131]. Sin embargo, la falta de datos relativos al efecto que presentan otro tipo de intervenciones que modifiquen en mayor medida el entorno[132], incluyendo la implementación de cambios más globales y cambios legislativos, debería incentivar a los profesionales de la salud pública para llevar a cabo estudios que permitan conocer en mayor profundidad qué tipos de intervención son los más efectivos para la población en su conjunto y que a su vez permitan reducir las desigualdades socioeconómicas en la salud.

Hasta el momento, la evidencia sugiere que las intervenciones denominadas "upstream" (de abajo hacia arriba) son las que mayor efecto han mostrado a la hora de reducir las desigualdades socioeconómicas en la dieta, ya que intentan reducir las diferencias debidas a la falta de recursos, y por tanto muestran mayor efectividad en los segmentos económicamente más desfavorecidos. Algunos ejemplos de dichas iniciativas serían las centradas en el coste de los productos (subvención de alimentos saludables y

tasas en aquellos menos saludables, disponibilidad de fruta y agua en la escuela, etc). Por el contrario, las intervenciones "downstream" (de arriba abajo), centradas en el comportamiento individual y en el mantenimiento del cambio (educación nutricional y consejo dietético), han mostrado menor capacidad para reducir desigualdades, llegando incluso a aumentarlas[133].

Los resultados globales de la presente Tesis Doctoral ponen de manifiesto la necesidad de seguir investigando en encontrar el mejor modo de promocionar hábitos de alimentación saludables en la población de manera que todos los segmentos, especialmente los más afectados, puedan beneficiarse. Para ello, es necesario que los estudios futuros planteen la valoración de los efectos diferenciales según nivel socioeconómico desde el inicio de la fase de diseño, para poder dotar a los mismos de suficiente poder estadístico. De esta manera, las futuras revisiones sistemáticas podrán contar con evidencia de mayor calidad, permitiendo a su vez conocer con mayor precisión hacia dónde encaminar los esfuerzos en el campo de la salud pública para la promoción de la alimentación saludable y la reducción de las desigualdades socioeconómicas en la prevalencia de sobrepeso y obesidad infantil.

6. Aportaciones principales de la tesis doctoral

Artículo I. En cinco de las ocho regiones investigadas (situadas en Bélgica, Estonia, Alemania, España y Suecia), la prevalencia de sobrepeso infantil mostró un gradiente socioeconómico inverso. Por el contrario, en las otras tres regiones (situadas en Chipre, Hungría e Italia), no se observó asociación entre el nivel socioeconómico y el sobrepeso infantil. Destaca que tanto la asociación entre el índice de desarrollo humano propio de cada país como los ingresos medios de cada región fueron capaces de explicar en gran medida la asociación entre nivel socioeconómico y sobrepeso infantil.

Artículo II. Los hijos de padres con nivel educativo medio o bajo consumieron alimentos bajos en azúcar y grasas (verduras, frutas, pasta/arroz, pan integral) con menor frecuencia y alimentos ricos en azúcar y grasas (patatas fritas, frutas con azúcar añadido, postres, snacks y refrescos) con mayor frecuencia comparado con los hijos de padres de nivel educativo alto.

Artículo III. Se encontró un patrón dietético "procesado" en las ocho regiones investigadas, además de un patrón "saludable" en siete de dichas regiones y diversos patrones específicos de cada país. Se encontró asociación inversa entre el nivel socioeconómico y el patrón "procesado" en todas las regiones salvo en una, mientras que el nivel socioeconómico mostró asociación directa con el patrón "saludable" en cuatro de las regiones.

Artículo IV. Se describieron tres patrones dietéticos denominados “Procesado”, “dulce” y “saludable” en dos momentos temporales. Los niños con madres y padres de nivel educativo alto, y aquellos con padres con ingresos altos tuvieron mayor probabilidad de permanecer en el patrón “saludable” en ambos momentos temporales. Los participantes hijos de inmigrantes tuvieron mayor probabilidad de permanecer en el patrón “procesado” en ambos puntos temporales.

Artículo V. Los participantes que mostraron un patrón “procesado” (mayor frecuencia de consumo de snacks y comida rápida) en ambos puntos temporales presentaron mayor incremento de IMC, circunferencia de cintura e índice de masa grasa comparado con los participantes con patrón “saludable” (mayor frecuencia de consumo de frutas, verduras y cereales integrales). Permanecer en el patrón “dulce” (mayor frecuencia de consumo de alimentos dulces y refrescos) también se asoció con mayor incremento en el IMC, circunferencia de cintura e índice de masa grasa.

6. Main thesis contributions

Manuscript I. In five of the eight investigated regions (located in Belgium, Estonia, Germany, Spain and Sweden) the prevalence of childhood overweight followed an inverse SES gradient. In the other three regions (located in Cyprus, Hungary and Italy), no association between SES and childhood overweight was found. The SES-overweight association was best explained by the country-specific human development index and the centre-specific mean income.

Manuscript II. Children in the low and medium parental education level groups had less frequent consumption of low-sugar and low-fat foods (vegetables, fruits, pasta/rice an wholemeal bread) and more frequent consumption of high-sugar and high-fat foods (fried potatoes, fruits with sugar added, snacks/desserts and sugared beverages) than children in the high parental education group.

Manuscript III. A "processed" pattern was found in the eight regions included. A "healthy" pattern was identified in seven of the eight regions, and region-specific patterns were also described. The "processed" pattern was inversely associated with the SES indicator in all countries except one, whereas the "healthy" pattern was positively associated with SES in four regions.

Manuscript IV. Three consistent clusters were described at two time points: "processed", "sweet" and "healthy". Children with higher-educated mothers and fathers and the highest household income were more likely to be allocated to the "healthy" cluster and

less likely to be allocated to the “sweet” cluster at the two time points. Migrants were more likely to be allocated to the “processed” cluster at the two time points.

Manuscript V. Children consistently allocated to the “processed” cluster (higher frequency of consumption of snacks and fast food) presented increased body mass index, increased waist circumference and increased fat mass gain over time compared to children allocated to the “healthy” cluster (higher frequency of consumption of fruits, vegetables and wholemeal products). Being in the “sweet” cluster (higher frequency of consumption of sweet foods and sweetened drinks) was also linked to increased body mass index, increased waist circumference and increased fat mass gain over time.

7. Conclusiones

Artículo I. En la mayoría de las regiones estudiadas se observó una asociación inversa entre factores socioeconómicos y el sobrepeso infantil.

Artículo II. Un nivel educativo bajo en los padres y madres se asoció con una ingesta más frecuente de alimentos ricos en azúcares y grasas por parte de sus hijos, mientras que los hijos de padres con mayor nivel educativo consumieron alimentos bajos en grasa y azúcar con mayor frecuencia.

Artículo III. El nivel socioeconómico familiar fue asociado inversamente con un patrón dietético denominado "procesado", de características muy similares en todos los centros participantes, mostrando que los hijos de familias con menor nivel socioeconómico presentan mayor riesgo de presentar hábitos dietéticos poco saludables.

Artículo IV. El uso del análisis de conglomerados para describir a la muestra en base a su frecuencia de consumo de alimentos en dos puntos temporales, permitió identificar a subgrupos de participantes con hábitos dietéticos poco saludables de manera persistente a lo largo del tiempo. La probabilidad de pertenencia a dichos subgrupos fue mayor para los participantes de menor nivel socioeconómico.

Artículo V. Los participantes que mostraron un patrón dietético "procesado" de manera persistente a lo largo del tiempo, así como aquellos que pasaron del patrón "procesado"

al patrón “dulce”, presentaron cambios en masa grasa y grasa abdominal más desfavorables a lo largo del tiempo.

7. Conclusions

Manuscript I. The association between socioeconomic factors and childhood overweight was shown to be heterogeneous across different European regions.

Manuscript II. Low parental education level was associated with intakes of sugar-rich and fatty foods among children, while high parental education level was associated with intakes of low-sugar and low-fat foods.

Manuscript III. Socioeconomic status was inversely associated with a "processed" pattern, with comparable food item profiles across the countries, showing that children of parents with lower socioeconomic status may be at higher risk of unhealthy eating.

Manuscript IV. Applying the cluster analysis to derive dietary patterns at two time points allowed the identification of groups of children from a lower socioeconomic background presenting persistently unhealthier dietary profiles.

Manuscript V. Children consistently showing a processed dietary pattern or changing from a processed pattern to a sweet pattern presented the most unfavourable changes in fat mass and abdominal fat.

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Apéndice [Appendix]

Factor de impacto de las revistas y ranking en "ISI *Web o Knowledge – Journal Citation Reports (JCR)*" dentro de sus areas temáticas correspondientes.

[Impact factor and ranking of each Journal in "ISI *Web o Knowledge – Journal Citation Reports (JCR)*" within their subject categories].

Articulos publicados o aceptados [*Published or accepted manuscripts*]:

	Revista [Journal]	**Factor de Impacto [Impact factor]**
Artículo I	Pediatric Obesity	2,419
	Ranking in 2013 ISI JCR: 23/118 (Pediatrics)	
Artículo II	Public Health Nutrition	2,483
	Ranking in 2013 ISI JCR: 39/79 (Nutrition and Dietetics) 45/162 (Public, Environmental and Occupational Health)	
Artículo III	European Journal of Clinical Nutrition	2,709
	Ranking in 2014 ISI JCR: 29/77 (Nutrition and Dietetics)	
Artículo IV	British Journal of Nutrition	3,311
	Ranking in 2015 ISI JCR: 23/80 (Nutrition and Dietetics)	

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Por fin llegué al destino, muy distinto de cuando partí: rico en experiencias, compañeros y amistades, agradecido por el bello viaje que me habéis brindado, único e irrepetible. Por fin entendí qué significan las Ítacas. Os tendré siempre en la memoria.

ÍTACA

Cuando te encuentres de camino a Ítaca,
desea que sea largo el camino,
lleno de aventuras, lleno de conocimientos.
A los Lestrigones y a los Cíclopes,
al enojado Poseidón no temas,
tales en tu camino nunca encontrarás,
si mantienes tu pensamiento elevado, y selecta
emoción tu espíritu y tu cuerpo tienta.
A los Lestrigones y a los Cíclopes,
al fiero Poseidón no encontrarás,
si no los llevas dentro de tu alma,
si tu alma no los coloca ante ti.

Desea que sea largo el camino.
Que sean muchas las mañanas estivales
en que con qué alegría, con qué gozo
arribes a puertos nunca antes vistos,
detente en los emporios fenicios,
y adquiere mercancías preciosas,
nácares y corales, ámbar y ébano,
y perfumes sensuales de todo tipo,
cuántos más perfumes sensuales puedas,
ve a ciudades de Egipto, a muchas,
aprende y aprende de los instruidos.

Ten siempre en tu mente a Ítaca.
La llegada allí es tu destino.
Pero no apresures tu viaje en absoluto.
Mejor que dure muchos años,
y ya anciano recales en la isla,
rico con cuanto ganaste en el camino,
sin esperar que te dé riquezas Ítaca.

Ítaca te dio el bello viaje.
Sin ella no habrías emprendido el camino.
Pero no tiene más que darte.

Y si pobre la encuentras, Ítaca no te engañó.
Así sabio como te hiciste, con tanta experiencia,
comprenderás ya qué significan las Ítacas.

Konstantinos Kavafis

(Alejandría, 1863- 1933)

Anexos [Annexes]

A continuación se adjunta una copia del resumen del artículo descriptivo-metodológico del estudio IDEFICS:

- **The IDEFICS cohort: design, characteristics and participation in the baseline survey.**

Ahrens W, Bammann K, Siani A, Buchecker K, De Henauw S, Iacoviello L, Hebestreit A, Krogh V, Lissner L, Marild S, Molnar D, Moreno LA, Pitsiladis YP, Reisch L, Tornaritis M, Veidebaum T, Pigeot I, on behalf of the IDEFICS Consortium. *Int J Obes* 2011; **35 Suppl 1**: S3-S15.

Background: The European IDEFICS (Identification and prevention of dietary- and lifestyle induced health effects in children and infants) study was set up to determine the aetiology of overweight, obesity and related disorders in children, and to develop and evaluate a tailored primary prevention programme.

Objective: This paper focuses on the aetiological element of the multicentre study, the measures and examinations, sociodemographic characteristics of the study sample and proportions of participation.

Design: Prospective cohort study with an embedded intervention study that started with a baseline survey in eight countries in 2007–2008.

Subjects and measurements: Baseline participants of the prospective cohort study were 16 224 children aged 2–9 years. Parents reported sociodemographic, behavioural, medical, nutritional and other lifestyle data for their children and families. Examinations of children included anthropometry, blood pressure, fitness, accelerometry, DNA from saliva and physiological markers in blood and urine. The built environment, sensory taste

perception and other mechanisms of children's food choices and consumer behaviour were studied in subgroups.

Results: Between 1507 and 2567, children with a mean age of 6.0 years and an even sex distribution were recruited from each country. Of them, 82% lived in two-parent families. The distribution of standardised income levels differed by study sample, with low-income groups being strongly represented in Cyprus, Italy and Germany. At least one 24-h dietary recall was obtained for two-thirds of the children. Blood pressure and anthropometry were assessed in more than 90%. A 3-day accelerometry was performed in 46%, motor fitness was assessed in 41%, cardiorespiratory fitness in 35% and 11% participated in taste perception tests. The proportion of children donating venous blood, urine and saliva was 57, 86 and 88%, respectively.

Conclusion: The IDEFICS cohort provides valuable data to investigate the interplay of social, environmental, genetic, physiological and behavioural factors in the development of major diet- and lifestyle-related disorders affecting children at present.

Cuestionario de frecuencia de consumo de alimentos (CEHQ-FFQ)

10. En el último mes, ¿con qué frecuencia ha consumido su hijo/a los siguientes alimentos y bebidas?

Por favor, limítese a las cuatro últimas semanas y excluya las comidas del colegio o guardería.

	Nunca/ menos de una vez por semana	**1 - 3 veces por semana**	**4 – 6 veces por semana**	**1 vez al día**	**2 veces al día**	**3 veces al día**	**4 o más veces al día**	**No lo sé**
Vegetales								
Verduras, patatas y legumbres cocinadas (también combinadas en el mismo plato)	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Patatas fritas, croquetas de patata	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Vegetales crudos (mezclados en la ensalada, zanahoria, pepino, lechuga, tomate, etc.)	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Frutas								
Frutas frescas (también licuadas) ***sin*** azúcar añadido	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Frutas frescas (también licuadas) ***con*** azúcar añadido	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Bebidas								
Agua	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Zumos de frutas (zumo de naranja, manzana, melocotón, piña,etc.)	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Bebidas edulcoradas incluyendo bebidas deportivas, té en lata o embotellado, refrescos, etc.	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Coca-cola light o bebidas refrescantes sin azúcar	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8

	Nunca/ menos de una vez por semana	1 - 3 veces por semana	4 – 6 veces por semana	1 vez al día	2 veces al día	3 veces al día	4 o más veces al día	No lo sé
Cereales de desayuno								
Cereales de desayuno azucarados o que se les ha añadido azúcar y muesli azucarado (ej. Corn flakes, crispies, etc.)	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Papillas, copos de avena, cereales no azucarados, muesli natural	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Leche								
Leche no azucarada	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Leche azucarada (ej. con azúcar, chocolate, cola-cao, miel, etc.)	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Qué tipo de leche consume su hijo/a habitualmente:	❍ 1 Entera ❍ 2 Semi-desnatada /desnatada							
Yogur								
Yogur natural o kéfir sin azúcar	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Yogur azucarado y bebidas lácteas fermentadas (ej. Actimel®, LC1®, etc.)	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Qué tipo de yogur consume su hijo/a habitualmente:	❍ 1 Entera ❍ 2 Semi-desnatada /desnatada							

	Nunca/ menos de una vez por semana	1 - 3 veces por semana	4 – 6 veces por semana	1 vez al día	2 veces al día	3 veces al día	4 o más veces al día	No lo sé
Pescado								
Pescado fresco o congelado, sin freír	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Pescado frito y varitas de pescado	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Carne y productos cárnicos								
Productos en lonchas y conservados, o listos para cocinar (ej. fiambres, embutidos, jamón, hamburguesas etc.)	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Carne fresca, sin freír (chuletas, bistec, bovino, cerdo, aves, etc.)	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Carne frita (chuletas, bistec, bovino, cerdo, aves, etc.)	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Huevos								
Huevos fritos o huevos revueltos	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Huevos duros o escalfados	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Mayonesa y productos derivados de la mayonesa (ej. Ligeresa, salsa rosa, etc.)	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Productos sustitutivos de la carne y productos de soja								
Tofu, tempé, leche de soja, yogures de soja, etc.)	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8

	Nunca/ menos de una vez por semana	1 - 3 veces por semana	4 – 6 veces por semana	1 vez al día	2 veces al día	3 veces al día	4 o más veces al día	No lo sé
Queso								
Queso (ej.curado, semicurado, tierno, fresco, tranchetes. etc.)	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Queso para untar (ej. Philadelphia, etc)	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Queso rallado	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Productos para untar								
Mermelada, miel	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Nocilla o crema de avellanas para untar	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Mantequilla, margarina en pan	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Productos bajos en grasa en pan (ej. Mermelada, etc.)	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Ketchup	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Productos hechos a base de cereales								
Pan blanco, panecillos blancos, biscotes blancos	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Pan integral , panecillos integrales, biscotes integrales	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Pasta, fideos, arroz	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Cuscús, bulgur, etc.	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Pizza como plato principal	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Sandwiches (rellenos con queso, carne, vegetales, etc)	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8

	Nunca/ menos de una vez por semana	1 - 3 veces por semana	4 – 6 veces por semana	1 vez al día	2 veces al día	3 veces al día	4 o más veces al día	No lo sé
Aperitivos								
Frutos secos y semillas y frutas secas (ej. Pipas, cacahuetes, pasas etc.)	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Patatas fritas, aperitivos de maíz, palomitas de maíz, etc (ej. *Cheetos, Lay's, risketos,* etc.)	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Tortas o bollos, pasteles (ej. Tarta de manzana, crepes, palmeras de hojaldre, etc.)	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Chocolate, barritas de chocolate (Mars, Lions, Kit Kat, etc.)	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Caramelos, chucherías, gominolas, etc.)	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
galletas, pasteles envasados, tartas (ej.Donuts, bollycao, cañas de chocolate, etc.)	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8
Helados, polos, sorbetes de fruta(ej. Mágnum, calippo etc.)	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5	❍ 6	❍ 7	❍ 8

¡Gracias por contestar a las preguntas!

Por favor, compruebe una vez más que ha rellenado el cuestionario en su totalidad.

Por favor, anote la fecha en la que terminó de rellenar el cuestionario:

|___|___| Día |___|___| Mes |___|___|___|___| Año

Cuestionario sobre el nivel socioeconómico

Información socio-demográfica

Las siguientes preguntas nos ayudarán a comparar el estado de salud de su hijo/a con el de otros niños de sus mismas características.

64. ¿Nació su hijo/a en España?

❍1 Sí

❍2 No, por favor especifique: _____

¿Nació la madre del niño/a en España?

❍1 Sí

❍2 No, por favor especifique: _____

¿Nació el padre del niño/a en España?

❍1 Sí

❍2 No, por favor especifique: _____

65. ¿En qué idioma habla normalmente en casa con su hijo/a?

❍1 Español

❍2 Otro idioma, por favor especifique:

_____

66. ¿Cuál es el nivel más alto de educación escolar que usted y su cónyuge/pareja tienen?
Por favor, marcar solamente uno por persona.

	Yo	***Cónyuge/pareja***
Primaria /EGB	❍1	❍1
Secundaria /ESO	❍2	❍2
Formación profesional	❍3	❍3
Ciclos formativos de grado superior	❍4	❍4
Bachillerato/ BUP/COU	❍5	❍5
Sin graduación (todavía)	❍8	❍8
Otros/desconocido	❍9	❍9

67. ¿Cuál es el nivel más alto de cualificación profesional que usted y su cónyuge/pareja tienen?
Por favor, marcar solamente uno por persona.

	Yo	***Cónyuge/pareja***
Formación profesional	❍ 1	❍ 1
Ciclos formativos de grado superior	❍ 2	❍ 2
Diplomatura universitaria/ingeniería técnica	❍ 3	❍ 3
Licenciatura/ingeniería superior	❍ 4	❍ 4
Doctorado	❍ 5	❍ 5
No formado (todavía)	❍ 8	❍ 8
Desconocido/otros	❍ 9	❍ 9

68. ¿Cuál de los siguientes enunciados describe mejor su estado ocupacional actual y el de su cónyuge/pareja?
Por favor, marcar solamente uno por persona.

	Yo	***Cónyuge/pareja***
Trabajo a tiempo completo (30 horas o más a la semana)	❍ 1	❍ 1
Trabajo a tiempo parcial (menos de 30 horas a la semana)	❍ 2	❍ 2
Estudio o voy a la universidad	❍ 3	❍ 3
No tengo trabajo remunerado	❍ 4	❍ 4
Retirado (también jubilación anticipada)	❍ 5	❍ 5
Baja temporal de la empresa (ej. baja por maternidad o paternidad)	❍ 6	❍ 6
En el paro, desde hace menos de un año	❍ 7	❍ 7
En el paro, desde hace un año o más	❍ 8	❍ 8
En asistencia pública (asistencia social)	❍ 9	❍ 9
Otro, por favor especifique: _____	❍ 10	❍ 10

69. ¿En que posición laboral están actualmente ocupados usted y su cónyuge/pareja?

Si usted o su cónyuge/pareja ya no están ocupados o actualmente no están ocupados, por favor, indique la última posición laboral.

	Yo	***Cónyuge/pareja***
Obrero		
Obrero no cualificado	❍ 1	❍ 1
Obrero semi-cualificado	❍ 2	❍ 2
Obrero cualificado, artesano	❍ 3	❍ 3
Maestro artesano, capataz	❍ 4	❍ 4
Patrón o autónomo (incluyendo la ayuda de miembros de la familia)		
Agricultor y/o ganadero autónomo	❍ 1	❍ 1
Autónomo, trabajador por cuenta propia	❍ 2	❍ 2
Patrón con hasta 9 empleados	❍ 3	❍ 3
Patrón con 10 o más empleados	❍ 4	❍ 4
Ayudo a algún miembro de la familia	❍ 5	❍ 5
Empleado		
Empleado (ej. dependiente, recepcionista, oficinista)	❍ 1	❍ 1
Empleado cualificado (ej. auxiliar contable, auxiliar dental)	❍ 2	❍ 2
Empleado altamente cualificado o con funciones de gestión (ej. científico, jefe de departamento)	❍ 3	❍ 3
Empleado con extensas funciones ejecutivas (ej. director, director general, junta directiva)	❍ 4	❍ 4
Funcionario público		
Categoría A	❍ 1	❍ 1
Categoría B	❍ 2	❍ 2
Categoría C	❍ 3	❍ 3
Categoría D	❍ 4	❍ 4
Categoría E	❍ 5	❍ 5
No trabajo	❍ 6	❍ 6

70. ¿Cuáles son los ingresos mensuales familiares, es decir, el beneficio neto que usted (en total) percibe a parte de impuestos y de retenciones?

Cuando decimos familiares nos referimos a todos aquellos que están residiendo en el mismo hogar que el niño/a seleccionado y que también participan en los gastos.

Por favor, incluya también ingresos procedentes de alquileres o arrendamientos, pensiones, subvenciones para los niños, pensiones alimenticias, etc.

	hasta	*800 €*	❍ 1
800 €	hasta	*1050 €*	❍ 2
1050 €	hasta	*1300 €*	❍ 3
1300 €	hasta	*1550 €*	❍ 4
1550 €	hasta	*1900 €*	❍ 5
1900 €	hasta	*2500 €*	❍ 6
2500 €	hasta	*3000 €*	❍ 7
3500 €	hasta	*4000 €*	❍ 8
	Por encima de	*4000 €*	❍ 9

¡Gracias por contestar a las preguntas!
Por favor, compruebe una vez más que ha rellenado el cuestionario en su totalidad.

Por favor, anote la fecha en la que terminó de rellenar el cuestionario:

|___|___| Día |___|___| Mes |___|___|___|___| Año