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Mª Isabel Iguacel Azorín

Desventajas socioeconómicas, obesidad y factores relacionados

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Tesis Doctoral

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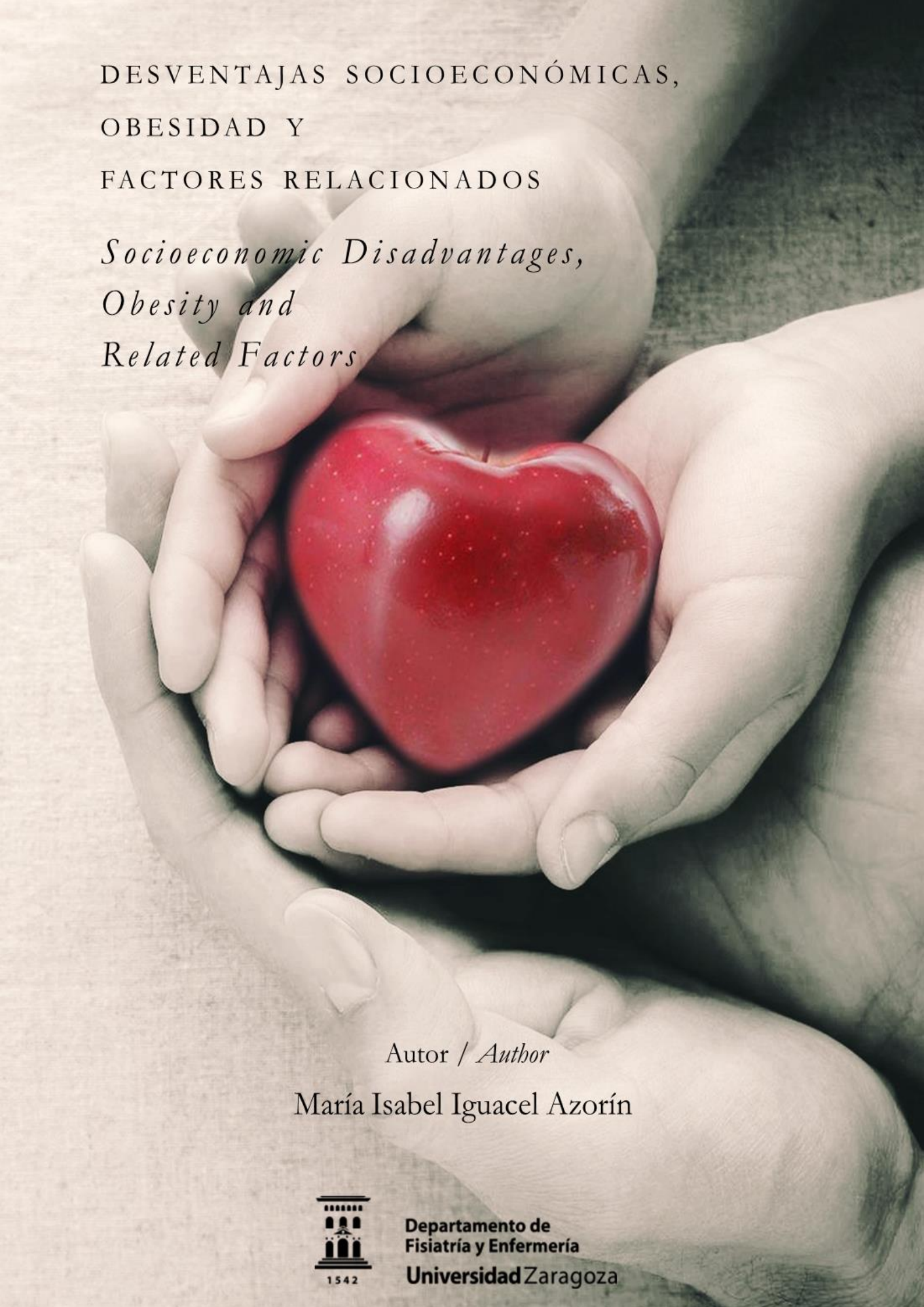
Fisiatría y Enfermería

2018

DESVENTAJAS SOCIOECONÓMICAS, OBESIDAD Y FACTORES RELACIONADOS

Socioeconomic Disadvantages, Obesity and Related Factors



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Tesis Doctoral Internacional

SOCIOECONOMIC DISADVANTAGES, OBESITY AND RELATED FACTORS

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Socioeconomic disadvantages, obesity and related factors

Departamento de Fisiatría y Enfermería

Facultad de Ciencias de la Salud

UNIVERSIDAD DE ZARAGOZA

MARÍA ISABEL IGUACEL AZORÍN

UNIVERSIDAD DE ZARAGOZA,

ZARAGOZA, OCTUBRE DE 2018

A todas aquellas personas que me hacen la vida más fácil: mi familia y amigos

Dr. Luis A. MORENO AZNAR

Catedrático de Universidad

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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 "Desventajas socioeconómicas, obesidad y factores relacionados" que presenta Dña. **MARÍA ISABEL IGUACEL AZORÍN** 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 autora en condiciones tan aventajadas que le hacen merecedora del Título de Doctora, siempre y cuando así lo considere el citado Tribunal.

Fdo.: Luis A. Moreno Aznar

En Zaragoza, a 17 de marzo de 2018

Dr. Juan Miguel FERNÁNDEZ-ALVIRA

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CERTIFICA:

Que la Tesis Doctoral titulada "Desventajas socioeconómicas, obesidad y factores relacionados" que presenta Dña. **MARÍA ISABEL IGUACEL AZORÍN** 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 autora en condiciones tan aventajadas que la hacen merecedora del Título de Doctora, siempre y cuando así lo considere el citado Tribunal.

Fdo.: Juan Miguel Fernández-Alvira

En Madrid, a 17 de marzo de 2018

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Leibniz Institute for Prevention Research and Epidemiology – BIPS, Bremen, Germany

CLAUDIA BÖRNHORST, researcher at the Leibniz Institute for Prevention Research and Epidemiology – BIPS, Bremen, Germany.

I HEREBY DECLARE THAT:

The doctoral thesis entitled "Desventajas socioeconómicas, obesidad y factores relacionados/ Socioeconomic disadvantages, obesity and related factors" presented by Ms. **MARÍA ISABEL IGUACEL AZORÍN** has been carried out under my supervision, being an expression of the technical and interpretative capacity of the author in conditions that make her deserving the Doctoral Degree, as long as the members of the jury will have this consideration.

Claudia Börnhorst

Bremen, 17 March 2018

Lista de publicaciones [List of publications]

La presente Tesis Doctoral es un compendio de trabajos científicos previamente publicados, aceptados para su publicación o enviados para su revisión. Los artículos que constituyen la presente tesis se detallan a continuación:

I. Iguacel I, Fernández-Alvira JM, Bammann K, De Clercq B, Eiben G, Gwozdz W, Molnár D, Pala V, Papoutsou S, Russo P, Veidebaum, T, Wolters M, Börnhorst C and Moreno LA. Associations between social vulnerabilities and dietary patterns in European children: the Identification and prevention of Dietary- and lifestyle-induced health EFfects In Children and infantS (IDEFICS) study. Br J Nutr. 2016;116(7):1288-97.

II. Iguacel I, Fernández-Alvira JM, Bammann K, Chadjigeorgiou C, De Henauw S, Heidinger-Felso R, Lisnner, L, Michels N, Page, A, Reisch LA, Russo P, Sprengeler, O, Veidebaum, T, Börnhorst C and Moreno LA. Social vulnerability as a predictor of physical activity and screen time in European children. Int J Public Health. 2017:63(2):283-295.

III. Iguacel I, Michels N, Fernández-Alvira JM, Bammann K, De Henauw S, Felso R, Gwozdz W, Hunsberger M, Reisch L, Russo P, Tornaritis M, Thumann BF, Veidebaum T, Börnhorst C and Moreno LA. Associations between social vulnerabilities and psychosocial problems in European children. Results from the IDEFICS study. Eur Child Adolesc Psychiatry. 2017;26(9):1105-17.

IV. Iguacel I, Fernández-Alvira JM, Labayen I, Moreno LA, Samper MP and Rodríguez G. Social vulnerabilities as determinants of overweight in 2-, 4- and 6-year-old Spanish children. Eur J Public Health. 2018;28(2):289-295.

V. Iguacel I, Fernández-Alvira JM, Ahrens W, Bammann K, Gwozdz W, Lissner L, Michels N, Reisch L, Russo P, Szommer A, Tornaritis M, Veidebaum T, Börnhorst C and Moreno LA. Prospective associations between social vulnerabilities and children's weight status. Results from the IDEFICS study.

VI. Iguacel I, Fernández-Alvira JM, Ahrens W, Bammann K, Eiben G, Fernández-Alvira JM, Mårild S, Molnár D, Reisch L, Russo P, Tornaritis M, Veidebaum T, Wolters M, Moreno LA. Associations between socially disadvantaged groups and metabolic syndrome in European children. Results from the IDEFICS study.

Contenidos [Contents]

Proyecto de investigación [Research Project]

La presente tesis incluye seis artículos basados en datos obtenidos en dos proyectos 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

2. Estudio CALINA (Crecimiento y Alimentación durante la Lactancia y la primera Infancia en Niños Aragoneses). Este estudio ha sido financiado por tres becas del Instituto de Salud Carlos III: 1) Crecimiento y Alimentación durante la Lactancia y la primera Infancia en Niños Aragoneses (CALINA), ref. PI08/0559; 2) Factores ambientales que determinan la aparición precoz de obesidad infantil y la programación de la composición corporal, ref. PI13/2359; y 3) Red de Salud Materno Infantil y Desarrollo – SAMID. RETICS financiada por el PN I+D+I 2008-2011, ISCIII - Subdirección General de Evaluación y Fomento de la Investigación y el Fondo Europeo de Desarrollo Regional (FEDER), ref. RD12/0026.

Coordinador: Gerardo Rodríguez

Resumen

La obesidad infantil sigue siendo un problema de salud importante. A pesar de la estabilización descrita en la prevalencia de obesidad infantil de algunos países desarrollados, esta tendencia se ha limitado comúnmente a los niños con mayores recursos sociales y económicos. La obesidad es una enfermedad multifactorial y compleja, resultado de un desequilibrio energético entre la energía consumida y la energía gastada. La alimentación, la actividad física y los comportamientos sedentarios son factores directamente relacionados con el balance energético. Por su parte, los factores psicosociales influyen en los comportamientos alimentarios y en los niveles de actividad física y sedentarismo. A su vez, todos estos factores están social y económicamente determinados tanto directa como indirectamente. En general, en los países desarrollados, los niños de familias con un nivel socioeconómico bajo consumen alimentos de menor calidad, son menos activos físicamente, son más sedentarios y presentan más frecuentemente problemas psicosociales que los niños de familias de alto nivel socioeconómico. Por lo tanto, los niños de familias de bajo nivel socioeconómico tienen mayor riesgo de desarrollar sobrepeso, obesidad y enfermedades cardiovasculares a lo largo del ciclo vital que los niños de familias de nivel socioeconómico más alto. Además de los indicadores socioeconómicos clásicos, existen otras condiciones de vulnerabilidad socioeconómica, menos exploradas en la literatura, relacionadas con la estructura familiar, las redes de apoyo, la situación de desempleo o el origen inmigrante y que podrían afectar negativamente a los menores a través de su impacto en los estilos de vida y la salud mental, independientemente de la educación, la ocupación y los ingresos. En la presente Tesis Doctoral se analizaron cuatro grupos vulnerables: 1) los niños cuyos padres carecían de una red social de apoyo, 2) los niños con un origen

inmigrante, 3) los niños con una estructura familiar no tradicional y 4) los niños con padres desempleados.

La presente Tesis Doctoral tiene como objetivo explorar las asociaciones entre grupos vulnerable y diferentes resultados de salud, particularmente:

1) la asociación entre las vulnerabilidades sociales en los niños y factores relacionados con el balance energético (alimentación, actividad física y conductas sedentarias)

2) la asociación entre las vulnerabilidades sociales en la infancia y los problemas psicosociales

3) la relación entre las diferentes vulnerabilidades con la obesidad y el síndrome metabólico.

Todas estas asociaciones se estudiaron de forma transversal y longitudinalmente por lo que esta tesis también tuvo como objetivo:

4) evaluar el impacto de las vulnerabilidades sociales a lo largo del tiempo, así como el efecto de la acumulación de estas desventajas socioeconómicas en la obesidad y en sus factores relacionados, independientemente de la educación y de los ingresos familiares.

Para lograr estos objetivos, se consideraron los datos de dos estudios: 1) Identification and Prevention of Dietary- and Lifestyle-induced Health Effects in Children and Infants (IDEFICS), un estudio prospectivo multicéntrico de cohortes, que incluía una intervención para la prevención de la obesidad en ocho países europeos (Bélgica, Chipre, Estonia, Alemania, Hungría, Italia, España y Suecia) y 2) el Crecimiento y la Alimentación durante la Lactancia y la Primera Infancia en Niños

Aragoneses / Crecimiento y Alimentación durante la infancia y la primera infancia en niños de Aragón, el estudio CALINA, basado en una cohorte de niños aragoneses seguidos desde el nacimiento hasta los 6 años de edad.

El tamaño muestral total al comienzo del estudio IDEFICS fue de 16.229 niños y en el estudio CALINA de 1.540 niños. El tamaño de la muestra utilizado en los diferentes artículos varió de 1.031 a 13.891 niños, según el número de participantes con información completa disponible en cada caso.

Los resultados de este trabajo mostraron que los niños cuyos padres carecían de red social tenían un mayor riesgo de presentar problemas psicosociales, patrones alimentarios poco saludables (caracterizados por una mayor frecuencia de consumo de aperitivos y comida rápida), más tiempo dedicado a comportamientos sedentarios y mayor frecuencia de obesidad. Los niños con un origen inmigrantes y o pertenecientes a minorías étnicas también tenían un mayor riesgo de tener sobrepeso u obesidad, de seguir un patrón alimentario poco saludable y de dedicar más tiempo a comportamientos sedentarios. En el estudio en España, los niños romaníes (gitanos) y aquellos de origen latinoamericano tenían respectivamente cuatro y tres veces más probabilidades de tener sobrepeso u obesidad que los niños españoles no gitanos. Los niños de familias no tradicionales también corrieron un mayor riesgo de informar problemas psicosociales. Finalmente, los niños con padres desempleados también presentaban niveles más altos de tiempo de pantalla.

Si bien las vulnerabilidades sociales parecen afectar negativamente a la alimentación de los niños y a los comportamientos sedentarios, nuestros resultados no mostraron ninguna asociación estadísticamente significativa entre las vulnerabilidades sociales y la actividad física evaluada objetivamente mediante acelerómetros. No

obstante, los resultados apuntaron en la dirección esperada y todos los grupos vulnerables tuvieron menos probabilidades de ser miembros de un club deportivo.

Teniendo en cuenta el efecto de las desventajas socioeconómicas en el síndrome metabólico, los niños de familias con bajo nivel educativo, los niños de familias no tradicionales, los niños cuyos padres estaban desempleados y los niños que acumulaban más de tres desventajas mostraron una puntuación en el riesgo de síndrome metabólico significativamente mayor en comparación con los grupos no desfavorecidos.

Finalmente, al evaluar el impacto de las vulnerabilidades sociales a lo largo del tiempo y la acumulación de éstas sobre la obesidad infantil y factores relacionados, se observó en general un mayor riesgo en aquellos niños que fueron vulnerables en ambos momentos, en aquellos que cambiaron su estado de no vulnerabilidad a uno vulnerable y aquellos que acumularon más vulnerabilidades.

Estos resultados fueron observados incluso tras ajustarse por indicadores socioeconómicos clásicos (educación e ingresos), lo que sugiere un efecto independiente de estas vulnerabilidades sociales.

Las principales limitaciones de los resultados incluidos en la presente tesis doctoral fueron:

1) Un posible sesgo de selección derivado de los participantes que decidieron aceptar llevar a cabo el estudio así como del hecho que grupos más desfavorecidos, con mayores tasas de obesidad o mayor riesgo de síndrome metabólico, más problemas psicosociales o con estilo de vida menos saludables no completaron toda la información requerida o no continuaron en el estudio de seguimiento.

2) Las situaciones vulnerables pueden ser diferentes dentro del mismo grupo vulnerable. Por ejemplo, los niños con ambos padres desempleados pueden tener más

dificultades en comparación con los niños con un solo miembro desempleado. Además, los niños inmigrantes incluyen a niños con un origen, recursos y situaciones diferentes que pueden implicar dificultades de adaptación más favorables. Sin embargo, debido a razones estadísticas derivadas de un tamaño de muestra pequeño, estas situaciones en el grupo vulnerable se incluyeron en la misma categoría.

3) Otra limitación es la confianza en las medidas autoinformadas,como el peso y la estatura de los padres, los informes de estos sobre la alimentación de los niños y los patrones de actividad y otros aspectos del balance energético, que no se midieron objetivamente.

Las principales fortalezas de este estudio incluyen el diseño prospectivo, la gran muestra de niños europeos de diferentes edades, los exámenes físicos repetidos y las mediciones de laboratorio en niños pequeños siguiendo un procedimiento estandarizado.

En conclusión, las vulnerabilidades sociales en la primera infancia (principalmente la falta de una red social de apoyo) se asociaron con estilos de vida menos saludables (caracterizados por un patrón de consumo de alimentos procesados y conductas sedentarias) y con más problemas psicosociales, independientemente de la educación, ocupación e ingresos familiares, lo que puede estar asociado con tasas más altas de obesidad y síndrome metabólico en aquellos grupos vulnerables. En consecuencia, los responsables de la formulación de políticas deberían centrarse en estos grupos socialmente más desfavorecidos para mejorar sus estilos de vida y la situación psicosocial de los niños a fin de reducir las desigualdades en materia de salud.

Abstract

Childhood obesity continues to be a major health problem. Despite the reported stabilization in the prevalence of childhood obesity in some high-income countries, this trend has been commonly limited to children with greater social and economic resources. Obesity is a multi-factorial and complex disease resulting from an energy imbalance between energy consumed and energy expended. Diet, physical activity and sedentary behaviours are factors directly related with energy imbalance. On the other hand, psychosocial factors have an impact on eating and sedentary behaviours and levels of physical activity. Simultaneously, all these factors are social and economic patterned directly and indirectly.

Overall, in developed countries, those children from low socioeconomic status families consume low quality diets, are less physically active, are more sedentary and reported to have more psychosocial problems than children from high socioeconomic households. For that reason, children from low socioeconomic families are at higher risk of overweight or obesity than children from high socioeconomic families.

Apart from the classical socioeconomic indicators, there are other conditions less explored in the literature, related to family structure, social support, employment status and migrant origin that might affect children's well-being and lifestyle regardless of education, occupation and income. In the present Doctoral thesis, we analysed four vulnerable groups: 1) children whose parents lack a social network, 2) children with a migrant background, 3) children with a non-traditional family structure and 4) children with unemployed parents.

This thesis aims to explore associations between these vulnerable groups and different health outcomes, in particular:

1) the association between social vulnerabilities in children and obesity-related factors (diet, physical activity and sedentary behaviours),

2) the association between social vulnerabilities early in childhood and psychosocial problems and

3) the relationship between different social vulnerabilities with obesity and metabolic syndrome.

Yet, all these associations were studied cross-sectionally and longitudinally, so in addition this thesis aims to:

4) assess the impact of social vulnerabilities over time as well as the effect of accumulation of these social vulnerabilities on obesity and related factors regardless of parental education and income.

In order to achieve these objectives, data from two studies were considered: 1) The Identification and Prevention of Dietary-and Lifestyle-induced Health Effects in Children and Infants (IDEFICS) Study, a multi-centre prospective cohort study, that included a school- and community-based obesity prevention intervention in eight European countries (Belgium, Cyprus, Estonia, Germany, Hungary, Italy, Spain and Sweden) and 2) the Crecimiento y Alimentación durante la Lactancia y la primera Infancia en Niños Aragoneses/Growth and Feeding during Infancy and Early Childhood in Children from Aragón, the CALINA study, based on a cohort of children from Aragon (Spain) followed from birth to 6 years of age.

The total sample size at the beginning of the study IDEFICS was 16,229 children and 1,540 children in CALINA study. The sample size used in the different articles varied from 1,031 to 13,891 children, based on the number of participants providing the required complete information for the respective investigation.

The results of these studies revealed that children whose parents lack a social network were at a higher risk of having psychosocial problems, unhealthy dietary patterns (characterized by a higher frequency of consumption of snacks and fast food), higher levels of sedentarism and higher proportions of obesity. Migrant children were also at higher risk of having overweight or obese, following an unhealthy dietary pattern and having higher levels of sedentary behaviour. In Spain, Roma (gypsy) and children with a Latin American background were four and three times more likely to have overweight/obesity than non-Roma Spanish children, respectively. Children from non-traditional families were also at a higher risk of reporting psychosocial problems. Finally, screen time was higher in children with unemployed parents.

While social vulnerabilities appear to negatively affect children's diet and sedentary behaviours, no association was found between social vulnerabilities and objectively assessed physical activity. However, results still pointed to the expected direction and all vulnerable groups were less likely to be sports club members.

Considering the effect of socioeconomic disadvantages on metabolic syndrome, children from children from non-traditional families, children whose parents were unemployed and children who accumulate more than three disadvantages showed a significantly higher metabolic syndrome score compared to non-disadvantaged groups.

Finally, when assessing the impact that social vulnerabilities over time and the accumulation of these social vulnerabilities have on children's obesity and related factors, children who were vulnerable at both time points, those who changed their non-vulnerable status to a vulnerable one and those who accumulated more vulnerabilities were at higher risk.

These results were observed even when adjusting for classical socioeconomic indicators (education and income), which suggests an independent effect of these social vulnerabilities.

Main limitations of the results included in this Doctoral thesis were:

1) Possible selection bias because some participants (i.e those from more disadvantaged groups, with higher rates of obesity or higher risk of metabolic syndrome, more psychosocial problems or poor lifestyle behaviours) did not complete all required information or did not continue the study at follow-up.

2) Vulnerable situations can be different in the same vulnerable group. For example, children with both unemployed parents can have more difficulties compared to children with only one member unemployed. Also, migrants include children with a different origin, resources and situations that can entail more favourable or difficulties of adaptation. However, due to statistical reasons derived from a small sample size these situations in the vulnerable group were included in the same category.

3) Reliance on self-reported measures such as maternal weight and height, parental reports of children's diets, activity patterns, and other aspects of energy balance that we were not able to measure that could be predisposing under- and overweight in children.

Major strengths of this study include the prospective design, the large sample of European children of different ages and repeated physical examinations and laboratory measurements in young children following a standardized procedure.

To conclude, early childhood social vulnerabilities (mainly children whose parents lack a social network) were associated with poorer behaviours (unhealthy dietary patterns and sedentary behaviours) and more psychosocial problems irrespective

of family income and education, which may be associated with higher rates of obesity and metabolic syndrome. Consequently, policy makers should focus on these socially disadvantaged groups to improve lifestyle and children's mental health to reduce health inequalities.

1. Introducción [Introduction]

La obesidad infantil está catalogada por la Organización Mundial de la Salud (OMS) como uno de los problemas de salud pública más serios a los que nos enfrentamos en el siglo XXI[1]. Durante la década de los años 1980 y 1990, los niveles de obesidad infantil experimentaron un rápido crecimiento; sin embargo, en los últimos años esta tendencia parece haberse estancando en los países de mayor desarrollo, aunque en niveles excesivamente altos[2, 3]. La prevalencia de la obesidad infantil varía ampliamente entre los distintos países. Según los últimos datos presentados por el Centro Nacional para la Estadística de Salud de Estados Unidos, el 33.4% de los niños y adolescentes estadounidenses de entre 2 y 19 años padecían sobrepeso u obesidad (concretamente, un 16.2% padecía sobrepeso y un 17.2% padecía obesidad) en 2011-2014[4]. En Europa, de acuerdo a las estimaciones de la OMS aproximadamente 1 de cada 3 niños de 6-9 años tienen sobrepeso u obesidad[5]. Concretamente, según los últimos datos del 2015-2017 de la Iniciativa de la Vigilancia de la Obesidad Infantil (Childhood Obesity Surveillance Initiative, COSI) la prevalencia de sobrepeso (incluyendo obesidad según las definiciones de la OMS) varía entre el 9% al 43% entre los niños y entre un 5 y un 43% en niñas. La prevalencia de obesidad particularmente en los niños varía entre el 2 y el 31% tenía obesidad y entre un 1-19% en niñas[6]. No obstante, se observaron grandes diferencias entre las distintas regiones europeas, mostrándose niveles más altos en los países mediterráneos que en los países del norte de Europa[7]. Concretamente, el porcentaje de sobrepeso y obesidad más alto fue registrado en los niños de Chipre (43% en niños y en niñas) seguido de los niños de España (42% en niños y 41% en niñas), Grecia (42% en niños y 38% en niñas) e Italia (42% en niños y 38% en niñas). En un artículo reciente en el que se incluyen más de 1,000 niños

aragoneses, se observó que a la edad de los 6 años, un 31.9% de los niños y un 31.1% de las niñas presentaba sobrepeso u obesidad[8].

A pesar de la estabilización observada en algunos países de altos ingresos, diferentes estudios han señalado que esta tendencia puede no haber sido compartida por todos los grupos socioeconómicos y que la obesidad haya aumentado en aquellos niños de nivel socioeconómico más bajo mientras se haya estancado o incluso disminuido en aquellos niños de familias con un nivel socioeconómico más alto[9]. La educación, la ocupación o los ingresos son indicadores socioeconómicos clásicos que han sido ampliamente estudiados para explicar las desigualdades de salud existentes en la población. En concreto, a mejor situación socioeconómica, mejor salud; y a peor situación, peor salud. Se trata de una asociación que se observa tanto en España como en casi todos los países del mundo, independientemente de su nivel medio de renta. A esto se le llama el gradiente socioeconómico de la salud, y discurre desde la cúspide hasta la base del espectro socioeconómico, afectando a toda la población de todos los grupos de edad. Además de los indicadores socioeconómicos clásicos, existen otros, no tan estudiados en la literatura, como son la cantidad y la calidad de las redes sociales de apoyo, el tipo de estructura familiar, el desempleo y el origen inmigrante de los padres, que afectan a la salud infantil independientemente de la educación, de la ocupación y de los ingresos de los padres. Entre las causas que se han esgrimido para explicar las diferencias en salud observadas en estos grupos, con alguna de las desventajas socioeconómicas, están los factores de comportamiento (estos grupos muestran un mayor consumo de comidas altamente energéticas y de bajo nivel nutricional así como mayores niveles de sedentarismo y menores niveles de actividad física) y mecanismos psicológicos (las desventajas socioeconómicas provocan un mayor nivel de estrés en estos grupos con importantes repercusiones metabólicas).

En la presente Tesis Doctoral, por razones prácticas, se va a utilizar el término de desventaja socioeconómica para hacer referencia globalmente a las vulnerabilidades sociales analizadas (niños con una red social de apoyo escasa, niños con origen inmigrante o etnia minoritaria, niños con una estructura familiar no tradicional y niños con algún progenitor desempleado) y grupos de bajo nivel socioeconómico (niños de familias con un bajo nivel de ingresos, de educación y de ocupación). Esta denominación permite hacer una distinción entre las vulnerabilidades sociales a que hacen referencia los cuatro grupos arriba mencionados y los indicadores socioeconómicos clásicos.

Es probable que los niños que desarrollan sobrepeso y obesidad sigan manteniéndola en la edad adulta y que desarrollen distintas comorbilidades como la resistencia a la insulina, diabetes tipo 2, enfermedades cardiovasculares como hipertensión arterial, aterosclerosis, accidentes cardiovasculares, alteraciones musculoesqueléticas y ortopédicas, problemas durante el embarazo, enfermedades relacionadas con la vesícula biliar, hepáticos y renales, además de algunos cánceres (como el de mama, colon y endometrial) a una edad más temprana[10]. Además de los problemas físicos hay que considerar los importantes problemas psicosociales derivados del estigma y acoso escolar al que se enfrentan en muchos casos los niños con obesidad (mayor tendencia a la depresión, peor calidad de vida percibida, desórdenes emocionales y de comportamiento)[11]. Así, la obesidad infanto-juvenil tiene importantes consecuencias sociales y económicas futuras como peores salarios, una menor educación, o mayores dificultades para tener una familia en la adultez[12]. Es por ello esencial su detección y prevención temprana para evitar posteriores consecuencias adversas en edades adultas y desarrollar las acciones adecuadas que permitan reducir las desigualdades detectadas en salud. Aunque existen múltiples problemas derivados del

sobrepeso y la obesidad mencionados anteriormente se describirán en más profundidad aquellos incluidos en la presente Tesis Doctoral.

1.1. Obesidad infantil y riesgo metabólico

La obesidad se define como la acumulación excesiva o anormal de grasa que deteriora la salud, fruto de la interacción de distintos factores. El índice de masa corporal (IMC) se utiliza a menudo para determinar el sobrepeso y la obesidad. El sobrepeso infantil se define a menudo cuando el IMC del niño se encuentra entre el percentil 85 y menor al 95 mientras que la obesidad infantil se define cuando ese IMC está en el percentil 95 o más alto[13]. Para calcular el IMC se divide el peso (en kg) por la altura (en metros) al cuadrado. El IMC de niños y adolescentes es específico de la edad y el sexo.

En la práctica, entre los estándares internacionales de referencia del IMC están el del Centro de Control de Enfermedades (CDC) de Estados Unidos, el del IOTF y el de la OMS[14]. El IMC no es reflejo directo de la cantidad de grasa, no obstante, la investigación ha mostrado que el IMC se asocia con medidas más directas de la grasa corporal obtenidas mediante la medida de los pliegues cutáneos, o el uso de la impedancia bioeléctrica, la hidrodensitometría, la densitometría de rayos X, la pletismografía por desplazamiento de aire, etcétera[15, 16].

El aumento de peso es consecuencia del desequilibrio a largo plazo entre la ingesta de energía y el gasto energético. Entre los factores que se han esgrimido para explicar esta falta de equilibrio figuran los genéticos y los comportamientos individuales. Los comportamientos que influencian el exceso de peso incluyen la ingesta de dietas de alto contenido calórico, el consumo de alimentos y bebidas de bajo nivel nutricional, un insuficiente nivel de actividad física, un exceso de comportamientos sedentarios y rutinas de sueño inadecuadas.

Estos comportamientos están determinados en gran parte por el entorno y medio ambiente, de forma que los hábitos alimentarios y de actividad o inactividad son resultado no tan solo de las elecciones individuales, sino también de ambientes que no apoyen o promocionen unos hábitos saludables. El precio de las opciones saludables, entornos seguros que faciliten la realización de actividad física, la disponibilidad de comidas saludables, el apoyo social, el marketing y las promociones de empresas de comida rápida y las políticas públicas son factores claves en las decisiones individuales[17, 18]. Asimismo existen otros factores de riesgo relacionados con la obesidad infantil y que se dan a una edad temprana como los prenatales (hábitos tabáquicos de la madre durante el embarazo, el IMC de los padres antes del nacimiento del hijo, diabetes gestacional, inadecuada ganancia ponderal de la madre durante el embarazo); perinatales (como la práctica de la cesárea, el peso del niño al nacer) y postnatales (lactancia de fórmula frente a la lactancia materna, y la ganancia ponderal rápida durante el primer año de vida[19-21].

Muy relacionado con la obesidad infantil se encuentra el síndrome metabólico(22, 23). De hecho, la mayoría de los casos de síndrome metabólico en la infancia y en la adolescencia ocurren en individuos con obesidad. En el 2001, el National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III) acuñó el término "síndrome metabólico" para describir la presencia de cualquiera de tres de los cinco riesgos particulares siguientes: hiperglucemia, hipertrigliceridemia, adiposidad central, presión arterial elevada y bajo colesterol de lipoproteínas de alta densidad (HDL-C)[24]. En niños y adolescentes, sin embargo, se han propuesto muchas definiciones diferentes de síndrome metabólico y no existe un consenso claro sobre cuál usar, en parte porque no hay valores de referencia de los diferentes componentes a usar durante la infancia. Por esta razón, algunos estudios han desarrollado un score cuantitativo de riesgo

cardiovascular[25, 26]. La estimación de la prevalencia del síndrome metabólico varía entre un 4.2% y un 9.2%[25, 27, 28]. Aunque estos porcentajes son más bajos en niños que en adultos, las tasas crecientes de obesidad infantil y de vida sedentaria durante las últimas décadas podrían estar asociadas con una mayor prevalencia de síndrome metabólico en niños y adolescentes en el futuro[22].

1.2. Desventajas socioeconómicas: nivel socioeconómico y vulnerabilidades sociales

Definimos las desventajas socioeconómicas como las situaciones familiares y socioeconómicas (p.ej. familias con nivel educativo o de ingresos bajos, padres que carecen de una red social de apoyo, familias no tradicionales, origen inmigrante o etnia minoritaria y el desempleo) que pueden afectar negativamente al niño a través de factores biológicos, de comportamiento y estilos de vida y de salud mental. Con este término incluimos situaciones que abarcan tanto indicadores clásicos del nivel socioeconómico como otro tipo de indicadores que hemos denominado de vulnerabilidad social y que quedan definidos a continuación:

El estatus o nivel socioeconómico es la posición o clase social de un individuo o grupo. A menudo se cuantifica en base a una combinación de la educación, de la ocupación y de los ingresos, aunque en ocasiones se utiliza solo uno de ellos como indicador del nivel socioeconómico. El nivel socioeconómico se considera como uno de los predictores más robustos y consistentes de la morbilidad y mortalidad de una persona. Aunque estas dimensiones están muy interrelacionadas, se ha propuesto que cada una de ellas refleja de alguna forma facetas individuales y sociales diferentes, asociadas con la salud y la enfermedad[29-32].

Educación: es la principal medida del nivel socioeconómico en la mayoría de los países de altos ingresos porque, al contrario que la ocupación y los ingresos, la educación es una medida más estable y permanente, además de señalarse como el mejor

predictor de una buena salud. La educación captura el conocimiento relacionado con los activos de una persona. Puede ser medida como una variable continua (años de educación completada) o como una variable categórica (valorando la finalización de la escuela primaria, secundaria, o universitaria o incluso pudiendo distinguir entre diferentes niveles). Este indicador está más relacionado con los requisitos para adquirir una posición social, psicológica y económica más estable[33].

Ingresos: representa la capacidad de una familia para adquirir recursos materiales y la posibilidad de acceder a diferentes estilos de vida. A menudo los ingresos se valoran a través de los ingresos familiares, es decir como la suma de todos los ingresos provenientes de todos los miembros del hogar durante un tiempo determinado (normalmente durante un año o mensualmente). Cuando se incluye también la riqueza familiar (stock de los activos financieros del hogar), el ingreso familiar mide además la capacidad para proporcionar a los niños comida, refugio, y una casa de calidad o un entorno seguro y estimulante para el niño[34].

Ocupación laboral: las ocupaciones asociadas a un nivel más alto confieren mayores ingresos, más control y más prestigio. Las condiciones de trabajo parecen moldear los valores y la personalidad de los trabajadores. Las características de trabajos de alto prestigio como tareas altamente complejas y autónomas estás asociadas con una orientación hacia la auto-dirección y la flexibilidad intelectual mientras que los trabajos que tienen una flexibilidad más baja están asociadas a una orientación hacia la conformidad. Los valores adquiridos, las orientaciones y las habilidades cognitivas son transmitidos a los hijos a través de las prácticas parentales[35].

Existen otras desventajas sociales además de los niveles de educación, ocupación e ingresos bajos que afectan negativamente a los niños y adultos, y que pueden dar lugar a desigualdades en la salud de los individuos. Debido a los profundos cambios sociales

(como la inmigración y nuevos modelos familiares) y económicos (derivados por ejemplo de la crisis económica del 2008, que llevó a la pérdida de muchos puestos de trabajo) vividos en las últimas décadas, muchas familias se han visto bajo condiciones económicas y emocionales de estrés, incrementando en muchos casos la situación de desigualdad entre familias. Las desventajas tienen diferentes formas y pueden ser absolutas o relativas. Pueden incluir, entre otras, estar en situación de desempleo, tener una red social de apoyo escasa, tener un origen inmigrante, pertenecer a una etnia minoritaria o tener una estructura familiar no tradicional. Estas circunstancias desfavorables suelen converger en los mismos individuos y sus efectos en la salud son acumulativos[36-38].

Situación laboral: Perder un trabajo no solo tiene consecuencias financieras sino también consecuencias psicológicas. Sus efectos empiezan incluso antes de la propia situación de desempleo, cuando las personas sienten que sus trabajos están amenazados[30, 39].

Red social de apoyo: el apoyo social y las redes sociales satisfactorias tienen una contribución importante para la salud. El apoyo social proporciona los recursos emocionales y prácticos que se necesitan. Tener una red social con la que contar puede hacer que las personas se sientan queridas, repercutiendo positivamente en su auto-estima.

Origen inmigrante y minorías étnicas: los inmigrantes de otros países y los grupos de minorías étnicas son particularmente vulnerables a la exclusión social y a menudo tienen menos posibilidades para acceder a un trabajo y a la educación. Además, el racismo, la discriminación y la hostilidad a la cual se enfrentan pueden dañar su salud.

Estructura familiar: los cambios en el matrimonio, divorcio y fertilidad en las últimas décadas han llevado a cambios muy importante en la estructura familiar. Se ha señalado que las familias monoparentales tienen una peor salud mental, debido no solo a la inseguridad financiera en la que en muchos casos se enfrentan, sino también al número de estresores que experimentan.

Por una cuestión práctica llamaremos a estas desventajas sociales vulnerabilidades sociales para distinguirlas de los indicadores clásicos de educación, ocupación e ingresos.

El estudio del nivel socioeconómico en niños y adolescentes confiere más dificultades que en el caso de los adultos. Una medida alternativa para medir la situación económica de los menores es la Escala de Afluencia Familiar (Family Affluence Scale, FAS) desarrollada por la OMS, en la que se pregunta a los estudiantes acerca de número de coches que poseen su familia, si tienen una habitación para ellos mismos, el número de veces que se han ido de vacaciones o la posesión de ordenadores en su familia[40]. Entre las limitaciones del FAS se ha señalado el hecho de que la información deba ser adecuada a la realidad del momento y del país donde se lleve a cabo, y que la comparabilidad entre estudios sea menor.

1.3. Vulnerabilidades sociales y alimentación

Existe diversidad de estudios en los que se ha señalado la relación entre el nivel socioeconómico y la calidad de la alimentación[41-43]. En países desarrollados, el consumo de alimentos de mayor calidad nutricional, particularmente caracterizados por el consumo de más frutas y verduras, son en general consumidos por personas con un mayor nivel socioeconómico[44] siendo la educación de la madre uno de los factores más determinantes en la alimentación del niño[45, 46]. Los determinantes de la calidad de la alimentación incluyen determinantes individuales, entorno físico, políticas públicas y

factores culturales. Uno de los factores que más determina la decisión de los individuos es el coste de los alimentos, la accesibilidad y la disponibilidad de los productos. A menudo, las comidas con menos nutrientes y alta densidad calórica son fuentes de calorías más baratas mientras que las dietas de alta calidad están asociadas con un mayor coste. Por ello, las desigualdades socioeconómicas en la alimentación pueden ser explicadas por el coste más alto de los patrones de alimentación más saludables[47]. Asimismo, los barrios en los que viven las personas de un nivel socioeconómico más bajo tienen a menudo una mayor proporción de establecimientos de comida rápida, y menor acceso a alimentos frescos más saludables[48].

La influencia de la red social, la situación de desempleo, la estructura familiar y origen inmigrante pueden determinar asimismo los hábitos dietéticos tanto en los adultos como en los niños y adolescentes.

Las circunstancias sociales pueden influenciar de distinta manera el tipo y la variedad de comidas consumidas, a través de mecanismos psicológicos que incluyen el apoyo y red social. Se ha observado que aquellas personas con una red social más escasa consumen más calorías, tienen una alimentación menos variada y toman una menor cantidad de frutas y verduras[49].

La estructura familiar determina también los hábitos dietéticos de la familia. Algunos estudios han descrito que los niños y adolescentes que no vivían con ambos progenitores mostraban hábitos de alimentación menos saludables[50, 51]. Los niños que viven con ambos padres consumían más frutas, leche y productos lácteos[52].

Asimismo, la situación laboral de los padres parece condicionar sus hábitos dietéticos y el de sus hijos[53, 54]. En una reciente revisión sistemática se ha observado

que patrones de consumo de alimentos menos saludables están relacionados con el desempleo de los padres[55].

Por último, respecto a los hábitos dietéticos de las familias inmigrantes, a pesar de las diferencias existentes en función del país de origen, entorno urbano o rural, factores socioeconómicos y culturales, después de su llegada al nuevo país de acogida se ha observado en diversos estudios un aumento en su ingesta energética y de grasas, en el consumo de carbohidratos refinados y de carne y lácteos, así como una disminución del consumo de verduras[56-58].

1.4. Vulnerabilidades sociales, actividad física, y comportamientos sedentarios

Numerosos estudios han puesto de manifiesto que grupos de nivel socioeconómico más bajo tienen unos niveles de sedentarismo mayores y menores niveles de actividad física en comparación con aquellos grupos de nivel socioeconómico más alto[59, 60]. No obstante, parece que la actividad física y el sedentarismo están influenciados por diferentes determinantes. Mientras la actividad física de los niños y adolescentes estaría más influenciada por el entorno, como los programas de actividad física de los centros escolares e instalaciones deportivas en la comunidad, el sedentarismo estaría más determinado por el nivel socioeconómico [61, 62].

Algunos estudios han analizado otro tipo de desventajas sociales, por ejemplo, Bagley y colaboradores encontraron que las niñas de familias monoparentales pasaban más tiempo viendo la televisión que aquellas que vivían con ambos progenitores[63].

El origen inmigrante de los padres parece también determinar el nivel de actividad física y sedentarismo infantiles. En un estudio realizado en Holanda, se apreciaron niveles de actividad física significativamente menores en los niños inmigrantes (sobre

todo en aquellos de origen turco, marroquí y otros niños no occidentales) comparados con los nativos[64].

El apoyo y las redes sociales condicionan asimismo la actividad física y el sedentarismo. Existen diversas investigaciones que han observado mayores niveles de actividad física y menores niveles de tiempo de pantalla en aquellos con una red de amigos más amplia, sobre todo si estos amigos eran físicamente activos[65].

El desempleo juega un importante papel en los hábitos de actividad física y sedentarismo, no solo en aquellos padres que lo sufren directamente, sino también en sus hijos. Los desempleados y sus hijos muestran menores niveles de actividad física y mayores niveles de sedentarismo que aquellos con trabajo a tiempo completo [66-68].

1.5. Vulnerabilidades sociales y problemas psicosociales

Una de las consecuencias más importantes de las desventajas sociales son los problemas psicológicos, tanto en los adultos como en los niños[69]. Un bajo nivel de educación, ocupación e ingresos de los padres está asociado a mayores problemas internalizados y particularmente a problemas externalizados en niños y adolescentes[70].

En estudios previos, la estructura familiar se ha revelado como un factor predictivo del bienestar mental, concretamente aquellas familias no tradicionales (entendidas en el estudio como familias reconstituidas, familias monoparentales y aquellas monoparentales con otros familiares presentes) manifiestan más síntomas depresivos[71].

Una de las medidas del apoyo social es el tamaño de la red social y la satisfacción con la misma. La importancia del apoyo recibido por los padres, aunque decrece durante la adolescencia, aumentando paralelamente el de los amigos, se mantiene como el mejor indicador de los problemas emocionales de los niños y adolescentes. Así, una red social

de apoyo escasa está asociada a peores niveles de bienestar mental en todas las generaciones[72].

Las distintas revisiones de la literatura han señalado que el proceso de inmigración puede ser un fenómeno altamente estresante, aunque no todos los inmigrantes pasen por el mismo proceso y varíe de forma muy importante según el país de origen, el país de acogida o el nivel socioeconómico, entre otros factores[73]. La pérdida de apoyo y de redes sociales, las dificultades con el idioma, la discriminación, el estrés de la adaptación y las dificultades económicas y materiales pueden hacer que los inmigrantes tengan mayores riesgos de problemas psicosociales[73-75].

El desempleo es un predictor de los problemas psicosociales sobre todo en los hombres[76]. Se ha propuesto que, para alcanzar una personalidad y desarrollo correcto, la persona necesita creer que está haciendo progresos para enriquecerse contribuyendo con su familia y con la comunidad. De lo contrario la auto-estima se ve comprometida, llevando a ansiedad y a la falta de confianza en la persona[77]. El desempleo de los padres parece arrojar distintos resultados en la salud mental de los hijos dependiendo de si el desempleo recae sobre la madre o el padre y de la edad del menor[78].

1.6. Vulnerabilidades sociales, obesidad infantil y síndrome metabólico

Las desventajas sociales en la infancia están asociadas con un aumento en el riesgo de enfermedad cardio-metabólica[79]. En el estudio IDEFICS, que incluyó a niños de ocho países europeos, la prevalencia del síndrome metabólico se estimó en 5.5%, aunque con grandes diferencias entre el norte, con una prevalencia menor, y el sur de Europa, con unos porcentajes más elevados[25]. No obstante, el aumento de la frecuencia de obesidad en los niños y de los comportamientos sedentarios en las últimas décadas podrían estar detrás del aumento en la prevalencia de diabetes, hipertensión y del síndrome metabólico en niños y adultos[22]. Los niños que acumulan mayores

desventajas sociales y económicas presentarían asimismo un mayor riesgo, ya que es en estos grupos donde el porcentaje de obesidad infantil es mayor[80]. Las desigualdades en salud son desigualdades evitables entre los grupos de personas en el país y entre países. Las condiciones sociales y económicas y sus efectos en la vida de las personas determinan el riesgo de enfermedad. El gradiente social se refiere al hecho de que las personas con menos recursos económicos y sociales tienen una peor salud, resaltando la sensibilidad de los niños y adultos a los factores socioeconómicos. El aumento de las desigualdades socioeconómicas en la obesidad está acentuando el gradiente social. Y los grupos con más desventajas socioeconómicas tienen niveles de obesidad mayores. Una de las complicaciones más importantes del exceso de peso es el síndrome metabólico.

Tal y como se ha señalado anteriormente el síndrome metabólico engloba un conjunto de factores de riesgo cardiovasculares, principalmente obesidad central o abdominal, resistencia a la insulina/intolerancia a la glucosa/diabetes de tipo 2, dislipemia (concentraciones elevadas de triglicéridos y bajas de HDL-colesterol) e hipertensión arterial. Para el diagnóstico del síndrome metabólico se necesitan al menos la presencia de tres de estos factores de riesgo. Existen no obstante diferentes definiciones del síndrome metabólico ya que no hay valores de referencia para los diferentes componentes para ser usados durante la infancia. Entre las definiciones del síndrome metabólico pediátrico (tabla 1) destaca la de Cook y colaboradores[27], la de Viner y colaboradores[81], la de la Federación Internacional de la Diabetes (IDF)[82] y la desarrollada por Ahrens y colaboradores[25].

Tabla 1. Definiciones del síndrome metabólico pediátrico

Definición	**Exceso de adiposidad**	**Presión arterial**	**Lípidos en sangre**	**Glucosa en sangre/insulina**
Cook et al.[27]	Circunferencia de cintura ⩾ percentil 90	TAS o TAD ⩾ percentil 90	Triglicéridos ⩾ 110 mg dl^{-1} o colesterol HDL⩽ 40 mg dl^{-1}	Glucosa en ayunas alterada ⩾ 110 mg dl^{-1}
Viner et al.[81]	IMC ⩾ percentil 90	TAS ⩾ percentil 95	Triglicéridos ⩾ 150 mg dl^{-1} o colesterol HDL⩽ 35 mg dl-1 o colesterol alto total⩾ 95 mg dl-1	Hiperinsulinemia ⩾ 15mU I^{-1} o glucosa en ayunas alterada ⩾ 110 mg dl^{-1}
IDF[82]	Circunferencia de cintura ⩾ percentil 90	TAS⩾ 130 mm Hg o TAD ⩾85mm Hg	Triglicéridos ⩾ 150 mg dl^{-1} o colesterol HDL⩽ 40 mg dl^{-1}	Glucosa en ayunas alterada ⩾ 100 mg dl^{-1}
IDEFICS nivel de control[25]	Circunferencia de cintura ⩾ percentil 90	TAS o TAD ⩾ percentil 90	Triglicéridos ⩾ percentil 90 o	HOMA-IR⩾ percentil 90 o glucosa en

			colesterol HDL⩽ percentil 10	ayunas ⩾ percentil 90

Abreviaciones: IDF: Federación Internacional de la Diabetes, IMC: Índice de Masa Corporal, HOMA-IR: Modelo Homeostático para evaluar la Resistencia a la Insulina TAS: Tensión Arterial Sistólica, TAD: Tensión Arterial Diastólica,

1.7. Marco conceptual

Para la mejor comprensión de la presente Tesis Doctoral se ha realizado el siguiente modelo conceptual (figura 1) que resume las principales relaciones estudiadas (la asociación entre las vulnerabilidades sociales y los factores psicosociales, la alimentación, la actividad física y los comportamientos sedentarios, los factores tempranos de riesgo y finalmente con la obesidad y el síndrome metabólico infantil).

Existen no obstante otras relaciones que están asociadas con la obesidad y el síndrome metabólico que no han sido investigadas en el presente trabajo como son la disfunción familiar relacionada con la violencia y el abuso infantil, la psicopatología de los padres o el abuso de sustancia tóxicas. Asimismo, tampoco se ha examinado la importancia del sueño en estas relaciones. Diversos estudios han mostrado un incremento de riesgo de la obesidad y de alteraciones metabólicas entre aquellos con falta de sueño o con algún tipo de desorden del mismo[83, 84].

La hipótesis planteada en el presente modelo conceptual parte de la idea de que las desventajas socioeconómicas y otras adversidades durante la infancia y la primera infancia parecen jugar un papel crítico en la obesidad y en el síndrome metabólico, a través de mecanismos tales como la inseguridad, el estrés y la agitación emocional, que eventualmente conducen a unos peores estilos de vida (alimentación, actividad física, comportamientos sedentarios, sueño).

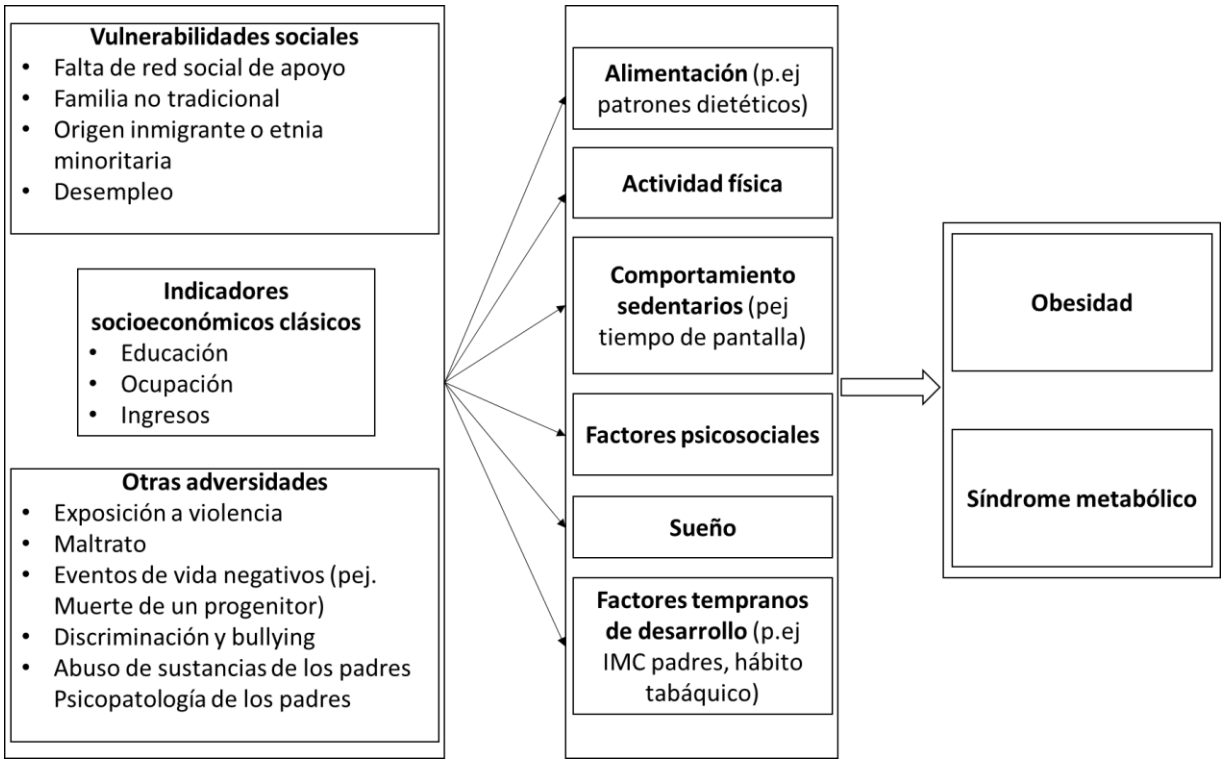

Figura 1. Marco conceptual (hipótesis). Fuente: Elaboración propia.

2. Objetivos

Los objetivos generales de la presente Tesis Doctoral son valorar la asociación entre las vulnerabilidades sociales, los estilos de vida (dieta, actividad física y comportamientos sedentarios) y la salud mental en niños europeos, así como explorar el papel de las vulnerabilidades sociales en la frecuencia de sobrepeso y obesidad infantil y de síndrome metabólico.

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

Artículo I. Valorar la asociación entre diferentes vulnerabilidades sociales y su posible efecto acumulativo con los patrones dietéticos en niños europeos

Artículo II. Explorar la asociación entre las vulnerabilidades sociales y el cumplimiento de las recomendaciones de actividad física (medida objetiva y subjetivamente) y el tiempo de pantalla en niños europeos.

Artículo III. Investigar la relación entre las vulnerabilidades sociales y los problemas psicosociales en niños europeos y analizar el impacto entre la evolución de las vulnerabilidades en el tiempo y su acumulación en el riesgo de padecer problemas psicosociales en esta población.

Artículo IV. Valorar la asociación entre el país de origen/etnia de los padres, con el riesgo de sobrepeso/obesidad en niños españoles de 6 años así como la influencia de la acumulación de un bajo nivel socioeconómico y de pertenecer a minorías étnicas en el riesgo de sobrepeso/obesidad a los 2, 4 y 6 años.

Articulo V. Investigar la asociación entre las vulnerabilidades sociales y el peso en los niños europeos además del efecto de las vulnerabilidades a lo largo del tiempo y su acumulación el peso infantil.

Articulo VI. Analizar la asociación entre las desventajas sociales, su evolución en el tiempo y su acumulación y el riesgo de síndrome metabólico en niños europeos.

2. Objectives

The general objectives of this Doctoral Thesis are to study the association between social vulnerabilities and lifestyle factors (diet, physical activity and sedentary behaviours) and mental health in European children, as well as to explore the role of social vulnerabilities in the presence of overweight/obesity and risk of metabolic syndrome disturbances in children.

The specific objectives of the six articles that make up the Doctoral Thesis are the following:

Paper I. To study the association between different social vulnerabilities and its possible cumulative effect with dietary patterns in European children.

Paper II. To explore the association between social vulnerabilities and the compliance to recommendations for physical activity (measured objectively and subjectively) and screen time in European children.

Paper III. To investigate the relationship between social vulnerabilities and psychosocial problems in European children. Moreover, the impact of changes in social vulnerabilities over time and accumulation of vulnerabilities on the risk of psychosocial problems was investigated.

Paper IV. To assess the association between socioeconomic status and parental origin/ethnicity with the risk of overweight/obesity in Spanish children at age 6 years. Also, the effect of an accumulation of a number of vulnerabilities (low socioeconomic status and belonging to an ethnic minority in the risk of overweight/obesity) at age 2, 4 and 6 years was assessed.

Paper V. To investigate the association between social vulnerabilities and weight status in European children. Furthermore, the effect of changes in vulnerabilities over time on childhood weight status was studied.

Paper VI. To analyse the association between socioeconomic disadvantages, its evolution over time and risk of metabolic disturbances in European children.

3. Material y métodos

La presente Tesis Doctoral se ha elaborado teniendo en cuenta resultados de dos proyectos de investigación: 1) datos del estudio europeo IDEFICS (Identification and Prevention of Dietary- and Lifestyle-induced Health Effects in Children and Infants) y 2) datos del estudio con niños aragoneses CALINA (Crecimiento y Alimentación durante la Lactancia y la primera Infancia en Niños Aragoneses).

3.1 Comités de ética

Ambos estudios, IDEFICS y CALINA se realizaron siguiendo las pautas éticas de la Declaración de Helsinki de 1961 (revisión de Edimburgo 2000), las normas de la Buena Práctica Clínica y la legislación sobre investigación clínica en humanos y fueron aprobados por el Comité Ético de Investigación Clínica de Aragón (CEICA), en el caso de la Universidad de Zaragoza. El protocolo del estudio en el resto de los países europeos participantes en IDEFICS fue aprobado por los comités éticos locales correspondientes, para cada centro participante en el estudio. Los padres o tutores legales de los niños participantes en el estudio firmaron un consentimiento informado mostrando su aceptación para la participación en el estudio. Asimismo, los menores también dieron verbalmente su consentimiento antes de realizar las distintas pruebas a las que se vieron sometidos.

3.2 Muestra y diseño de estudio

3.2.1 Estudio IDEFICS

El estudio IDEFICS es un estudio prospectivo, multicéntrico de cohortes que incluyó un programa de intervención de salud a distintos niveles: individual (niño), familiar (padres), escolar y comunitario para mejorar los hábitos alimentarios, aumentar los niveles de actividad física, disminuir el tiempo sedentario y el nivel de estrés de los

niños e intentar así disminuir la prevalencia de obesidad. Al comienzo del estudio (T0), se incluyeron 16.228 niños de entre 2.0 y 9.9 años, de ocho países europeos (Suecia, Alemania, Hungría, Italia, Chipre, España, Bélgica, Estonia), reclutados desde septiembre de 2007 hasta junio de 2008 a través de las escuelas infantiles y de primaria, con el acuerdo del equipo directivo de cada centro. El seguimiento del estudio (T1) se llevó a cabo dos años más tarde (desde septiembre de 2009 a junio de 2010) aplicándose los mismos métodos estandarizados de valoración, donde 11.041 niños de entre 4.0 a 11.9 años fueron re-evaluados. En cada país, la muestra quedó dividida en dos áreas comparables socio-demográficamente, la de control y aquella donde se realizó la intervención.

Para la realización de la presente Tesis Doctoral se ha utilizado principalmente datos del estudio IDEFICS (excepto el artículo 4 que incluyó datos del estudio CALINA). Todos los artículos incluyen análisis prospectivos, por lo que las muestras incluidas en los mismos se redujeron considerablemente, al necesitar que los niños contaran con datos en diferentes momentos temporales. No obstante, aquellos niños de familias que habían completado las pruebas pero dejaron sin rellenar información sobre las distintas desventajas socioeconómicas (información sobre el nivel socioeconómico y vulnerabilidades sociales) fueron incluidos como una categoría separada (con información perdida) ya que estos grupos pueden no representar un conjunto aleatorio de la población y eliminarlos podría causar un cierto sesgo en los resultados.

La muestra del **artículo I** incluyó datos de 9.301 niños, los cuales tenían que tener al menos la mitad de la información sobre la frecuencia de consumo de alimentos completa tanto en T0 como en T1.

El **artículo II** contó con datos de 13.981 niños con información completa sobre la actividad física, tiempo de pantalla y pertenencia a un club deportivo medidos a través

de cuestionarios en T0 y con datos de 8.482 niños en ambos momentos de tiempo (T0 y T1). Para tener datos de la actividad física medida objetivamente, se seleccionaron aquellos niños que tenían información completa y válida obtenida mediante acelerometría en T0 (5.892 niños) y en ambos momentos, T0 y T1 (2.285 niños).

Un total de 5.987 niños fueron incluidos en el **artículo III**, para los cuales se obtuvo información completa en T0 y en T1 sobre posibles problemas psicosociales. Para valorar los problemas psicosociales se utilizaron dos instrumentos principales: el Cuestionario para Medir la Calidad de Vida relacionada con la Salud en Niños y Adolescentes (KINDL) y el Cuestionario de Fortalezas y Dificultades (SDQ). También se tuvo en cuenta información en T0 sobre los estilos de vida medidos con cuestionarios (frecuencia de consumo de frutas y verduras, actividad física y tiempo de pantalla).

El **artículo V** incluyó datos de 8.624 niños con información en T0 y en T1 sobre sus estilos de vida medidos con cuestionarios (frecuencia de consumo de frutas y verduras, actividad física y tiempo de pantalla) y el índice de masa corporal de la madre.

La muestra del **artículo VI** quedó reducida a 2.401 niños que contaron con información completa en T0 y en T1 para calcular el score de riesgo de síndrome metabólico (perímetro de la cintura, tensión arterial, lípidos en sangre y resistencia a la insulina) así como información sobre los estilos de vida del niño medidos con cuestionarios (frecuencia de consumo de frutas y verduras, actividad física y tiempo de pantalla).

3.2.2 Estudio CALINA

El estudio CALINA es un estudio observacional en una cohorte representativa de la población de niños aragoneses seguidos desde el nacimiento hasta la actualidad (en el caso concreto del artículo que incluye los datos del proyecto CALINA, se valoró a los

niños hasta los 6 años). El objetivo principal del estudio CALINA fue evaluar los patrones de crecimiento, la composición corporal y los aspectos de alimentación de los niños, así como los factores pre-, peri-, post-natales y socioculturales que puedan influenciarlos. El estudio se ha desarrollado en una muestra aleatoria de Centros de Salud representativos de la Comunidad Autónoma de Aragón que cumplían los siguientes criterios de inclusión: tener personal de pediatría y enfermería que llevaran a cabo el Programa de Salud Infantil para el seguimiento del niño en Atención Primaria, con al menos 2 años de antigüedad, con cumplimiento y cobertura de dicho programa superior al 80% de la población asignada. Los sujetos considerados en el estudio fueron todos los nacidos durante un año natural (desde marzo del 2009 hasta febrero del 2010, ambos inclusive), que acudieron a la primera visita de las revisiones programadas por los Centros de Salud seleccionados y cuyos padres firmaron el consentimiento informado. Los menores con malformaciones, enfermedades y minusvalías físicas que provocaban alteraciones del crecimiento y/o del estado nutricional fueron excluidos. En el estudio CALINA se contactó con 1.630 familias, de las cuales aceptaron participar 1.602. Finalmente, 1.540 niños participaron al comienzo del estudio (T0) y fueron examinados al nacimiento y re-examinados en los centros de atención primaria a las dos semanas, mensualmente (1, 2, 4, 6 y 9 meses) y anualmente (después de 1, 2, 4 y 6 años). Después de 6 años 1.217 niños siguieron participando en el estudio.

El **artículo IV** fue el único artículo que incluyó datos del estudio CALINA y la muestra incluyó a 1.031 niños aragoneses para los cuales se disponía de datos sobre el peso del niño a los 6 años, sobre el nivel económico de los padres, origen/etnicidad y datos sobre aspectos pre-, peri- y post-natales como el peso de los padres, el hábito tabáquico de la madre, la ganancia de peso de la madre durante el embarazo, el peso al

nacer, la ganancia de peso durante los primeros meses de la vida del niño y las prácticas de lactancia materna.

3.3. Métodos de medida en el estudio IDEFICS

3.3.1. Factores socioeconómicos y demográficos

La información demográfica (como el sexo, fecha de nacimiento del niño, país de residencia) y la relativa a las desventajas sociales, fue recogida a través de los cuestionarios cumplimentados por los padres.

- Educación: Los padres indicaron cuál fue su máximo nivel de educación completado, así como el de su pareja. Las respuestas particulares para cada país fueron codificadas según la International Standard Classification of Education, Clasificación Internacional Normalizada de la Educación, (ISCED) de 1997[85]. En el presente análisis, las categorías fueron recodificadas en tres, según el nivel de educación: bajo (nivel ISCED 0-2), medio (nivel ISCED 3-4) y alto (nivel ISCED 5-6). Se tuvo en cuenta el nivel educativo más alto de los padres, bien el del padre o el de la madre.
- Ingresos: Los padres también proporcionaron información sobre los ingresos netos mensuales del hogar sin incluir impuestos y deducciones, que corresponden a nueve categorías específicas de país (1: de la categoría más baja a 9: la categoría más alta). Los límites de categoría fueron diseñados para ser específicos del país según un esquema fijo basado en el ingreso equivalente mediano, lo que garantiza la comparabilidad entre países. Los resultados fueron organizados en tres categorías: bajo (1-3), medio (4-6) y alto ingreso (7-9).
- Ocupación: los padres especificaron su ocupación con 18 opciones posibles, que fueron más tarde transformadas en la versión de tres clases de la Clasificación Socioeconómica europea: clase trabajadora, intermedia y alta[86].

- Origen de los padres: se consideró al niño con origen inmigrante si uno o ambos progenitores había nacido en otro país distinto al de residencia frente a los nativos en los que ambos padres habían nacido en el país de residencia.
- Situación de empleo: se consideró al niño con padres desempleados si uno o ambos progenitores se encontraban en situación de desempleo.
- Estructura familiar: las familias tradicionales fueron definidas como aquellas en la que el niño vivía con ambos progenitores en contraste con las familias no tradicionales, las cuales incluían el resto de modelo familiares.
- Apoyo social: si los padres a la pregunta "en caso de necesidad, ¿con cuántas personas de confianza además de tu familia puedes realmente contar?" contestaban una persona o ninguna se consideraba que tenían una red social de apoyo escasa.

Los análisis incluyeron el impacto de la evolución de las vulnerabilidades de T0 a T1, en las diferentes variables dependientes de nuestro estudio (patrones dietéticos, actividad física y tiempo de pantalla, problemas psicosociales, sobrepeso/obesidad y síndrome metabólico). Los patrones de vulnerabilidad a lo largo del tiempo fueron recogidos en las siguientes categorías: (vulnerable en T0 y T1, vulnerable en T0 y no vulnerable en T1, no vulnerable en T0 y vulnerable en T1; y no vulnerables en T0 y T1)

Los patrones de vulnerabilidad no fueron evaluados para el estatus de inmigrante, ya que es un estado permanente que no cambia.

Se calculó un marcador de vulnerabilidad total, sumando el número de desventajas sociales a las que un niño estuvo expuesto. En total, se incluyeron seis desventajas (bajo nivel de educación, bajo nivel de ingreso, red social mínima, familia no tradicional, inmigrante, desempleado). El marcador de vulnerabilidad varió de 0 (el niño no tenía ninguna vulnerabilidad) a 6 (el niño tenía las seis vulnerabilidades) y se

dividió en cinco categorías (de tres a seis vulnerabilidades, dos vulnerabilidades, una vulnerabilidad, ninguna vulnerabilidad y con información perdida).

3.3.2. Consumo de alimentos

Los patrones de consumo de alimentos en los niños fueron valorados con el cuestionario de frecuencia de consumo de alimentos denominado Children's Eating Habits Questionnaire-food frequency section (CEHQ-FFQ)[87-89]. Este instrumento fue desarrollado para valorar la frecuencia de consumo de alimentos relacionados positiva o negativamente con el riesgo de sobrepeso y obesidad. El CEHQ-FFQ fue cumplimentado por los padres, reflejando las frecuencias habituales de consumo de 42 alimentos en el hogar durante el mes anterior (no se incluyeron las comidas fuera del control de los padres, como las consumidas en los centros educativos). Este cuestionario no incluye información sobre la ingesta energética total. Los 42 alimentos incluidos se agrupaban en 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 (frutos secos, dulces, pasteles, chocolate, palomitas de maíz, ganchitos, etc.). Las categorías de respuesta para cada ítem incluían las siguientes: "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".

3.3.3. Antropometría

La talla (cm) (con precisión de 0.1 cm) se midió con un estadiómetro calibrado (estadiómetro Seca 225, Birmingham, Reino Unido), con los niños descalzos. El peso corporal (kg) de los niños (con precisión de 0.1 kg) se midió en ayunas, en ropa interior ligera y con los pies descalzos, en una báscula electrónica (Tanita BC 420 SMA, Tanita

Europe GmbH, Sindelfingen, Alemania). Se calculó el IMC como el peso (kg) dividido por la talla (en metros) al cuadrado, así como los z-scores correspondientes según los estándares de referencia respecto a la edad y sexo utilizando los criterios de acuerdo a los puntos de corte establecidos por Cole y Lobstein[90]. El perímetro de la cintura (cm) se midió en posición vertical con el abdomen relajado y los pies juntos, en el punto medio entre el borde costal más bajo y la cresta ilíaca con una precisión de 0,1 cm (cinta inelástica: Seca 200).

3.3.4. Actividad física y comportamientos sedentarios

La actividad física de los niños fue estimada a través de dos métodos (cuestionarios y acelerómetros). Por un lado, se valoró la actividad física con cuestionarios en los que los padres informaban sobre el total de horas y minutos que los niños pasaban jugando al aire libre, entre semana y durante los fines de semana, así como el tiempo que sus hijos invertían haciendo deporte en un club deportivo en una semana típica, en el mes anterior. La actividad física declarada se calculó como: [(horas jugando al aire libre entre semana* 5) + (horas jugando al aire libre los fines de semana * 2) + horas de participación deportiva semanal]/7. Para los análisis realizados, los participantes se clasificaron en dos grupos: aquellos que cumplían con las recomendaciones actuales de actividad física, de al menos 1 hora de actividad física al día frente a aquellos que no cumplían esta pauta[91]. Los padres también informaron sobre la pertenencia (o no) del niño a un club deportivo.

De forma complementaria, también se analizó la actividad física de forma objetiva, mediante acelerómetros. Para ello se instruyó a los niños para que usaran desde que se levantaban hasta que se acostaban un acelerómetro uniaxial (ActiGraph o ActiTrainer, ActiGraph, Pensacola, FL, EE. UU.), situado en la cadera derecha a modo de cinturón, durante al menos 3 días, incluyendo un día de fin de semana y que solo

debían quitarse durante las actividades acuáticas. En los análisis realizados, para no perder una muestra importante de niños, se consideró a aquellos con un registro de la actividad de al menos 8 horas al día, que tuvieran al menos dos días de registro (un día entre semana y otro día de fin de semana). Los días entre semana fueron ponderados por cinco y los fines de semana por dos.

Se estableció un epoch de 15 segundos, pero los datos fueron reintegrados a 60 segundos de epoch para el análisis, ya que algunos países del estudio involuntariamente utilizaron el epoch de 60 segundos. La duración de la actividad moderada a intensa fue determinada de acuerdo con los puntos de corte de Evenson[92].

Los padres también informaron sobre las horas que pasaban sus hijos viendo la TV/DVD/vídeo y jugando a la consola o al ordenador entre semana y los fines de semana. El tiempo de pantalla total diario se calculó como: (5 * valores de la semana + 2 * valores de fin de semana)/7. Los participantes se dividieron en dos grupos en base a las pautas de tiempo de pantalla de la Academia Americana de Pediatría: menos de 2 h al día versus al menos 2 horas al día[93].

3.3.5. Aspectos psicosociales

Los padres contestaron a varias preguntas que valoraban la salud mental de los niños, con dos instrumentos previamente validados: el KINDL® y el SDQ[94, 95].

El KINDL evalúa aspectos de la calidad de vida relacionada con la salud, en niños y adolescentes, en seis dimensiones: bienestar emocional, autoestima, relaciones familiares, contactos sociales, bienestar físico y funcionamiento diario[96]. Estas dos últimas áreas no fueron incluidas en el estudio IDEFICS. Las respuestas siguieron una escala Likert de 4 puntos (nunca, rara vez, a veces y a menudo/siempre). Las puntuaciones totales variaron entre 12-48 puntos, con aquellas más altas representando

indicadores más favorables de bienestar. Los niños cuya puntuación estuvo comprendida entre los 0 y los 36 puntos (percentil menor o igual a 20), se definieron con un bienestar mental bajo mientras que aquellos con una puntuación entre los 37 a 48 puntos fueron definidos con un bienestar normal o alto. Dado que el cuestionario KINDL original no proporciona un valor de referencia para todos los países, el percentil 20 fue escogido como punto de corte para los análisis.

El SDQ es un cuestionario de 25 ítems, dividido en cinco escalas (problemas emocionales, problemas de conducta, hiperactividad-inatención, problemas con los compañeros o pares y comportamiento prosocial). Dado que el estudio IDEFICS no incorporó la Escala de hiperactividad no se valoraron los problemas externalizados y solo se analizaron los problemas internalizados (que incluyen las subescalas de problemas emocionales y problemas de pares). De acuerdo a los puntos de corte publicados, se dividió a los niños entre aquellos con problemas internalizados y aquellos con una puntuación normal[97].

3.3.6. Síndrome metabólico

Ahrens y colaboradores propusieron una nueva definición del síndrome metabólico pediátrico, a partir de los datos obtenidos en el estudio IDEFICS, basándose en puntos de corte específicos, según la distribución de los componentes del síndrome metabólico en niños sanos[25]. La puntuación del síndrome metabólico se calculó como la suma de los z-scores específicos de edad y sexo del perímetro de la cintura, del índice de resistencia a la insulina (HOMA-IR), media de los z-score de la tensión arterial sistólica y diastólica y la media del z-score de las concentraciones séricas de colesterol HDL (multiplicado por -1) y z-score de las concentraciones séricas de triglicéridos.

Circunferencia de cintura

Se midió la circunferencia de la cintura (cm) en posición vertical con el abdomen relajado y los pies juntos, a medio camino entre el margen costal más bajo y la cresta ilíaca con una cinta inelástica de aproximadamente 0,1 cm (Seca 200).

Presión arterial

La presión arterial se midió con un dispositivo electrónico Welch Allyn Inc., Nueva York, EE. UU.) de acuerdo con un procedimiento estandarizado. La longitud del manguito para la medición de la presión arterial se eligió de acuerdo con el valor de circunferencia del brazo. Los niños se sentaron al menos durante 5 minutos antes de la medición. Se tomaron dos mediciones en un intervalo de 2 minutos y se realizó una tercera medición si diferían en> 5%. Para el análisis estadístico se utilizó el promedio de las dos (o tres) mediciones.

Extracción de sangre para valoración de las concentraciones séricas de lípidos y glucosa

Para recoger la sangre en ayunas se usó la venopunción o el muestreo capilar dependiendo de las preferencias de los participantes. Las muestras de sangre se analizaron centralmente en un laboratorio acreditado por la Organización Internacional de Normalización (ISO) 15189 usando un inmunoensayo de luminiscencia (AUTO-GA Immulite 2000, Siemens, Eschborn, Alemania) para insulina (µIU / ml). La evaluación del modelo de homeostasis (HOMA) se utilizó como medida de la resistencia a la insulina con la siguiente fórmula: HOMA = insulina en ayunas (µIU / ml) × glucosa en ayunas (mg / dl) / 405.

3.4. Métodos de medida en el estudio CALINA

Para el proyecto CALINA se consideraron las siguientes variables:

3.4.1. Factores socioeconómicos y demográficos

En entrevistas con los padres, se recogió información sobre el nivel educacional (codificado de acuerdo a la clasificación del ISCED de 1997)[85] y ocupacional de los padres (clasificado de acuerdo con las normas del ESEC en tres categorías)[86] de igual forma que se hizo para el estudio IDEFICS.

En estas mismas entrevistas, los padres informaron sobre su país de origen y/o etnicidad. Aunque todos los niños considerados en el estudio CALINA nacieron en España, según el país de origen de sus padres se crearon cuatros grupos basado en la etnicidad (niños españoles gitanos) o el origen de sus padres: niños con origen latinoamericano (de América central o de América del sur), de Europa del este, africanos (del norte de África y subsaharianos) y niños españoles no gitanos. En la mayoría de los casos el origen o etnicidad de los padres era coincidente; sin embargo, en aquellos en los que difería se tomó el origen o etnicidad materno.

3.4.2. Antropometría

Hasta los dos años, la altura del niño (en cm) se midió usando un tallímetro pediátrico horizontal con precisión de 0,1 cm y el peso (kg) se determinó con una báscula pesabebés con una precisión de 5 gramos. Para niños mayores de 2 años, la altura se midió con el niño de pie, descalzo, en ayunas y con ropa ligera con una precisión de 0,1 cm y el peso corporal en kg con una precisión de 10 g.

Los padres de los niños facilitaron su peso y altura al nacimiento de su hijo (en el caso de las madres indicaron además su peso previo al embarazo) y después se calculó su IMC.

Para calcular los puntajes z del IMC específicos por edad y sexo desde el nacimiento hasta los 5 años, utilizamos las tablas de estándares de crecimiento infantil

de la OMS, usando una desviación estándar > +2 y > +3 para el sobrepeso y la obesidad respectivamente(98). Para calcular los puntajes z del IMC específicos por edad y sexo a los 6 años utilizamos las tablas de referencia de crecimiento de la OMS establecidas para niños de 5 a 19 años usando una desviación estándar > +1 y > +2 para el sobrepeso y la obesidad respectivamente[99].

3.4.3. Factores prenatales, perinatales y postnatales

Los factores de riesgo temprano relacionados con la obesidad son factores pre-, peri- y post-natales de riesgo, asociados con el sobrepeso y la obesidad en los niños. En el estudio CALINA se recogió dicha información de los registros hospitalarios y obstétricos. A continuación, se describen únicamente las variables que se utilizaron en los análisis del artículo incluido en la presente Tesis:

- Uso de tabaco materno durante el embarazo: la madre se consideró fumadora independientemente del número de cigarros que fumaba.
- Aumento del peso materno durante el embarazo, obtenido de la historia médica obstétrica.
- El peso del niño al nacer, también obtenido de los registros del hospital.
- Ganancia de peso rápida: incremento en el peso desde el nacimiento hasta los 6 meses de vida. por encima de 0.67 de la desviación típica[100].
- Las madres también informaron sobre las prácticas de lactancia y su duración. Los niños se dividieron entre aquellos con lactancia materna exclusiva durante al menos 4 meses frente a aquellos niños que tomaban leche de fórmula.

3.5. Análisis estadístico: consideraciones generales

Los estadísticos descriptivos permitieron analizar las características generales de los participantes, plasmadas en forma de porcentajes en el caso de las variables categóricas y como media y desviación típica para el caso de las variables continuas.

Se llevaron a cabo modelos multinivel, concretamente modelos mixtos generalizados para capturar la variabilidad atribuible a la naturaleza multinivel de la muestra seleccionada. Los niños de un mismo país, de un mismo centro o escuela, son más similares que aquellos de distintos países, centros o escuelas. Es por ello que los modelos estadísticos tienen que tener en cuenta las correlaciones debido a las agrupaciones que se deban al diseño del estudio. De esta manera, se pudo tener en cuenta el efecto de la escuela, comunidad y país en las asociaciones.

La estructura de IDEFICS tiene múltiples niveles, tales como países, comunidades, escuelas y familias. Cada país, centro y escuela fue asignado a un código distinto, lo que hizo posible explorar la variabilidad de las variables dependientes en los distintos niveles de la jerarquía. De igual forma, en el estudio CALINA se incluyeron niños de varios centros de salud de distintas localidades de Aragón donde se observó también una gran variabilidad entre los distintos niveles jerárquicos. Por ello, los artículos incluidos en la presente Tesis Doctoral incluyeron un efecto aleatorio de la localidad o el país y del centro/escuela.

Los procedimientos fueron modificados para adaptar los análisis según el carácter de la variable dependiente (categórica o lineal). Como norma general, el nivel de significación se estableció al 0.01 para tener en cuenta parcialmente el problema de las comparaciones múltiples. Todos los análisis estadísticos se realizaron con el paquete estadístico SPSS versión 22.

Para estudiar la asociación entre las diferentes vulnerabilidades sociales y los patrones dietéticos (procesado, dulce y saludable) en niños, previamente identificados con el análisis de conglomerados (o cluster analysis) de K-medias por Fernández-Alvira y colaboradores[42], se utilizó la regresión logística multinomial de efectos mixtos **(Artículo I)**.

Para evaluar la asociación entre las diferentes vulnerabilidades sociales y los niveles de actividad física y sedentarismo en niños (cumplimiento de las recomendaciones versus no cumplimiento) se utilizó la regresión logística binaria de efectos mixtos **(Artículo II)**.

La regresión logística binaria de efectos mixtos se utilizó también para estimar la relación entre las vulnerabilidades sociales y los problemas psicosociales (problemas internalizados y de bienestar mental) en niños europeos **(Artículo III)** y para analizar la relación entre las vulnerabilidades sociales y el sobrepeso/obesidad en los niños españoles **(Artículo IV)**.

La regresión logística multinomial de efectos mixtos se empleó para valorar la influencia de las vulnerabilidades sociales en el peso de los niños europeos (infrapeso, normopeso, sobrepeso/obesidad) (**Articulo V)**.

Por último, se utilizó un modelo lineal de efectos mixtos para valorar el efecto de las desventajas sociales en el riesgo de síndrome metabólico (mediante un marcador calculado como la suma de los z-scores de perímetro de la cintura, tensión arterial, lípidos y resistencia a la insulina) en niños europeos **(Artículo VI)**.

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 quedan reflejados como artículos científicos.

4. Results

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

Artículo I [Paper I]: Associations between social vulnerabilities and dietary patterns in European children: the Identification and prevention of Dietary- and lifestyle-induced health EFfects In Children and infantS (IDEFICS) study.

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Associations between social vulnerabilities and dietary patterns in European children: the Identification and prevention of Dietary- and lifestyle-induced health EFfects In Children and infantS (IDEFICS) study

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Abstract

Socio-economic inequalities in childhood can determine dietary patterns, and therefore future health. This study aimed to explore associations between social vulnerabilities and dietary patterns assessed at two time points, and to investigate the association between accumulation of vulnerabilities and dietary patterns. A total of 9301 children aged 2–9 years participated at baseline and 2-year follow-up examinations of the Identification and prevention of Dietary- and lifestyle-induced health EFfects In Children and infantS study. In all, three dietary patterns were identified at baseline and follow-up by applying the K-means clustering algorithm based on a higher frequency of consumption of snacks and fast food (processed), sweet foods and drinks (sweet), and fruits and vegetables (healthy). Vulnerable groups were defined at baseline as follows: children whose parents lacked a social network, children from single-parent families, children of migrant origin and children with unemployed parents. Multinomial mixed models were used to assess the associations between social vulnerabilities and children's dietary patterns at baseline and follow-up. Children whose parents lacked a social network (OR 1·31; 99 % CI 1·01, 1·70) and migrants (OR 1·45; 99 % CI 1·15, 1·83) were more likely to be in the processed cluster at baseline and follow-up. Children whose parents were homemakers (OR 0·74; 99 % CI 0·60, 0·92) were less likely to be in the processed cluster at baseline. A higher number of vulnerabilities was associated with a higher

Abbreviations: CEHQ-FFQ, Children's Eating Habits Questionnaire-FFQ; IDEFICS, Identification and prevention of Dietary- and lifestyle-induced health EFfects In Children and infantS; SES, socio-economic status.

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probability of children being in the processed cluster (OR 1·78; 99 % CI 1·21, 2·62). Therefore, special attention should be paid to children of vulnerable groups as they present unhealthier dietary patterns.

Key words: Vulnerable groups: Dietary patterns: Inequalities: Socio-economic status: Children

The persistence and growth of socio-economic health inequalities continue to attract researchers, clinicians and politicians[1–3]. These differences can arise during childhood and determine future health[4]; thus, it is very important to identify them at early stages. Even though it is well recognised that lower socio-economic groups have poorer health[5], its determinants are complex. Diverse theories have been devel- oped to explain the mechanisms behind the inequalities in health, such as material conditions, occupational, psychosocial, behavioural and biomedical factors[6–9]. Quality of diet has been observed to be associated with indicators of socio- economic status (SES), such as parental education, household income and parental occupation[10–12]. There is consistent evidence that lower SES individuals are more likely to follow diets that are associated with lifestyle-related diseases[13,14]. Children of parents from the lowest income, occupation and education groups tend to consume more sweets, soft drinks and processed meat and less fruits and vegetables than their counterparts[15,16]. In general, researchers are interested in dietary patterns to assess the overall diet of an individual rather than the consumption of single food items[17]. Only when the entire pattern is considered, combined effects of various nutrients and foods can be observed, allowing the establishment of a relationship between diet and disease risk[18]. Principal component analysis (PCA) and cluster analysis (CA) are two common methods used to derive dietary patterns. PCA identifies common patterns of food consumption on the basis of linear combinations of foods, whereas CA allows for grouping individuals according to their overall diet. For this reason, CA allows for a better understanding of dietary patterns in children and for identification of possible groups of children with an overall unhealthy/healthy diet.

Using this technique, a recent analysis based on the data of the European IDEFICS study (Identification and prevention of Dietary- and lifestyle-induced health EFfects In Children and infantS) explored the associations between dietary patterns and classical SES indicators over a 2-year period. Children with higher educated parents and higher household income were found to be more likely in a healthy cluster (higher frequency of consumption of fruits, vegetables and wholemeal products) and less likely in a sweet cluster (higher frequency of consumption of sweet foods and sweetened drinks) at baseline and 2 years later, whereas migrants were more likely to be in a processed cluster (higher frequency of consumption of snacks and fast foods). To better understand the relationship between social inequalities and dietary patterns, the present study goes beyond the previous IDEFICS investigation[19] and studies not only the association between classical SES and dietary patterns but also the indicators of social vulnerability and the influence of accumulated vulnerability[20]. These are less frequently explored in the literature. Given the evidence on the social gradient in health, this study focuses on vulnerable groups compared with non-vulnerable groups[21]. Most previous studies have investigated the association between family structure[22,23], social support[24] and employment status[25] with obesity. Nevertheless, there have been several investiga- tions that have looked into these variables and their relationship with children's dietary patterns. In particular, family structure has been found to have a relationship with children's dietary patterns. Children from single-parent families were shown to be at higher risk of adopting unhealthier dietary patterns than children living with two parents[26,27] because of the absence of adults in the home to monitor mealtimes[28]. Having a small social network has also been shown to be associated with a reduced consumption and lower variety of vegetables and fruits[29]. Regarding vulnerabilities related to migrant status, children whose parents had a migrant background were found to have a more sedentary way of life and adverse dietary patterns, as compared with non-migrant children, owing to socio-economic and cultural factors[30]. Finally, children of unemployed mothers have been thought to be related to a higher consumption of energy-dense drinks than children of employed mothers[31]. Studying these vulnerabilities in relation to dietary patterns may give further insights into the association between vulnerabilities and children's overall eating habits and into the possibly increased adverse influence on dietary patterns when co-occurrence of vulnerabilities exists. In this regard, four vulnerable groups were investigated in the present study: (1) children from single-parent families, (2) children whose parents lacked a social network, (3) children of migrant origin and (4) children with either one or both parents unemployed[32]. The present study aimed to explore (i) the cross-sectional and prospective associations between being a member (*v.* non-member) of a vulnerable group and dietary patterns in European children and to study (ii) the association of accumulated vulnerability with dietary patterns.

Methods

Study population

IDEFICS is a multi-centre, prospective cohort study, conducted with a school and community-based obesity prevention inter- vention embedded in two selected regions comparable in their infrastructural, socio-demographic and socio-economic char- acteristics[33] in eight European countries (Belgium, Cyprus, Estonia, Germany, Hungary, Italy, Spain and Sweden). The IDEFICS study was conceived to collect information on risk factors and habits and to design, implement and evaluate an obesity prevention intervention. For comprehensive informa- tion about IDEFICS, a detailed description is given by Ahrens *et al.*[34]. In brief, a total of 16 228 children aged 2–9 years were examined from September 2007 to June 2008 in the different

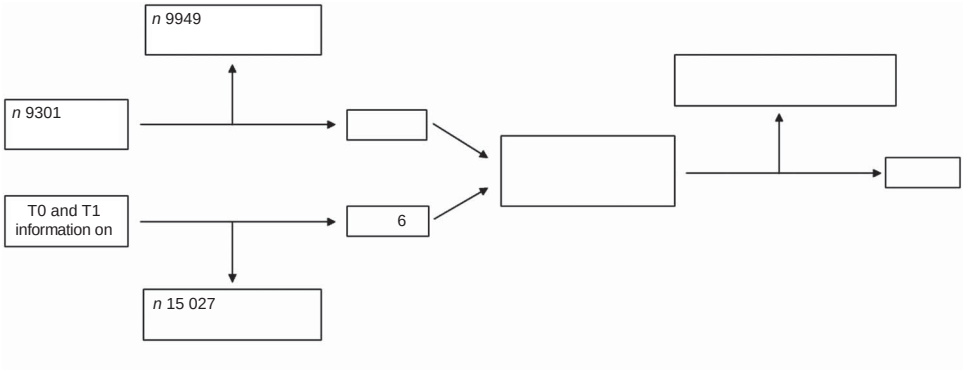

Fig. 1. Final study sample. SES, socio-economic status.

countries at baseline (T0). The first follow-up (T1) took place 2 years later (September 2009–June 2010), where 11 038 children aged 4–11 years were re-examined. After excluding children with >50 % of missing values in the food frequency section of the Children's Eating Habits Questionnaire (CEHQ-FFQ) and children with no socio-economic data at T0 and T1, the present analysis finally included 9301 children (50·3 % boys, 49·7 % girls) (see also Fig. 1).

Parents or legal guardians gave their written informed consent for examinations and data collection for their children, whereas children expressed oral consent. Ethics approval was obtained from the research ethics authority of each participating centre.

Measurements

Dietary data. Dietary data were collected at both T0 and T1 from the food frequency section of the CEHQ-FFQ. This FFQ was a self-administered screening tool in which parents were asked to report usual at-home consumption frequencies of forty-two food items of fourteen food groups, being shown to be positively or negatively associated with obesity and over- weight in the preceding 4 weeks, not referring to meals at the school canteen or childcare centres. Therefore, this method did not include quantitative intakes and did not capture foods eaten out of parental control[35]. Results from previous IDEFICS investigations indicate that the CEHQ-FFQ gives reproducible estimates of consumption frequencies in European children[36]. The relative validity of the food questionnaire was also tested, comparing estimates from the CEHQ-FFQ with the mean intakes from two repeated 24-h dietary recalls. Moderately strong correlations were observed for the most frequently consumed foods[37]. The categories of consumption were as follows: 'never/less than once a week', '1–3 times a week', '4–6 times a week', '1 time/d', '2 times/d', '3 times/d', '4 or more times/d' and 'I have no idea'. By assigning frequencies to the different responses, these categories were converted to a continuous scale ranging from 0 up to 30 times per week.

Covariates

Weight categories. Anthropometric measurements were assessed at T0 and T1 according to standardised procedures in all participating countries. Barefoot body height was measured to the nearest 0·1 cm by trained staff using a portable stadiometer (SECA 225; Seca GmbH & KG). Body weight in kg was measured using a child-adapted version of the electronic scale TANITA BC 420 SMA, with the children in fasting state and wearing only light clothes. BMI was calculated by dividing body weight in kg by body height in m^2 and then transformed into age- and sex-specific *z*-scores[38]. Weight groups (thin/normal *v.* overweight/obese) were categorised using age- and sex-specific cut-off points according to criteria of the International Obesity Task Force[39].

Demographic and socio-economic data were collected from a standardised parent report questionnaire at baseline and were used to define the variables of classical SES indicators and vulnerable groups.

Classical socio-economic status indicators. Education: parents were asked to indicate the highest level of education of both themselves and their partners. The particular response categories for each country were coded according to the International Stan- dard Classification of Education (ISCED 1997) and re-categorised into the following three categories: low (ISCED level 0–2), medium (ISCED level 3–4) and high (ISCED level 5–6)[40].

Income: parents also provided information on the monthly net income of the household after taxes and deductions responding to nine country-specific categories (1: from the lowest category to 9: the highest category). The category cut-off points were designed to be country specific according to a fixed scheme based on the median equivalent income, thus guaranteeing comparability between countries. The results were organised into three categories: low[1–3], medium [4–6] and high income[7–9].

Occupation: parents were further asked to specify their occupational position with eighteen possible options, which were later transformed into the three-class version of the European Socio-economic Classification: working class, intermediate and salariat[41].

For occupation and education, the highest level of either the mother or the father was taken into account for the purpose of the study.

Definition of vulnerable groups. A total of four vulnerabilities were defined as our main exposures using baseline information:

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Social network: three categories were used based on parental response to the question of how many persons they could rely on in case of need including their family: low (0–1 person), taken as the vulnerable category, medium (2–3 persons) and high (>3 persons), considering the last two categories as non-vulnerable.

Family structure: single-parent families (vulnerable group) were defined as such if only one adult was living in the household or if the child was mostly living with the mother or with the father. Other types of families were considered as non-vulnerable.

Origin of the parents: a migrant background (vulnerable group) was assumed if one or both parents were born in a country different from where the study took place. Children whose parents were born in the local country were considered as non-migrant, and therefore non-vulnerable.

Employment status: parents were asked to describe their main occupational status within ten given categories, finally recoded into the following five groups: at least one of the parents was unemployed or living on social assistance or welfare (considering only this group as vulnerable); at least one of the parents was a homemaker or on temporary leave (e.g. maternal or paternal leave); at least one of the parents was in a part-time job (<30 h a week), both parents were in a full-time job (>30 h a week) and other combinations (e.g. parents were attending school or university or they were retired, including early retirement).

A total vulnerability score was calculated by adding up the numbers of vulnerabilities a child was exposed to. In all, four vulnerability indicators (low social network, single-parent family, migrant background, unemployed) and two more vulnerabilities derived from classical SES indicators (low-income and low-education) were considered. Occupation status was not included as it was highly correlated with employment status. On the basis of this approach, the total vulnerability score ranged from 0 (the child had none of the six vulnerability indicators) to 6 (the child had all six vulnerability indicators) and was divided into four categories (three to six vulnerabilities, two vulnerabilities, one vulnerability and no vulnerability).

Statistical analyses

To identify clusters of children with common dietary patterns, K-means cluster analysis was applied, based on the relative frequencies of consumption. The relative frequency of consump- tion was calculated for each food item by dividing the frequency of consumption of a specific food item by the total frequency of consumption of all food items included in the CEHQ-FFQ.

A total of three consistent clusters were identified at both T0 and T1, as previously described[19]: (1) a processed cluster characterised by a higher-than-average consumption frequency of snacks and fast foods compared with the whole study group including all countries; (2) a sweet cluster, showing a higher-than-average consumption frequency of sweet foods and sweetened drinks; and (3) a healthy cluster, characterised by a higher-than-average consumption frequency of fruits, vegetables and wholemeal products. Details on the CA procedure and validation are given in the study by Fernandez-Alvira *et al.*[19].

Multinomial mixed models were used to assess the cross-sectional and longitudinal associations between the four exposures (social network, family structure, migrant origin and employment status) and children's dietary patterns (processed, sweet, reference category: healthy). In the cross-sectional analysis, for each exposure assessed at T0, a model with basic adjustment (baseline age, sex and BMI *z*-score) and with full adjustment (basic model plus classical SES indicators parental income, education and occupation) was estimated to assess the associa- tions with T0 dietary patterns. All models included a random kindergarten/school and a random country effect to account for the clustered study design. Analogously, in the longitudinal analysis, dietary patterns assessed at T1 were related to the T0 exposures again with the basic and full adjustment, adding a variable indicating intervention *v.* control region and adjusting for baseline dietary patterns.

Before model building, correlations among SES indicators were checked, resulting in the exclusion of occupation status in models with employment status as the main exposure to avoid collinearity problems.

The significance level was set at 0·01 to account at least partially for multiple testing. The analyses were performed using Statistical Package for the Social Sciences (version 22.0; SPSS, Inc.).

Results

Table 1 summarises the distributions of age, sex, weight category, country, social network, family structure, migrant status, employment status and classical SES indicators in the three clusters at T0 and T1.

Concerning T0, older children represented a lower percen- tage in the healthy cluster (29 %) compared with younger children (35·2 %). A higher percentage of both boys and girls were allocated to the processed cluster (47·8 and 47·4 %, respectively) compared with the other two clusters. Children who were obese had a higher percentage in the processed cluster (62·3 %) compared with the sweet (12·9 %) and healthy (24·8 %) clusters.

Regarding dietary patterns in the different countries, the processed cluster was mainly observed in Spain, Italy and Cyprus. The sweet cluster was mostly represented by Belgian and German children, whereas almost all the Swedish children were in the healthy cluster. The proportion of children whose parents reported to have a small social network was higher in the processed cluster. Children from single-parent families represented a lower percentage in the healthy cluster (27·8 %) than the other two clusters. Children with migrant origin represented a lower percentage in the sweet cluster (14·9 %) and a higher percentage in the processed cluster (52·6 %) compared with non-migrant children. The proportion of children with both parents in a full-time job was higher in the healthy cluster (36·9 %) compared with children whose parents were unemployed (22·1 %). Finally, children from families with low education, income or occupation were more often in the processed cluster compared with the other two clusters. The proportion of children whose parents did not answer these questions, represented as missing category, was higher in the processed cluster.

Table 1. Description of the study population, stratified by cluster membership at baseline (T0) and follow-up (T1) (Number of participants and percentages)

	T0						T1					
	Processed		Sweet		Healthy		Processed		Sweet		Healthy	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Total (9301)	4427	47·6	1910	20·5	2964	31·9	2554	27·4	1939	20·9	4808	51·7
Age groups												
2–6 years (4250)	1858	43·7	895	21·1	1497	35·2	1042	24·5	903	21·2	2305	54·2
6–10 years (5051)	2569	50·9	1015	20·1	1467	29·0	1512	29·9	1036	20·5	2503	49·6
Sex of the child												
Male (4683)	2240	47·8	999	21·3	1444	30·8	1342	28·7	1037	22·1	2304	49·2
Female (4618)	2187	47·4	911	19·7	1520	32·9	1212	26·2	902	19·5	2504	54·2
BMI category												
Thinness (1061)	452	42·6	258	24·3	351	33·1	279	26·3	270	25·4	512	48·3
Normal weight (6522)	2976	45·6	1407	21·6	2139	32·8	1741	26·7	1433	22·0	3348	51·3
Overweight (1113)	622	55·9	167	15·0	324	23·0	335	30·1	171	15·4	607	54·5
Obese (605)	377	62·3	78	12·9	150	24·8	199	32·9	65	10·7	341	56·4
Country												
Italy (1474)	1032	70·0	181	12·3	261	17·7	579	39·4	221	15·0	674	45·7
Estonia (1246)	749	60·1	100	8·0	397	31·9	393	31·5	110	8·8	743	59·6
Cyprus (1036)	795	76·7	6	0·6	235	22·7	680	65·6	8	0·8	348	33·6
Belgium (1090)	72	6·6	877	80·5	141	12·9	43	3·9	867	79·5	180	16·5
Sweden (1355)	64	4·7	34	2·5	1257	92·8	35	2·6	53	3·9	1267	93·5
Germany (978)	161	1·7	558	57·1	259	26·5	98	10·0	464	47·4	416	42·5
Hungary (986)	680	69·0	99	10·0	207	21·0	328	33·3	148	15·0	510	51·7
Spain (1136)	874	76·9	55	4·8	207	18·2	398	35·0	68	6·0	670	59·0
Social network*												
Missing (418)	272	65·1	45	10·8	101	24·2	184	44·0	46	11·0	188	45·0
Low (840)	525	52·5	133	15·8	132	21·7	300	35·7	156	18·6	384	45·7
Medium (2960)	1661	56·1	576	19·5	723	24·4	977	33·0	595	20·1	1388	46·9
High (5083)	1969	38·7	1156	22·7	1958	38·5	1093	21·5	1142	22·5	2848	56·0
Family structure*												
Missing (280)	153	54·6	47	16·8	80	28·6	106	37·9	44	15·7	130	46·4
Single-parent family (935)	435	46·5	240	25·7	260	27·8	261	27·9	243	26·0	431	46·1
Nuclear or extensive family (8086)	3839	47·5	1623	20·1	2624	32·5	2187	27·0	1652	20·4	4247	52·5
Migrant status												
Missing (139)	73	54·5	20	14·4	46	33·1	55	39·6	22	15·8	62	44·6
Migrant origin (1246)	656	52·6	186	14·9	404	32·4	432	34·7	189	15·2	625	50·2
Native (7916)	3698	46·7	1704	21·5	2514	31·8	2067	26·1	1728	21·8	4121	52·1
Employment status												
Missing (659)	396	60·1	96	14·6	167	25·3	274	41·6	94	14·3	291	44·2
Unemployed/living on welfare (312)	179	57·4	64	20·5	69	22·1	98	31·4	68	21·8	146	46·8
Homemaker/parental leave (1893)	1001	52·9	379	20·0	513	27·1	600	31·7	367	19·4	926	48·9
At least one part-time job (1742)	684	39·3	560	32·1	498	28·6	380	21·8	548	31·5	814	46·7
Other situations (808)	379	46·9	146	18·1	283	35·0	197	24·4	150	18·6	461	57·1
Both parents are in full-time job (3887)	1788	46·0	665	17·1	1434	36·9	1005	25·9	712	18·3	2170	55·8
Parental education (ISCED)												
Missing (97)	55	56·7	9	9·3	33	34·0	46	47·4	8	8·2	43	44·3
Low (658)	371	56·4	179	27·2	108	16·4	244	37·1	163	24·8	251	38·1
Medium (4566)	2406	52·7	923	20·2	1237	27·1	1346	29·5	933	20·4	2287	50·1
High (3980)	1595	40·1	799	20·1	1586	39·8	918	23·1	835	21·0	2227	56·0
Income category												
Missing (896)	523	58·4	167	18·6	206	23·0	354	39·5	161	18·0	381	42·5
Low (2825)	1665	58·9	556	19·7	604	21·4	1020	36·1	593	21·0	1212	42·9
Medium (3905)	1491	38·2	954	24·4	1460	37·4	811	20·8	933	23·9	2161	55·3
High (1675)	748	44·7	233	13·9	694	41·4	369	22·0	252	15·0	1054	62·9
Parental occupation (ESEC)												
Missing (571)	379	66·4	45	7·9	147	25·7	270	47·3	36	6·3	265	46·4
Working class (2790)	1497	53·7	624	22·4	669	24·0	859	30·8	649	23·3	1282	45·9
Intermediate (3316)	1521	45·9	737	22·2	1058	31·9	839	25·3	773	23·3	1704	51·4
Salariat (2624)	1030	39·3	504	19·2	1090	41·5	586	22·3	481	18·3	1557	59·3

ISCED, International Standard Classification of Education; ESEC, The European Socio-economic Classification.
* Social network was assessed with a question regarding how many persons they could rely on in case of need including their family: low (0–1 person), medium (2–3 persons) and high (>3 persons).

Regarding T1, results were similar to T0, except for the obese (56·4 %) and overweight (54·5 %) children who represented this time a higher percentage in the healthy cluster compared with the sweet or processed cluster. In general, the percentage of children allocated to the healthy cluster was much higher in T1 (51·7 %) than in T0 (31·9 %). Children's BMI and socio-economic

Table 2. Cross-sectional associations between the four vulnerability indicators and dietary patterns at baseline (T0) (reference: healthy) for the basic and fully adjusted models*
(Multinomial linear mixed model: odds ratios and 99 % confidence intervals)

	Dietary pattern T0							
	Processed *v.* healthy				Sweet *v.* healthy			
	Basic adjustment†		Full adjustment‡		Basic adjustment†		Full adjustment‡	
Vulnerability indicators	OR	99 % CI	OR	99 % CI	OR	99 % CI	OR	99 % CI
Social network§								
Low (840)	1·31	1·01, 1·70	1·25	0·96, 1·63	0·98	0·68, 1·43	0·95	0·65, 1·39
Medium (2960)	1·39	1·17, 1·64	1·36	1·15, 1·61	1·11	0·89, 1·38	1·07	0·86, 1·34
Missing (418)	1·05	0·72, 1·54	0·82	0·49, 1·35	0·90	0·45, 1·81	0·84	0·40, 1·74
High (5083)	1·00		1·00		1·00		1·00	
Family structure								
Single-parent family (935)	1·24	0·95, 1·60	1·17	0·89, 1·52	1·05	0·76, 1·45	1·02	0·73, 1·43
Missing (280)	0·95	0·63, 1·43	0·89	0·58, 1·37	1·29	0·68, 2·45	1·24	0·64, 2·41
Nuclear or extensive family (8086)	1·00		1·00		1·00		1·00	
Migrant status								
Migrant origin (1246)	1·45	1·15,1·83	1·37	1·08,1·73	0·61	0·45,0·84	0·57	0·41,0·78
Missing (139)	0·69	0·40,1·19	0·68	0·29,1·58	0·55	0·21,1·43	0·57	0·19,1·69
Native (7916)	1·00		1·00		1·00		1·00	
Employment status								
At least one unemployed (312)	1·36	0·87, 2·12	1·12	0·71, 1·75	0·94	0·54, 1·65	0·80	0·45, 1·43
At least one homemaker/parental leave (1893)	0·82	0·67, 1·01	0·74	0·60, 0·92	1·09	0·82, 1·45	1·00	0·75, 1·34
At least one in part-time job (1742)	0·89	0·71, 1·11	0·86	0·69, 1·08	1·08	0·82, 1·44	1·06	0·79, 1·40
Other situations (808)	1·00	0·76, 1·32	0·88	0·66, 1·17	1·03	0·70, 1·52	0·93	0·63, 1·39
Missing (659)	1·16	0·84, 1·60	1·21	0·83, 1·76	1·00	0·62, 1·59	0·97	0·59, 1·59
Both parents are in full-time jobs (3887)	1·00		1·00		1·00		1·00	

* All models included random effects (school, country) to account for the study design.
† Basic models at T0 were adjusted for baseline age, sex and *z*-scores of BMI by Cole & Lobstein[39].
‡ Fully adjusted models at T0 were additionally adjusted for baseline classical SES indicators (education, occupation and income).
§ Social network was assessed with a question regarding how many persons they could rely on in case of need including their family: low (0–1 person); medium (2–3 persons) and high (>3 persons).

data of children lost to follow-up were analysed to study a possible selection bias. Children lost to follow-up showed a higher BMI and on average belonged to a lower SES group than those who were *fi*nally included in the present study.

Table 2 presents the OR and 99 % CI for the cross-sectional associations between the four vulnerability indicators and dietary patterns at T0 for the basic and fully adjusted models. In the basic models, children whose parents reported to have low (OR 1·31; 99 % CI 1·01, 1·70) or medium social network (OR 1·39; 99 % CI 1·17, 1·64) and children of migrants (OR 1·45; 99 % CI 1·15, 1·83) were more likely to be in the processed cluster than in the healthy cluster at T0. No statistically signi*fi*cant associations were observed for the other groups, but the associations still pointed to the expected directions. When adding the classical SES indicators to the models (full adjustment), the OR were slightly attenuated, but overall the results remained unaltered. Children with one or both parents considered as homemakers or on a parental leave (OR 0·74; 99 % CI 0·60, 0·92) were less likely to be in the processed cluster compared with the healthy cluster in the fully adjusted model only.

Table 3 shows the OR and 99 % CI for the longitudinal associations between the four vulnerability indicators at study baseline T0 and dietary patterns after the 2-year follow up (T1) for the basic and fully adjusted models. Associations were slightly attenuated in the fully adjusted model but pointed to the same directions as in the cross-sectional models.

Table 4 displays the association between the accumulation of vulnerabilities assessed at baseline and dietary patterns at T0 and T1. A higher number of vulnerabilities was associated with a higher probability of children being in the processed cluster compared with the healthy cluster in both T0 and T1, where the OR increased with the number of present vulnerabilities: one vulnerability (OR 1·19; 99 % CI 0·98, 1·45); two to three vulnerabilities (OR 1·70; 99 % CI 1·31, 2·23); and four to six vulnerabilities (OR 1·78; 99 % CI 1·21, 2·62). Similar results were found for the T1 dietary patterns with associations showing the same trend but being slightly attenuated.

In order to check whether the effects of vulnerabilities are independent of each other, we also ran the model adding not only the classical SES indicators (education and income) but also the other four social vulnerabilities together into one model. However, the results remained similar (signi*fi*cance remained and OR were in the same magnitude). Therefore, only separate models for vulnerabilities are shown.

Discussion

The present study investigated the association between belonging to a vulnerable (*v.* non-vulnerable) group and dietary patterns (processed, sweet and healthy) over a 2-year period in children aged 2–9 years participating in a European study. This study found that children whose parents lack a social network and children with a migrant origin had a higher risk of having a processed

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Table 3. Longitudinal associations between the four vulnerability indicators at baseline and dietary patterns at follow-up (T1) (reference: healthy) for the basic and fully adjusted models*
(Multinomial linear mixed model: odds ratios and 99 % confidence intervals)

	Dietary pattern T1							
	Processed *v.* healthy				Sweet *v.* healthy			
	Basic adjustment‡		Full adjustment§		Basic adjustment‡		Full adjustment§	
Vulnerability indicators†	OR	99 % CI	OR	99 % CI	OR	99 % CI	OR	99 % CI
Social network								
Low (840)	1·33	1·05, 1·68	1·23	0·97, 1·58	1·14	0·83, 1·56	1·10	0·80, 1·51
Medium (2960)	1·32	1·13, 1·55	1·23	1·04, 1·45	1·03	0·85, 1·25	1·00	0·82, 1·22
Missing (418)	0·67	0·46, 0·96	0·50	0·30, 0·82	0·81	0·43, 1·53	0·79	0·41, 1·54
High (5083)	1·00		1·00		1·00		1·00	
Family structure								
Single-parent family (935)	1·00	0·68, 1·48	0·99	0·65, 1·50	1·03	0·58, 1·86	0·96	0·71, 1·29
Missing (280)	1·06	0·83, 1·35	1·00	0·78, 1·29	1·01	0·75, 1·34	0·98	0·54, 1·78
Nuclear or extensive family (8086)	1·00		1·00		1·00		1·00	
Migrant status								
Migrant origin (1246)	0·86	0·50, 1·48	1·00	0·41, 2·43	0·78	0·32, 1·91	0·88	0·32, 2·42
Missing (139)	1·27	1·03, 1·57	1·227	0·98, 1·53	0·69	0·52, 0·91	0·66	0·49, 0·87
Native (7916)	1·00		1·00		1·00		1·00	
Employment status								
At least one unemployed (312)	0·95	0·70, 1·28	0·873	0·61, 1·25	1·03	0·67, 1·57	1·01	0·65, 1·57
At least one homemaker/parental leave (1893)	1·20	0·82, 1·75	1·02	0·68, 1·53	1·02	0·63, 1·63	0·87	0·53, 1·42
At least one in part-time job (1742)	1·04	0·86, 1·27	1·01	0·82, 1·24	1·06	0·83, 1·37	0·98	0·76, 1·27
Other situations (808)	0·96	0·77, 1·19	0·96	0·77, 1·20	1·20	0·93, 1·53	1·16	0·91, 1·49
Missing (659)	0·88	0·68, 1·15	0·80	0·61, 1·06	0·97	0·69, 1·37	0·88	0·62, 1·24
Both parents are in full-time job (3887)	1·00		1·00		1·00		1·00	

* All models include random effects (school, country) to account for the study design.
† Social network was assessed with a question regarding how many persons they could rely on in case of need including their family: low (0–1 person), medium (2–3 persons) and high (>3 persons).
‡ Basic models at T1 were adjusted for baseline age, sex and *z*-scores of BMI by Cole & Lobstein[39] and for study region (intervention *v.* control).
§ Fully adjusted models were additionally adjusted for baseline classical socio-economic indicators (education, income and occupation except for employment status model) and dietary pattern at T0.

Table 4. Association between the accumulation of vulnerabilities at T0 and dietary patterns at T0 and T1 (reference: healthy)*
(Multinomial linear mixed model: odds ratios and 99 % confidence intervals)

	Accumulation of vulnerability in T0†				Accumulation of vulnerability in T1‡			
	Processed *v.* healthy		Sweet *v.* healthy		Processed *v.* healthy		Sweet *v.* healthy	
	OR	99 % CI	OR	99 % CI	OR	99 % CI	OR	99 % CI
Number of vulnerabilities§								
Missing (1478)	1·32	1·04, 1·67	0·99	0·73, 1·34	1·25	1·00, 1·55	0·98	0·75, 1·28
3–6 vulnerabilities (435)	1·78	1·21, 2·62	0·98	0·62, 1·55	1·65	1·17, 2·32	1·05	0·71, 1·57
2 vulnerabilities (1098)	1·71	1·31, 2·23	1·31	0·93, 1·85	1·35	1·07, 1·71	1·20	0·90, 1·61
1 vulnerability (2285)	1·19	0·98, 1·45	1·07	0·82, 1·38	1·18	0·99, 1·55	1·07	0·85, 1·35
Non-vulnerable (4005)	1·00		1·00		1·00		1·00	

* All models include random effects (school, country) to account for the study design.
† Models at T0. Basic models were adjusted for baseline age, sex and *z*-scores of BMI by Cole & Lobstein[39].
‡ Models at T1 were additionally adjusted for age, sex, *z*-score of BMI by Cole & Lobstein[39] and study region (intervention *v.* control).
§ A total vulnerability score was calculated by adding up the scores (1 *v.* 0) of the six vulnerability indicators (low social network, single-parent family, migrant background, unemployed, low income and low education). Total vulnerability score ranged from 0 (the child has none of the six vulnerability indicators) to 6 (the child has all six vulnerability indicators).

dietary pattern at T0 and T1 compared with non-vulnerable groups, and this result was cumulative when adding up vulnerabilities. In particular, those showing four to six vulnerabilities at baseline were 65 % more likely to being in the processed cluster at follow-up when compared with those with no vulnerabilities. In the course of obesity, the importance of SES is well established, but there is a lack of research determining the impact of SES and interrelated factors such as vulnerable groups over dietary patterns[42,43]. According to our results, for most vulnerabilities, when adding the classical SES indicators, associations with dietary patterns were slightly attenuated. This means that these associations may be partly explained by classical SES variables; however, associations of vulnerable groups independent of classical SES indicators were present. For children of parents who were homemakers and/or on parental leave, associations appeared only in the fully adjusted model at baseline.

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Changes in vulnerability from T0 to T1 were quite rare between the vulnerable groups studied, which was the reason for not studying changes in vulnerabilities in the present analysis.

Respondents with missing socio-economic information may not be a random subset of population-based survey participants, and excluding records with missing income infor- mation from analyses may bias study results[44]. For this reason, missing values of socio-economic data were coded as a separate category.

In a sensitivity analysis, models were additionally estimated stratified by country. For two countries, the model could not be estimated as most of the children were mainly allocated just in one cluster, particularly in the processed (Cyprus) and healthy cluster (Sweden). Moreover, in spite of the fact that in some countries the model could run satisfactorily, the small sample of some categories led to unstable results. For these reasons, no country-specific results were presented.

The findings of our study are in line with the results of previous studies despite some disparities being found. Several studies have explored the relationship between different socio-economic and cultural factors and dietary patterns[45]. A result from the IDEFICS study showed a strong inverse association of SES with the processed pattern, suggesting that children of parents with lower SES were at a higher risk of developing unhealthy dietary behaviours[46]. According to our conclusions, family structure was not significantly associated with any dietary pattern in accordance with some studies[47]. However, different results can be found in the literature. A recent study concluded that children living with both parents had higher scores for 'fruits' and 'milk and dairy products' groups compared with children living with one parent[48].

Regarding the relationship between social network and dietary patterns, we found a statistically significant association between children whose parents reported to have a low or medium social network with processed patterns, which are in consonance with previous studies that associated infrequent contact with friends and family with unhealthier patterns[29].

Concerning children of migrant origin, the present study revealed that these children were more likely to have a processed dietary pattern and less likely to have a sweet dietary pattern. Similar to our results, a systematic review suggested that dietary habits of some migrant groups living in Europe were more likely to become less healthy as they increase the consumption of processed foods. In contrast to our results, they found that children of migrant origin consumed higher levels of sugar[49].

We found no statistically significant associations between children's dietary patterns and parental employment status, except for children whose parents were homemakers or on parental leave. In these cases, the children were more likely to be allocated to the processed cluster independently of classical SES indicators.

This outcome contradicted the conclusions of Sweeting & West[47] who found that children of homemakers were more likely to have a less healthy pattern compared with children of mothers working part-time, full time or those who were unemployed. Along with the results of our study, some inves- tigations have found no association between time mothers spent with their children and maternal work outside the home with any dietary pattern[50–52]. Nevertheless, previous findings, in contrast to our study, suggest an association between maternal employment and unhealthier dietary patters due to time constraints and reduced supervision of meals[53]. Employed mothers were more likely to have fast food for family meals, spent less time preparing food and provided less encouragement for their child to eat healthy food[54], which resulted in a higher consumption of processed foods by the child[55].

Some limitations of the present study should be acknowl- edged. First, the IDEFICS study is not representative of either the European population or the countries participating, as each survey centre only covered a delimited geographic area within a country. There were some groups (from the lowest or the highest SES) that could be underestimated as this study was voluntary, and usually these populations are less likely to take part in research, making the extrapolation of the results to each respective country difficult. Moreover, a selection bias cannot be precluded as there were some participants (overall those who present a higher BMI and lower SES groups) who did not complete all the information required or did not continue the study at follow-up. A further limitation is the fact that clusters are typically labelled quite arbitrarily, as their objective is to globally characterise the dietary pattern of each group. In our analysis, the healthy cluster was characterised by a more frequent consumption of fruits, vegetables and wholemeal foods and a less frequent consumption of simple sugar and junk foods compared with the other groups. This, however, does not imply that dietary recommendations were met.

Other limitations that should be considered include the dietary assessment method. As the CEHQ-FFQ was limited to forty-two items being shown to be positively or negatively associated with obesity and overweight, it did not cover the whole diet. Further, it was not designed to assess portion sizes. Finally, in this questionnaire, parents reported usual at-home consumption frequencies; thus, the number of meals was limited to those under parental control. Therefore, incomplete reports of food and beverage consumption may also contribute towards reporting bias[56].

A special strength of the present study is the fact that, to our knowledge, no research has been carried out to date concerning the association of vulnerabilities such as social network, family structure and employment status with dietary patterns and the association of vulnerabilities accumulated in a longitudinal study. A large sample size of eight different countries and use of standardised procedures and validated instruments are also strengths of our study.

Conclusions

The current study suggests complex relationships between vul- nerabilities and dietary patterns and highlights the influential role of early socio-economic deprivations in children. A future chal- lenge is to promote healthier diets in children with cumulative vulnerabilities in order to make those in disadvantaged settings have healthier dietary patterns and potentially help in decreasing levels of obesity. Thus, policymakers should pay special attention

to vulnerable groups as a higher number of vulnerabilities seems to increase the risk of unhealthy behaviours.

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The authors' contributions were as follows: I. I. carried out the statistical analysis and drafted the manuscript. C. B. designed the statistical analyses. K. B., J. M. F.-A., W. G., V. P. and P. R. developed the measurement instruments; and G. E.,
D. M., L. A. M. and T. V. supervised the national data collection procedures. All authors read and critically reviewed the manuscript.

The authors declare that there are no conflicts of interest.

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Artículo II [Paper II]: Social vulnerability as a predictor of physical activity and screen time in European children.

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Social vulnerabilities as determinants of overweight in 2-, 4- and 6-year-old Spanish children

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Background: Differences in obesity prevalence among vulnerable groups exist in childhood but it remains unclear whether these differences may be partly determined by socioeconomic status (SES), parental body mass index (BMI) and early life risk factors. We aimed to explore (i) longitudinal associations between belonging to a minority group and being overweight/obese at age 2, 4 and 6 and (ii) associations between accumulation of social vulnerabilities and being overweight/obese at age 6. Methods: In total, 1031 children (53.8% boys) were evaluated at birth and re-examined during a 6-year follow-up in a representative cohort of Aragon (Spain). Children from minority (vulnerable) groups included Spanish Roma/gypsies, Eastern Europeans, Latin Americans and Africans. Two more vulnerable groups were defined at baseline as children whose parents reported low occupation and education. Ethnicity, SES and parental BMI were collected via interviews. We used logistic mixed-effects models and adjusted for parental BMI, SES, mother's tobacco use, maternal weight gain, birth weight, infant weight gain and breastfeeding practices. Results: Regardless of confounders, Roma/gypsy children (OR = 4.63;[1.69–12.70]95%CI) and with Latin American background (OR = 3.04;[1.59–5.82]95%CI) were more likely to be overweight/obese at age 6 compared with non-gypsy Spanish group. Children with three vulnerabilities (OR = 2.18;[1.31–3.64]95%CI) were more likely to be overweight/obese at age 6 compared with children with no vulnerabilities. No associations were found between belonging to a minority group and overweight/obesity in children under 6. Conclusion: Interventions should target Roma/gypsy children, Latin American children and those who accumulate more vulnerabilities as they are at higher risk of being overweight/obese at age 6.

Introduction

Childhood obesity is considered one of the 21st century's most serious public health challenges.[1] Consequences of this condition include cardiovascular diseases, type 2 diabetes, musculoskeletal al- terations and psychological disorders.[2] Prevalence of overweight and obesity in Spanish children is among the highest in Europe and varies among minorities and socioeconomic groups.[3,4] Particularly, disadvantaged socioeconomic circumstances and some minority groups present increased obesity-related health problems.[5] Socioeconomic status (SES), including family income, parental education and occupational status, has been associated with a range of health, cognitive and socioemotional outcomes in children, with effects beginning prior to birth and continuing into adulthood.[6]

Most studies attempting to describe socioeconomic factors and differences among minority groups of childhood obesity epidemic have been conducted in the United States (US).[7] Results have showed a higher prevalence of overweight and obesity among Black and Hispanic children compared with non-Hispanic white children.[8] In Europe, studies have also examined ethnic variations in childhood overweight/obesity. Ethnic minority children (particularly Moroccan, Turkish, Latin American, Black African and black Caribbean) have proven to be more prone to overweight and obesity than non-minority children in some European countries.[9–11] Other minorities, such as Roma population (also known as Romani and Gypsies) present higher obesity rates than non-Gypsies.[12,13] Parental overweight and obesity, excessive weight gain during pregnancy, maternal smoking, rapid infant weight gain, low/high birth weight, poor breastfeeding practices and low SES are risk factors in prenatal period and early childhood.[14,15] Disparities in these risk factors due to differences in lifestyle behaviours, economic disadvantage and genetic characteristics could explain observed gaps in overweight and obesity rates between minority groups.[16]

Seemingly no studies in Spain or Europe have examined minority group differences as a risk factor of childhood obesity independently not only from classical SES indicators but also from pregnancy and infancy risk factors. Moreover, Spain has become a significant hub for international migration mainly consisting of medium-to-low income populations from Africa, Latin America and Eastern Europe of low SES, hence the interest in studying these groups.[12] A better understanding of childhood obesity will help guide inter- vention efforts and develop effective programmes and policies to avoid future diseases.

The present paper aims to explore (i) longitudinal associations between belonging to a minority group and being overweight or obese at three time points (ages 2, 4 and 6) in a cohort of children from Spain participating in the Growth and Feeding during Infancy and Early Childhood in Aragon (CALINA) study,
(ii) the extent to which differences in overweight and obesity prevalence in early childhood are explained by parental body mass index (BMI), SES, pregnancy and infancy risk factors and (iii) the association of accumulated social vulnerability (belonging to

multiple vulnerable groups) at baseline and being overweight or obese at age 6.

Methods

Design and study population

CALINA is an ongoing birth cohort study whose sampling design is described elsewhere in detail.[17] CALINAs study main objective was to assess growth patterns, body composition and feeding aspects in
this population and to examine prenatal, postnatal and socio-cultural factors which may influence them. The cohort was randomly drawn from births occurring from March 2009 to February 2010 in different localities located in northeastern Spain in the autonomous community of Aragon, recruited from Primary Care Centres that had permanent trained pediatric staff conducting the Spanish Child Health Program at least in the last 2 years before participating in the CALINA study and with compliance and attendance over 80% of the population living in this area. The study sample is a representative cohort of Aragonese population in Spain[18] which presents similar childhood obesity rates to that of the average reported by other northern regions in Spain.[19] 1630 families were contacted to participate in the CALINA study, of which 1602 accepted to participate (acceptance rate 98%), 1540 having basic information on sex, birth weight, length at birth, and date and place of birth of the child. These 1540 new-born infants without any malformation, diseases or physical disabilities were examined at birth and periodically re-examined in Primary Care Centres at 2 weeks, monthly (after 1, 2, 4, 6 and 9 months) and yearly (1, 2, 4 and 6 years later). After 6-year follow-up 323 children did no longer participate in our study, thus the retention rate was 79%. Children with missing values in any of the exposures, covariates or outcomes at baseline or follow-up were excluded. Moreover, Asians were not included due to the small size of the sample. Finally, the analysis included 1031 children (54.2% boys; Supplementary figure S1). An analysis was conducted on participants who were not included in the analysis either because they were lost after 6-year follow-up or they were excluded from the analysis based on missing values. Results confirmed children who had a migrant background, lower parental education and occupation were more likely to not participate in follow-up examinations.

Parents or legal guardians gave written informed consent for examinations for their children. Ethical approval was obtained from Aragon's Committee of Ethics in Clinical Research (CEICA).

Measurements

Outcome measure

Height and weight were obtained by trained staff using the homologated measuring SECA® device. Child length at age 2 was measured using a recumbent board. For children older than 2 years barefoot body height was measured to the nearest 0.1 cm and body weight in kg to the nearest 10 g standing up in a fasting state and wearing light clothes. We calculated age- and sex-specific BMI z- scores using World Health Organization (WHO) reference data.[18] Children with excess body weight included overweight children (BMI-for-age > 1 z-score from the median) and obese children (BMI-for-age > 2 z-score from the median.

Potential confounding factors

We recorded the following variables for all children as confounding factors:

Maternal and paternal BMI: We calculated paternal and maternal BMI from fathers' and mothers' (pre-pregnancy) weight and height reports. This information was obtained by a face-to-face interview with parents.

Early Life Risk Factors: Pregnancy and early infancy factors poten- tially related to overweight/obesity risk in children were included according to existing literature[14,20]):

Pregnancy: (i) *mother's tobacco use during pregnancy*, mother was considered as smoker if she smoked over pregnancy, regardless of the number of cigarettes, and (ii) *maternal weight gain during pregnancy*, obtained from the obstetric medical history.

Early infancy*:* (i) *birth weight*, obtained from hospital records*;* (ii) *rapid infant body weight gain*, considered as an increase in body weight above +0.67 standard deviation (SD) from birth to 6 months of age[21]; and (iii) *exclusive breastfeeding for at least 4 months* i.e. giving maternal milk as the only infant food source according to WHO.[22]

By an individual face-to-face interview with parents we collected data regarding their educational and occupation level and the country of birth.

Socioeconomic factors: Maternal and paternal educational level: parents were asked to indicate their highest level of education. Particular response categories were coded according to International Standard Classification of Education (ISCED 1997)[23] and re-categorized into three categories: low (0–2), medium (3–4) and high (5–6) ISCED educational levels.

Occupation: parents were further asked to specify their occupation which were later transformed into three-categories according to the European Socioeconomic Classification (ESeC): working class (sales and clerical occupations, lower services and technical occupations, routine occupations, non-employed) intermediate (intermediate occupation, small employers and self-employed in non-professional occupations, lower supervisory and technician occupations) and salariat (large employers, higher grade professional, administrative, managerial occupations and lower grade professional, administrative and managerial occupations and higher grade technician, supervisory occupations).[24]

Minority groups and social vulnerabilities

All children considered in this study were born in Spain. However, to classify children according to their minority status, we created four mutually exclusive groups defined as minority (vulnerable) groups based on ethnicity (Spanish Roma/gypsies) or parents' origin: Eastern Europeans, Latin Americans (Central, South America) and Africans (North Africa, Sub-Saharan Africa). Non- gypsy Spanish children, whose parents were both non-gypsies born in Spain, were defined as non-vulnerable.

In 94% of children, the category of both parents was the same and, then, was used as the child's minority group category. In those cases in which the minority group status of the 2 parents differed, it was based on mothers´ origin/ethnicity.

Social vulnerability score was calculated by adding up the number of social vulnerabilities a child was exposed to. In all, three vulner- ability indicators (belonging to a minority group; children of parents with low education levels and low occupational status) obtained from a parent-reported questionnaire were considered. For occupation and education, the mother's or father's highest level was taken into account. Vulnerability score ranged from 0 (no vulnerabilities) to 3 (all three vulnerability indicators) and was divided into four categories (three, two, one and no vulnerabilities).

Statistical analyses

Sociodemographic information was compared using *t*-tests for continuous variables and chi-square statistics for categorical variables. Logistic mixed-effects models were applied to assess lon- gitudinal associations between exposure (minority groups) and each outcome (overweight/obesity in children aged 2, 4 and 6). The reference category used was the normal BMI. All models included a random Primary Care Centre and random location of residence

Table 1 Descriptive characteristics of the study population stratified by children's weight status (normal vs. overweight/obese) at last follow-up (6 years old)

		Excess body weight at 6 years old		
		Normal weight (n = 706)	Overweight/obese (n = 325)	P-value
Categorical variables	N (%)	%	%	
Sex of the child				
Male	555 (53.8%)	68.1	31.9	0.783
Female	476 (46.2%)	68.9	31.1	
Maternal smoking				
Yes	200 (19.4%)	59.0	41.0	0.001
No	831 (80.6%)	70.8	29.2	
Exclusive breastfeeding[a]				
Yes	463 (44.9%)	71.9	28.1	0.028
No	568 (55.1%)	65.5	34.5	
Parental origin/Ethnicity				
Spanish Roma (Gypsy)	29 (2.8%)	27.6	72.4	< 0.001
Eastern European	40 (3.9%)	62.5	37.5	
Latin American	55 (5.3%)	47.3	52.7	
African	39 (3.8%)	69.2	30.8	
Non-gypsy Spaniard	868 (84.2%)	71.4	28.6	
Region				
Zaragoza	721 (69.9%)	68.9	31.1	0.461
Huesca	201 (19.5%)	69.7	30.3	
Teruel	109 (10.6%)	63.3	36.7	
Primary care centres				
Valdefierro	131 (12.7%)	69.5	30.5	
Actur	181 (17.6%)	70.1	29.3	
Torrero	64 (6.2%)	68.8	31.2	
Huesca	111 (10.8%)	73.0	27.0	
Sagasta	97 (9.4%)	69.1	30.9	0.914
Las Fuentes	70 (6.8%)	71.4	28.6	
Delicias	93 (9.0%)	67.7	32.3	
Teruel	109 (10.6%)	63.3	36.7	
Jaca	91 (8.8%)	65.9	34.1	
Tarazona	50 (4.8%)	64.0	36.0	
Borja	34 (3.3%)	61.8	38.2	
Maternal occupation				
Missing	118 (11.4%)	67.8	32.2	0.002
Working class	455 (44.1%)	63.3	36.7	
Intermediate	197 (19.1%)	69.5	30.5	
Salariat	261 (25.3%)	77.0	23.0	
Paternal occupation				
Missing	123 (11.9%)	72.4	27.6	0.001
Working class	504 (48.9%)	63.1	36.9	
Intermediate	189 (18.3%)	69.8	30.2	
Salariat	215 (20.9%)	77.7	22.3	
Maternal education				
Missing	10 (1.0%)	80.0	20.0	< 0.001
Low	258 (25.1%)	58.1	41.9	
Medium	349 (33.9%)	71.3	28.7	
High	414 (40.2%)	72.2	27.8	
Paternal education				
Missing	19 (1.9%)	73.7	26.3	0.001
Low	534 (32.0%)	59.7	40.3	
Medium	431 (41.8%)	71.5	28.5	
High	251 (24.3%)	74.5	25.5	
Accumulation of vulnerabilities[b]				
No vulnerabilities	411 (39.9%)	74.0	26.0	< 0.001
Missing	34 (3.3%)	70.6	29.4	
1 vulnerability	279 (27.1%)	69.5	30.5	
2 vulnerabilities	204 (19.8%)	65.2	34.8	
3 vulnerabilities	103 (10.0%)	49.5	50.5	
Continuous variables	Mean (SD)	Mean (SD)	Mean (SD)	P-value
Paternal BMI (kg/m^2)	26.29 (3.44)	25.86 (3.33)	27.23 (3.49)	< 0.001
Maternal BMI (kg/m^2)	23.53 (4.33)	22.98 (4.05)	24.75 (4.68)	< 0.001
Weight gain during pregnancy (kg)	11.80 (5.03)	11.90 (4.93)	11.66 (5.23)	0.569
Birth weight (g)	3230 (485)	3206 (471)	3283 (512)	0.018
Rapid infant weight gain (z-score)	0.16 (1.11)	0.01 (1.03)	0.49 (1.20)	< 0.001

Notes: BMI, Body Mass Index; SD, Standard Deviation. Statistical analyses were undertaken using t-Student (for continuous variables) and chi-square tests (for categorical variables); significant values at $p < 0.05$.

a: Exclusive breastfeeding was defined as giving maternal milk at the only infant food source for at least 4 months with no other liquids or food given.

b: A total social vulnerability score was calculated by adding up the numbers of vulnerabilities a child was exposed to: belonging to a minority ethnic group; parental low-occupation and low-education were considered. The vulnerability score ranged from 0 (the child had no vulnerabilities) to 3 (the child had all three vulnerability indicators).

Table 2 Longitudinal associations between belonging to a minority group and excess body weight in children at 6 years old (reference: normal weight) for the four models[a]

Parental origin/Ethnicity	Excess body weight (Overweight and obesity) at 6 years old											
	M1[b]			M2[c]			M3[d]			M4[e]		
	OR	95% CI	*P*-value	OR	95% CI	*P*-value	OR	95% CI	*P*-value	OR	95% CI	*P*-value
Spanish Roma (Gypsy)	6.77	2.94–15.57	<0.001	5.90	2.51–13.88	<0.001	5.18	2.03–13.17	0.001	4.63	1.69–12.70	0.003
Eastern European	1.51	0.78–2.92	0.221	1.56	0.78–3.11	0.205	1.19	0.50–2.27	0.829	1.16	0.51–2.63	0.713
Latin American	2.79	1.61–4.85	<0.001	3.26	1.84–5.77	<0.001	3.05	1.64–5.67	0.001	3.04	1.59–5.82	0.001
African	1.12	0.56–2.25	0.752	1.27	0.61–2.61	0.521	1.00	0.45–2.21	0.991	0.84	0.39–2.08	0.805
Non-gypsy Spaniard	1.00			1.00			1.00			1.00		

Notes: Results from the logistic mixed-effects models: odds ratios (OR), 95% confidence intervals (CI) and *P*-values are shown. Statistically significant results are shown in bold font.
a: All models include random effects (province and Primary Care Centres) to account for the study design.
b: M1 were adjusted for sex.
c: M2 were additionally adjusted for maternal BMI, parental BMI, weight gain during pregnancy and maternal smoking.
d: M3 were additionally adjusted for rapid infant weight gain, breast-feeding practices and birth weight.
e: M4 were additionally adjusted for parental (maternal and paternal) education and occupation.

Table 3 Association between the accumulation of social vulnerabilities and excess body weight in children aged 6 years old (reference: normal weight) for the three models[a]

Number of vulnerabilities	Excess body weight (Overweight and obesity) at 6 years old								
	M1[b]			M2[c]			M3[d]		
	OR	95% CI	*P*-value	OR	95% CI	*P*-value	OR	95% CI	*P*-value
Missing	1.17	0.42–3.23	0.688	1.16	0.52–2.57	0.703	1.42	0.61–3.30	0.404
Three vulnerabilities	2.89	1.85–4.50	<0.001	2.32	1.45–3.71	0.001	2.18	1.31–3.64	0.003
Two vulnerabilities	1.52	1.05–2.17	0.024	1.27	0.87–1.88	0.200	1.08	0.72–1.63	0.699
One vulnerability	1.25	0.89–1.74	0.202	1.02	0.72–1.46	0.913	0.98	0.68–1.43	0.942
Non-vulnerable	1.00			1.00			1.00		

Notes and Sources: Results from the logistic linear mixed model: odds ratios (OR) and 95% confidence intervals (CI) are shown. Statistically significant results are shown in bold font. A total social vulnerability score was calculated by adding up the numbers of vulnerabilities a child was exposed to: (belonging to a minority ethnic group; low-occupation and low-education) were considered. The vulnerability score ranged from 0 (the child had no vulnerabilities) to 3 (the child had all three vulnerability indicators).
a: All models include random effects (province and Primary Care Centres) to account for the study design.
b: M1 were adjusted for sex.
c: M2 were additionally adjusted for maternal BMI, parental BMI, weight gain during pregnancy and maternal smoking.
d: M3 were additionally adjusted for rapid infant weight gain, breast-feeding practices and birth weight.

(region) to account for the study design. Three levels then were modelled: individuals (level 1), nested within Primary Care Centres attended at baseline (level 2), nested within regions (level 3). Moreover, to explore the association between accumulation of social vulnerability at baseline and overweight/obesity in children aged 6 an additional longitudinal analysis was conducted.

To adjust for possible confounders, four different models were run. Model 1 was adjusted for sex. We also adjusted multivariable models for potential confounders at baseline, including maternal and paternal BMI, maternal weight gain during pregnancy and maternal smoking status (model 2). In subsequent models, we adjusted for birth weight, infant weight gain and breastfeeding practises (model 3) and socioeconomic variables including maternal and paternal education and occupation (model 4 or fully adjusted model). Each subsequent model includes adjustments in the prior model, with further adjustments.

Due to the likelihood of a non-random subset of respondents with missing socioeconomic information,[25] missing values of socioeconomic data were coded as a separate category.

Before model building, correlations among classical SES indicators were checked, however no collinearity problems were detected and both education and occupation were added.

Significance level was set at 0.01 to account for multiple testing. Analyses were performed using the Statistical Package for the Social Sciences (version 22.0; SPSS, Inc.).

Results

Table 1 summarizes descriptive characteristics of children and parents according to weight status (normal weight vs. overweight/obesity) of children at 6-year follow-up. For continuous covariates, mean and standard deviation (SD) are shown. The percentage of children presenting normal weight at age 6 was 68.4% (28.9% of the total number of children were underweight, data not shown). The percentage of children presenting excess body weight at age 6 was higher in those whose mothers reported having smoked during pregnancy (41.0%) compared with non-smokers (29.2%), and in those who used any kind of formula feeding (34.5%) compared with those who exclusively breastfed during at least 4 months (28.1%). Regarding minority group status, Roma children presented the highest percentage of overweight/obesity (72.4%) compared with non-gypsy Spanish children, who had the lowest percentage (28.6%). Children whose parents reported low SES (low education and working

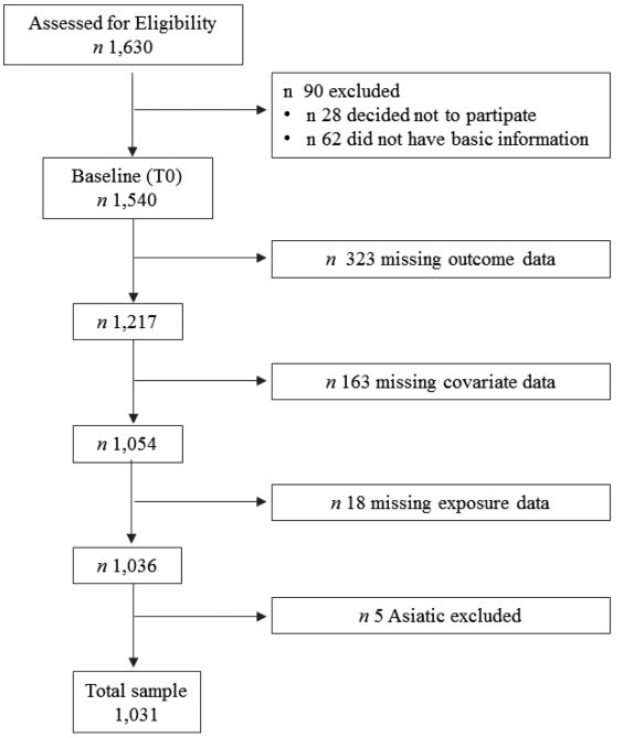

Figure 1 Selection of the final study sample

class) had a higher percentage of overweight/obesity compared with those from high SES (high education and salariat). Finally, children with a higher number of vulnerabilities had a higher percentage of overweight/obesity (50.5%) compared with those who reported no vulnerabilities (26.0%).

Table 2 shows odds ratio (OR), 99% confidence interval (CI) and *P*-values for models assessing longitudinal associations between minority group status and overweight/obesity in children aged 6 (see Supplementary table S1 for children aged 2 and Supplementary table S2 for children aged 4). No significant associations were found between belonging to a vulnerable group and excess body weight in children aged 2 or 4. However, Roma children (OR = 4.30;[1.13;16.23]99%CI) and children with Latin American background (OR = 2.93;[1.26;6.79]99%CI) were more likely to be overweight or obese at age 6 compared with non-gypsy Spanish children regardless of confounders (model 4).

Longitudinal associations between accumulation of social vulnerability indicators at baseline and being overweight/obese at age 6 are shown in table 3. Children with three vulnerabilities (OR = 2.08;[1.08;4.04]99%CI) were more likely to be overweight or obese at age 6 compared with children with no vulnerabilities regardless of confounders (model 4). Figure 1 shows normal weight vs. overweight/obesity prevalence in children aged 6 by the number of vulnerabilities the child was exposed to at baseline.

Discussion

This study aimed to explore longitudinal associations between belonging to a minority group and being overweight/obese at age 2, 4 and 6 and to investigate associations between accumulation of social vulnerabilities and being overweight/obese at age 6, independ- ent from perinatal and infancy risk factors, SES status and parental BMI. This study found belonging to Roma (gypsy) and Latin American groups increased the risk of overweight/obesity 4-fold and 3-fold, respectively, in children aged 6 compared with those from non-gypsy Spanish group after adjusting for parental BMI, weight gain during pregnancy, maternal smoking during pregnancy, birth weight, weight gain in the first 6 months, breast-feeding practices and SES.

Few studies have examined the association between belonging to Roma population and being overweight and obese. Conforming to our results, investigations have shown Roma/Gypsy children had a higher prevalence of obesity,[26,27] while one study in Macedonia found Roma children had a higher risk of being underweight than non-Roma children.[28] Regarding the Latin American group, similar results were found in studies conducted, mainly in the US, in which it was at higher risk for obesity than non-Hispanic white children.[29,30] However, no statistically significant associations in children under 6 were found, which differs from the conclusions of Kimbro, Brooks-Gunn & McLanahan, who observed Latin American children aged 3 were nearly twice as likely as non-Hispanic white children to be overweight or obese. This outcome suggests that the effect of belonging to a minority group on childhood overweight problems begin earlier[31] even though the effect seems to be higher in children who spend more time exposed to vulnerabilities.

Genetic and cultural diversity in minority groups and those related to SES could result in differences in Energy balance-related behaviours (EBRBs). These groups are at higher risk of adopting an unhealthy diet, insufficient physical activity and sedentary behaviours, explaining differences found in overweight and obesity prevalence among these groups.[28] Minorities groups (particularly, Roma/gypsies and Latin Americans) are more exposed to a higher number of vulnerabilities possibly leading to inadequate adaptation in obesogenic environments characterized by low levels of physical activity, high energy density diets and a sedentary lifestyle compared with non-vulnerable groups.

Children whose parents came from Africa and Eastern European countries did not present a significantly increased risk of being overweight/obese compared with non-gypsy Spanish group up to 6 years old. However, different results can be found in literature depending on the country the study took part in. Particularly, African migrant children in Europe and Australia presented higher prevalence of overweight and obesity than native children,[32] especially girls.[33,34] Previous analyses showed similar growth patterns and infant feeding practices in children whose parents were born in North Africa or in Sub-Saharan Africa. These findings could result from a shared cultural and religious background. Therefore, we finally decided to include children whose parents were born in North African and Sub-Saharan countries in the same minority group.

Since the mid-1990 s, Spain has received a large number of immigrants, mainly searching for better jobs and economic security. In general, these groups, usually members of low status occupations,[35] accumulate more social vulnerability than natives, which has been associated with a higher prevalence of overweight and obesity in this population.[5] Likewise, we observed the rate of overweight and obesity in children aged 6 was more than two times higher in those with an accumulation of three vulnerabilities (children belonging to a minority group, with parents from low occupation and educational level) than in children with no vulnerabilities. This is consistent with previous studies that have demonstrated than an accumulation of social vulnerabilities increases the risk of unhealthy lifestyle patterns.[36]

Some limitations of this study should be acknowledged. Firstly, the CALINA study is not representative of the Spanish population since Aragon covered a limited geographic area within the country and results might not be extrapolated to the whole population. Secondly, an analysis of further confounders highly associated with obesity levels such as family income, dietary patterns, sedentary behaviours, physical activity and sleep duration was not included in this study. Thirdly, another limitation is reliance on self-report measures for parents (such as parental weight and height and their education and occupation). Moreover, a selection bias cannot be precluded as there were participants (mainly children whose parents were originally from Eastern European countries, Africa

and Latin America and had lower parental education and occupation) who did not complete all information required or did not continue the study at follow-up. A special strength is the fact that to our knowledge, no previous research has investigated the association between minority groups and accumulation of social vulnerabilities and children's overweight and obesity in Spain. The prospective collection of data on a wide range of risk factors extending from pregnancy through infancy and the ability to adjust for several important confounding socioeconomic factors are among the strengths of this study.

Conclusion

Despite reported stabilization of prevalence rates of overweight and obesity in children in Spain and other developed countries, children from vulnerable groups (those who belong to minority groups and from low SES) have not benefited from this trend. This study suggests associations between belonging to a minority group and presenting overweight/obesity at age 6 regardless of parental BMI, SES, pregnancy and infancy risk factors. Mainly children with Latin American and Roma (gypsies) background were at a disadvantage compared with non-gypsy Spanish group. These findings suggest public health strategies for obesity prevention should pay special attention to these vulnerable groups as they are at higher risk.

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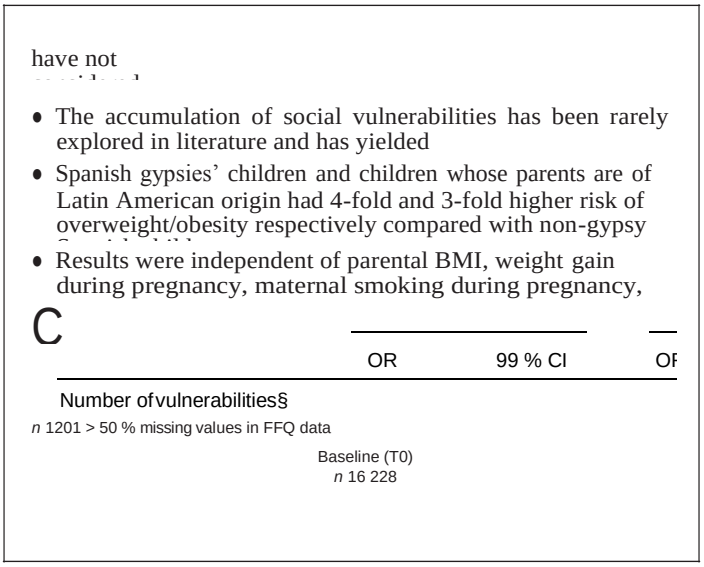
Supplementary data

Supplementary data are available at *EURPUB* online.

Conflicts of interest: None declared.



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Artículo III [Paper III]: Associations between social vulnerabilities and psychosocial problems in European children. Results from the IDEFICS study

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ORIGINAL CONTRIBUTION

Associations between social vulnerabilities and psychosocial problems in European children. Results from the IDEFICS study

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Abstract The effect of socioeconomic inequalities on children's mental health remains unclear. This study aims to explore the cross-sectional and longitudinal associa- tions between social vulnerabilities and psychosocial prob- lems, and the association between accumulation of vulner- abilities and psychosocial problems. 5987 children aged 2–9 years from eight European countries were assessed at baseline and 2-year follow-up. Two different instruments were employed to assess children's psychosocial problems: the KINDL (Questionnaire for Measuring Health-Related Quality of Life in Children and Adolescents) was used to evaluate children's well-being and the Strengths and Dif- ficulties Questionnaire (SDQ) was used to evaluate chil- dren's internalising problems. Vulnerable groups were defined as follows: children whose parents had minimal social networks, children from non-traditional families, children of migrant origin or children with unemployed parents. Logistic mixed-effects models were used to assess the associations between social vulnerabilities and psy- chosocial problems. After adjusting for classical socioeco- nomic and lifestyle indicators, children whose parents had minimal social networks were at greater risk of present- ing internalising problems at baseline and follow-up (OR 1.53, 99% CI 1.11–2.11). The highest risk for psychoso- cial problems was found in children whose status changed from traditional families at T0 to non-traditional families at T1 (OR 1.60, 99% CI 1.07–2.39) and whose parents had

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minimal social networks at both time points (OR 1.97, 99% CI 1.26–3.08). Children with one or more vulnerabilities accumulated were at a higher risk of developing psychoso- cial problems at baseline and follow-up. Therefore, policy makers should implement measures to strengthen the social support for parents with a minimal social network.

Keywords Vulnerable groups · Psychosocial problems · Well-being · Internalising problems · Inequalities · Children

Introduction

It has been widely acknowledged that disadvantaged socio-oeconomic circumstances are associated with increased health risk [24, 38]. Socioeconomic status (SES), including family income, parental education, and occupational status, has been associated with a wide range of health, cognitive, and socio-emotional outcomes in children, with effects beginning prior to birth and continuing into adulthood [24]. Particularly, children from low SES manifest more behav- ioural and emotional problems than children from high SES [45]. An array of mechanisms linking SES to child well- being has been proposed, with most involving differences in access to material and social resources or reactions to stress-inducing conditions by the children and their parents [8]. Since in most countries the gap between socioeconomi- cally advantaged and disadvantaged people has increased during the last two decades and given the evidence of the social gradient in health specifically in children [18, 36], it is important to study these associations with psychosocial problems in children [36, 43].

Other vulnerabilities apart from SES have rarely been analysed in relation to psychosocial problems as an out- come. Therefore, this study focuses on comparing socially vulnerable to non-vulnerable groups. Herein, social vulner- abilities can be defined as social (e.g. migrant) and eco- nomic (e.g. unemployment) situations that can amplify the susceptibility to harm and that also govern the ability to respond to this [19].

It has been stated that these social vulnerabilities increase the risk of poor mental health [53], e.g. by causing stress through different mechanisms [49]. In this regard, four vulnerable groups will be investigated in the present study: (1) children whose parents lack a social network, (2) children not living with both biological parents (for sim- plicity, referred to as non-traditional families), (3) children of migrant origin and (4) children with either one or both parents unemployed.

Specific social vulnerabilities have already been associ- ated with psychosocial health in existing literature. Some studies concluded that parents' social support was beneficial for children's well-being and negatively predicted delin- quency across adolescence [22, 55]. Parents' social support allows children to access other support agents, who reduce stress by promoting skills and resilience [54, 55]. Family structure might influence child well-being through differ- ent parental resources: mental health, relationship quality, parenting quality, and father involvement [59]. Particularly, children from traditional families had a lower risk of high school dropout and teenage pregnancy and had better adult outcomes, e.g. both higher socio-emotional and cognitive scores compared to non-traditional families [4, 10, 17].

Findings on the association between migrant origin and children's mental health were inconsistent with positive, non-significant or negative associations [1, 44, 57]. A pre- vious meta-analysis was not conclusive regarding migrant children's risk of mental health problems, since the impact of migration on children's mental health varied with the respondents studied and the characteristics of the migrant group and of their host country [53]. Concerning unem- ployment status, results are also inconclusive: some stud- ies reported that children with unemployed parents seemed to have more internalising and externalising problems than those whose parents were both employed [2]. Parental job loss reduces not only future family income but it disrupts individuals' status, time structure, demonstration of compe- tence and skill, and structure of relations. It carries soci- etal stigma that leads to anxiety, insecurity, and shame in parents, which can have a negative impact on children´s mental health [9]. However, while other studies have shown positive or non-significant associations among unemploy- ment and well-being [12, 46].

Nevertheless, social vulnerabilities should not be studied without considering contextual factors like SES and life- style. After all, SES plays an important role by increasing or lowering the negative impact of social vulnerabilities, e.g. a higher education allows to absorb and recover from losses and to be salient to negative impacts on life. In addi- tion, children from low SES and socially vulnerable groups have a lower consumption of fruit and vegetables, lower rates of physical activity, higher levels of sedentary behav- iours and higher BMI compared to children from high SES or non-vulnerable groups [32]. This pattern of obesogenic lifestyle has been associated with psychosocial health such as internalising problems (symptoms of depression) and lower levels of well-being [7, 27].

To measure psychosocial health, both positive and nega- tive aspects such as well-being and internalising problems, respectively, should be considered. In the current study, this will be measured using the KINDL® instrument and the Strengths and Difficulties Questionnaire (SDQ) instru- ment, respectively. These two instruments capture different aspects of mental health and are only partially correlated [30].

We hypothesised that the above-mentioned four socially vulnerable groups (social network, family structure, migrant status and employment status) have an effect inde- pendent of classical SES indicators and lifestyle indicators and that there is a cumulative effect on the likelihood of psychosocial problems (poor well-being and having inter- nalising problems). Therefore, the present paper aimed to explore (1) the cross-sectional and longitudinal associations between social vulnerabilities and psychosocial problems in European children, (2) the association between evolution of vulnerabilities over 2 years and psychosocial problems at follow-up and (3) the association of accumulated vulner- ability with psychosocial problems at two time points. Each time adjusts for classical SES indicators and lifestyle indi- cators. Understanding such relationships between social vulnerabilities and different indicators of psychosocial health can be a key strategy for prevention of future mental problems and thus increased health risks.

Materials and methods

Study population

The Identification and Prevention of Dietary-and Lifestyle-induced Health Effects in Children and Infants (IDEFICS) Study is a multi-centre prospective cohort study, including a school- and community-based obesity prevention inter- vention [20] in eight European countries (Belgium, Cyprus, Estonia, Germany, Hungary, Italy, Spain and Sweden). For comprehensive information about IDEFICS, a detailed description is given by Ahrens et al. [3]. 16228 children aged 2–9 years were examined from September 2007 to June 2008 at baseline (T0). The follow-up (T1) took place 2 years later (September 2009–June 2010) applying the same standardised assessments where 11041 children aged 4–11 years were re-examined.

Two different parent proxy-report instruments were employed to assess children's psychosocial problems at baseline and follow-up: the KINDL® (Questionnaire for Measuring Health-Related Quality of Life in Children and Adolescents-Revised Version) was used to evalu- ate children's well-being during the last week and the Strengths and Difficulties Questionnaire (SDQ), a behav- ioural screening questionnaire, was used in this study for evaluating children's internalising problems over the last 6 months.

Well- being from KINDL®

The KINDL®, a validated instrument for assessing health- related quality of life in children and adolescents, was com- pleted by the parents. The instrument included four of the six original KINDL dimensions: emotional well-being, self-esteem, family relations and social contacts [11]. Questions on physical well-being and everyday function- ing were excluded in the IDEFICS study. Answers were given according to a 4-point Likert scale (never, rarely, sometimes and often/always) with reversals according to the wording of the question [47]. Scores were summed with higher scores representing more favourable indicators of well-being. The 20th percentile of the total score was taken as threshold to differentiate between children with a poor score (from 0 to 36) and a normal or high score (from 37 to 48) to be consistent with previous investigations of IDEFICS [7]. The original KINDL questionnaire does not provide an established target value in all the survey coun- tries. Although KINDL® has been created for those aged 3 years and older, we included children aged 2 years (177 children in total) because those children, to be eligible for IDEFICS participation, were attending pre-schools or kin- dergartens and then exposed to similar psychosocial factors as their peers. Since analyses excluding these 2-year-old children shown similar results, we decided to include them.

Internalising problems from SDQ

The SDQ is a 25-item questionnaire [23] divided into five scales (emotional problems, conduct problems, hyperac- tivity–inattention behaviour, peer problems and prosocial behaviour) and validated for children aged 2–7 years old [48]. Since the IDEFICS study did not incorporate the Hyperactivity scale, only internalising problems (from the emotional and peer problems subscales) were included and scored in accordance with the published scoring instruc- tions [41]. The scale of internalising problems was dichot- omised into a normal score vs abnormal score according to the published cutoffs [41].

Definition of vulnerable groups

Four vulnerabilities obtained from the parental question- naire were defined at baseline as our exposures.

Social network A minimal social network (vulnerable group) 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 '2–3 persons' and 'more than 3 persons' and were labelled as non-vulnerable [5, 33, 40].

Family structure Answers on the question 'Who does your child live with most of the time?' were categorised as follows: (1) with two biological parents; (2) with one bio- logical parent; (3) with one parent and his/her new partner;
(4) half of the time with his/her mother and the other half with his/her father; (5) with grandparents; and (6) with

other adults. When the child was living with both his/her biological parents the family was defined as a 'traditional family' [59] as opposed to non-traditional family that included single-parent families, stepparent families, living with grandparents or foster parents or in an institution.

Origin of the parents A migrant background (vulnerable group) was assumed if one or both parents were born in a country different from where the study took place.

Employment status If at least one of the parents was unemployed or living on social assistance or welfare, the child was considered as belonging to the vulnerable group [2].

A total vulnerability score was calculated by adding up the numbers of social vulnerabilities a child was exposed to. In all, four vulnerability indicators (minimal social net- work, non-traditional family, migrant, unemployed) were considered. The vulnerability score ranged from 0 (the child had no vulnerability) to 4 (the child had all four vul- nerability indicators) and was divided into three catego- ries (two to four vulnerabilities, one vulnerability and no vulnerability).

Lifestyle indicators assessed at baseline Fruit and veg- etable consumption was obtained using the food frequency section of Children's Eating Habits Questionnaire-food frequency questionnaire (CEHQ-FFQ) [31]. This FFQ is a self-administered validated screening tool where par- ents reported usual at-home-consumption frequencies of 42 food items of the previous four weeks. The sum of the reported intake frequency of fresh fruits, raw and cooked vegetables per week as a healthy diet indicator was calculated.

Physical activity Parents reported the total weekly hours the children spent playing outdoors and children's participation in sports club activities in the previous month. Physical activity per week was obtained with this formula: [(hours playing outdoors on weekdays × 5) + (hours playing outdoors on weekend days × 2) + weekly sports participation].

Screen time Parents reported the daily screen time spent on audio-visual media (TV, video, DVD, computer, game console) by the children for a typical weekday and week- end day. Total screen time per week was calculated as:

(5 × weekday + 2 × weekend).

Weight categories

Anthropometric measurements were assessed at T0 according to the standardised procedures in all partici- pating countries. Barefoot body height was measured to the nearest 0.1 cm by trained staff using a portable sta- diometer (SECA 225). Body weight in kg was measured by a child-adapted version of electronic scale TANITA BC-420 SMA with the children weighted in a fasting state and wearing only light clothes. Body mass index (BMI) was calculated by dividing body weight in kilo- grams by squared body height in metres and then trans- formed into an age- and sex-specific *z*-score [15]. Weight groups were categorised using age and sex-specific cut points according to the criteria of the International Obe- sity Task Force [16].

Classical SES indicators

Education: parents were asked to indicate the highest level of education of both themselves and their partners. The response categories for each country were coded accord- ing to the International Standard Classification of Educa- tion (ISCED) and re-categorised into three categories: low (ISCED level 0–2), medium (ISCED level 3–4) and high (ISCED level 5–6) [52]. The highest level of either the mother or the father was taken into account.

Income Parents also provided information on the monthly net income of the household after taxes and deductions responding to nine country-specific categories (1: from the lowest category to 9: the highest category). The category cutoffs were designed to be country specific according to a fixed scheme based on the median equiva- lent income, thus guaranteeing comparability between countries. The results were organised into three categories: low (1–3), medium (4–6) and high income (7–9).

Occupation Parents were asked to specify their occupa- tional position with 18 possible options, which were later transformed into the three-class version of the European Socioeconomic Classification: working class, intermediate and salariat [25].

The highest level of either the mother or the father was taken into account.

After excluding children with missing values in any of the exposures or outcomes at baseline or follow-up or any of the covariates at baseline, the present analysis finally included 5987 children (50.6% boys) (see also Fig. 1). In the IDEFICS study, a detailed analysis has been conducted on the participants who were lost after 2-year follow-up. Results showed that children attending the baseline exami- nation who had a migrant background, non-traditional families, lower parental education, poorer well-being, and overweight were more likely to be lost in follow-up exami- nations [28]. In addition, a detailed table comparing chil- dren included in and excluded from the analysis on key variables can be found in the Appendix (Table S1).

Parents or legal guardians gave written informed con- sent for examinations and data collection for their children, while children expressed oral consent. Ethical approval was obtained from the research ethics authority of each partici- pating centre.

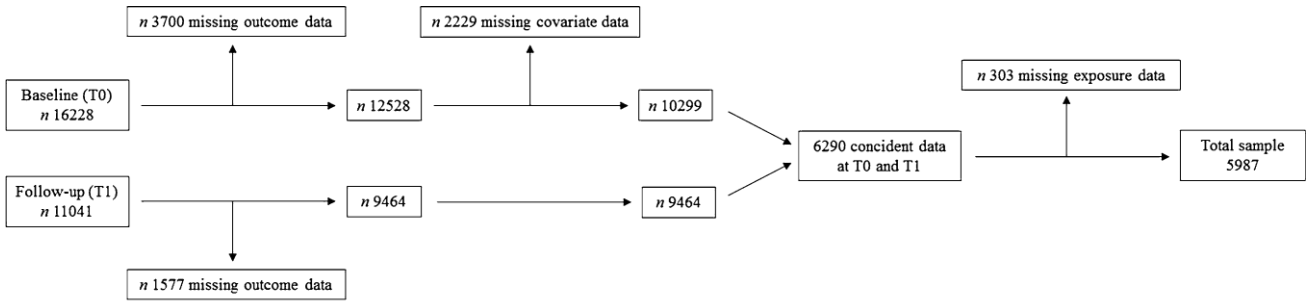

Fig. 1 Final study sample

Statistical analyses

Logistic mixed-effects models were used to assess the cross-sectional and longitudinal associations between the four dichotomised exposures (social network, family structure, migrant origin and employment status) and each outcome (well-being and internalising problems). The ref- erence category used was the normal (healthy) score for each outcome. All models included a random kindergarten/ school and a random country effect to account for the clus- tered study design.

Two cross-sectional and three longitudinal analyses were conducted. In the first cross-sectional analysis, covari- ates (lifestyle indicators and SES) and outcome variables from T0 were used. In the second cross-sectional analysis, we considered predictor and outcome variables from T0. In the first longitudinal analysis, children's well-being and internalising problems at T1 were related to the T0 covari- ates. In the second longitudinal analysis, children's well- being and internalising problems at T1 were related to the T0 exposures. In the third longitudinal analysis, evolution of vulnerability from T0 to T1 (vulnerable at T0 and T1, vulnerable at T0 and non-vulnerable at T1, non-vulnerable at T0 and vulnerable at T1; and non-vulnerable at T0 and T1) was related to children´s well-being and internalising problems at T1. The patterns of vulnerability were assessed for only three of the vulnerable groups considered since migrant status does not change between baseline and fol- low-up. Finally, two more analyses were conducted to esti- mate the accumulation of vulnerability at T0 and psychoso- cial problems at T0 and T1.

To adjust for possible confounders, three models were run for each analysis: model 0 for each outcome/expo- sure was adjusted for baseline age and sex, model 1 was additionally adjusted for frequency of fruit and vegetable consumption, physical activity, total screen time and BMI *z*-score and model 2 was additionally adjusted for baseline classical SES indicators (education, income and occupation except for employment status model). For both longitudi- nal analyses, a variable indicating intervention vs control region was added and models were additionally adjusted for baseline outcomes (well-being and internalising prob- lems at T0, respectively).

Before model building, correlations among classical SES indicators were checked resulting in the exclusion of occupation status in models with employment status as main exposure to avoid collinearity problems.

The significance level was set at 0.01 to account at least partially for multiple testing. The analyses were performed using the Statistical Package for the Social Sciences (ver- sion 22.0; SPSS, Inc.).

Results

Table 1 summarises the distributions of predictors and background variables for the two outcomes (well-being and internalising problems) at T0 and T1. For the continuous covariates, the median is shown.

Associations between tested potential confounders (life- style indicators and SES) and well-being and internalising problems at baseline (T0) and follow-up (T1) are presented in the Appendix (Table S2). Healthy lifestyle indicators (higher levels of weekly consumption of fruit and vegeta- bles, higher levels of weekly physical activity) and lower SES were statistically significant related to higher well- being or lower internalising problems. Moreover, higher levels of weekly screen time were statistically significant related to poorer well-being and internalising problems. BMI *z*-score was not statistically significant related to higher well-being or lower internalising problems.

Table 2 presents odds ratios (OR), 99% confidence intervals (CI) and *P* values for the models assessing the longitudinal associations between the four vulnerability

Table 1 Description of the study population, stratified by well-being and internalising problems (normal/abnormal) at baseline (T0) and follow-up (T1)

Total 5987 (100%)	*N* (%)	T0 (Baseline)				T1 (Follow-up)			
Categorical variables		Well-being		Internalising problems		Well-being		Internalising problems	
		Poor	Normal	Abnormal	Normal	Poor	Normal	Abnormal	Normal
Age groups									
2–6 years	2660 (44.0%)	13.5	86.5	15.3	84.7	20.2	79.8	12.6	87.4
6–10 years	3327 (55.6%)	21.3	78.7	16.4	83.6	27.9	72.1	15.9	84.1
Sex of the child									
Male	3028 (50.6%)	18.4	81.6	16.4	83.6	24.8	75.2	15.0	85.0
Female	2959 (49.4%)	17.2	82.8	15.4	84.6	24.1	75.9	13.8	86.2
BMI									
Thiness	680 (11.4%)	17.1	82.9	16.5	83.5	24.7	75.3	17.2	82.8
Normal weight	4228 (70.6%)	17.0	83.0	15.4	84.6	23.3	76.7	13.6	86.4
Overweight	687 (11.5%)	19.7	80.3	17.3	82.7	26.9	73.1	16.4	83.6
Obese	392 (6.5%)	24.5	75.5	17.6	82.4	31.4	68.6	15.6	84.4
Country									
Italy	917 (15.3%)	24.0	76.0	16.4	83.6	29.9	70.1	13.1	86.9
Estonia	939 (15.7%)	12.6	87.3	15.9	84.1	23.5	76.5	15.7	84.3
Cyprus	499 (8.3%)	29.3	71.7	16.2	83.8	18.4	81.6	13.4	86.6
Belgium	776 (13.0%)	12.1	87.9	21.4	78.6	20.0	80.0	20.5	79.5
Sweden	564 (9.4%)	7.8	92.2	5.5	94.5	12.8	87.2	4.3	95.7
Germany	628 (10.5%)	15.0	85.0	16.6	83.4	15.0	85.0	17.5	82.5
Hungary	780 (13.0%)	32.2	67.8	15.6	84.4	33.8	66.2	15.1	84.9
Spain	884 (14.8%)	11.9	88.1	17.0	83.0	26.8	73.2	13.5	86.5
Occupation (ESEC)									
Missing	99 (1.7%)	21.2	78.8	20.2	79.8	24.2	75.8	17.2	82.8
Working class	1769 (29.5%)	22.4	77.6	19.1	80.9	28.2	71.8	16.7	83.3
Intermediate	2306 (38.5%)	16.7	83.3	15.7	84.3	23.6	76.4	13.9	86.1
Salariat	1813 (30.3%)	14.6	85.4	13.0	87.0	21.8	78.2	12.7	87.3
Income									
Missing	301 (5%)	16.6	83.4	12.0	88.0	19.6	80.4	13.0	87.0
Low	1792 (29.9%)	24.6	75.4	20.8	79.2	10.0	90.0	18.7	81.3
Medium	1606 (26.8%)	16.6	83.4	16.1	83.9	10.3	89.7	14.3	85.7
High	2288 (38.2%)	13.5	86.5	12.5	87.5	10.3	89.7	11.4	88.6
Education (ISCED)									
Low	343 (5.7%)	25.9	74.1	29.2	70.8	28.9	71.1	21.9	78.1
Medium	2996 (50%)	18.6	81.4	16.7	83.3	25.1	74.9	15.4	84.6
High	2648 (44.2%)	15.9	84.1	13.3	86.7	23.1	76.9	12.4	87.6
Social network[a]									
Minimal	534 (9.9%)	29.6	70.4	22.8	77.2	35.4	64.5	22.3	77.7
Strong	5453 (91.1%)	16.7	83.3	15.2	84.8	23.4	76.6	13.7	86.3
Family structure[b]									
Non-traditional family	1101 (18.4%)	25.0	75.0	20.5	79.5	31.1	68.9	18.9	81.1
Traditional family	4886 (81.6%)	12.7	16.2	14.9	85.1	22.9	77.1	13.4	86.6
Migrant status									
Migrant origin	665 (11.1%)	26.1	73.9	20.6	79.4	31.4	68.6	14.0	86.0
Native	5322 (88.9%)	17.4	82.6	15.7	84.3	24.1	75.9	14.5	85.5
Employment status									
Unemployed	287 (4.8%)	13.2	86.8	20.6	79.4	9.7	90.3	21.3	78.7

Table 1 continued

Total 5987 (100%)	*N* (%)	T0 (Baseline)				T1 (Follow-up)			
Categorical variables		Well-being		Internalising problems		Well-being		Internalising problems	
		Poor	Normal	Abnormal	Normal	Poor	Normal	Abnormal	Normal
Non-unemployed	5700 (95.2%)	12.5	87.5	15.7	84.3	10.5	89.5	14.1	85.9
Patterns of social network evolution									
V–V	237 (4.0%)	31.6	68.4	23.6	76.4	39.7	60.3	25.7	74.3
NV–V	340 (5.7%)	22.9	77.1	24.1	75.9	38.8	61.2	20.6	79.4
V–NV	297 (5.0%)	27.9	72.1	22.2	77.8	32.0	68.0	19.5	80.5
NV–NV	5113 (85.4%)	13.4	86.6	14.6	85.4	22.3	77.7	13.2	86.8
Patterns of family structure evolution									
V–V	798 (13.3%)	24.4	75.6	21.1	78.9	32.0	68.0	20.2	79.8
NV–V	347 (5.8%)	22.5	77.5	21.6	78.4	29.4	70.6	21.0	79.0
V–NV	303 (5.1%)	26.4	73.6	19.1	80.9	28.7	71.3	15.5	84.5
NV–NV	4539 (75.8)	15.7	84.3	14.4	85.6	22.4	77.6	12.8	87.2
Patterns of employment evolution									
V–V	107 (1.8%)	22.4	77.6	23.4	76.6	33.6	66.4	18.7	81.3
NV–V	370 (6.2%)	21.9	78.1	21.1	78.9	30.5	69.5	17.8	82.2
V–NV	180 (3.0%)	28.3	71.7	18.9	81.1	30.0	70.0	22.8	77.2
NV–NV	5330 (89%)	17.1	82.9	15.3	75.4	23.6	76.4	13.8	86.2
Number of vulnerabilities[c]									
2–4 vulnerabilities	410 (6.8%)	31.0	69.0	23.7	79.3	33.2	66.8	19.8	80.2
1 vulnerability	1713 (28.6%)	22.3	77.7	18.2	81.8	28.4	71.6	17.5	82.5
0 vulnerabilities	3864 (64.5%)	14.4	85.6	14.1	85.9	21.8	78.2	12.5	87.5
Continuous variables (median)									
Fruit-vegetables (times/day)	2.3	2.0	2.3	2.0	2.3	2.0	2.3	2.0	2.3
Physical activity (h/week)	16.0	14.2	16.0	14.0	16.0	14.2	16.0	15.0	16.0
Total screen time (h/week)	10.5	12.0	10.5	11.5	10.5	12.0	10.5	12.0	10.5

Number of participants and percentages are shown for categorical variables and median for the continuous variables

KINDL KINDL Questionnaire for Measuring Health-Related Quality of Life in Children and Adolescents, *SDQ* Strengths and Difficulties Questionnaire, *V–V* Vulnerable at T0 and T1, *NV–V* Non-vulnerable at T0 and Vulnerable at T1, *NV–NV* Non-vulnerable at T0 and T1

[a] Social network was assessed with the question how many persons they could rely on in case of need: minimal (0–1 person) and strong (>2 persons)

[b] Family structure: If the child did not live with both biological parents, the family was defined as a 'non-traditional family'

[c] A total vulnerability score was calculated by adding up the scores (1 vs 0) of the four indicators (minimal social network, non-traditional family, migrant background, unemployed). Total vulnerability score ranges from 0 (the child has none of the four vulnerability indicators) to four (the child has all four vulnerability indicators)

indicators and well-being and internalising problems after 2-year follow-up. Cross-sectional associations between the four vulnerability indicators and well-being and internalising problems at baseline can be found in the Appendix (Table S3).

After adjusting for lifestyle indicators and the classical SES indicators (full adjustment model 2), those children whose parents had minimal social networks (OR 1.53, 99% CI 1.11–2.11) were more likely to have internalising prob- lems at T1 than those children whose parents had strong social networks. No statistically significant associations were observed for the other groups but associations still pointed to the expected directions.

Table 3 displays the results for the associations between the patterns of vulnerability evolution over time and well- being and internalising problems at T1. In model 2, those children whose parents reported to have a minimal social network just at T1 (OR 1.95, 99% CI 1.40–2.71) or at two time points (OR 1.57, 99% CI 1.06–2.33) as well as chil- dren from non-traditional families just at T1 (OR 1.28, 99% CI 1.00–1.65) were more likely to have a poor well-being than those who were non-vulnerable at two time points. Likewise, there was a higher likelihood of internalising problems in children whose parents reported to have a min- imal social network at two time points (OR 1.97, 99% CI 1.26–3.08) and those children from non-traditional families

Table 2 Longitudinal associations between vulnerability indicators and well-being and internalising problems at follow-up (T1) (reference: normal) for the three models

	Well-being at T1 from KINDL						Internalising problems at T1 from SDQ					
	M1[a]			M2[b]			M1[a]			M2[b]		
	OR	99% CI	*P* value	OR	99% CI	*P* value	OR	99% CI	*P* value	OR	99% CI	*P* value
Social network[c]												
Minimal (534)	1.28	0.97–1.69	0.020	1.26	0.95–1.66	0.035	1.60	1.16–2.20	**<0.001**	1.53	1.11–2.11	**0.001**
Strong (5453)	1.00			1.00			1.00			1.00		
Family structure[d]												
Non-traditional (1101)	1.22	0.99–1.51	0.015	1.17	0.94–1.46	0.062	1.30	1.01–1.67	**0.008**	1.11	0.85–1.45	0.301
Traditional (4886)	1.00			1.00			1.00			1.00		
Migrant status												
Migrant origin (665)	0.92	0.69–1.22	0.443	0.89	0.67–1.18	0.307	0.95	0.67–1.34	0.694	0.87	0.61–1.24	0.314
Native (5322)	1.00			1.00			1.00			1.00		
Employment status												
Unemployed (287)	1.19	0.82–1.74	0.229	1.14	0.78–1.67	0.385	1.56	1.02–2.39	**0.008**	1.35	0.87–2.11	0.074
Non-unemployed (5700)	1.00			1.00			1.00			1.00		

Results from the logistic mixed-effects models: odds ratios (OR), 99% confidence intervals (CI) and *P* values are shown

Statistically significant results shown in bold font

All models include random effects (school/kindergarten, country) to account for the study design

KINDL KINDL Questionnaire for Measuring Health-Related Quality of Life in Children and Adolescents, *SDQ* Strengths and Difficulties Questionnaire

[a] M1 at T1 was adjusted for baseline age, sex and lifestyle indicators: frequency of fruit and vegetable consumption, physical activity, total screen time and *z*-score of BMI (body mass index) by Cole and Lobstein [26], study region (intervention vs control) and well-being and internalising problems at T0 for KINDL and SDQ models, respectively

[b] M2 at T1 was additionally adjusted for baseline classical SES indicators (education, income and occupation except for employment status model)

[c] Social network was assessed with the question how many persons they could rely on in case of need including their family: minimal (0–1 person) and strong (>2 persons)

[d] Family structure: If the child did not live with both his/her parents, the family was defined as a 'non-traditional family'

just at T1 (OR 1.60, 99% CI 1.07–2.39) compared to those who were non-vulnerable at two time points.

Table 4 shows the association between the accumulation of the four social vulnerabilities assessed at baseline and well-being and internalising problems at T0 and T1 (associ- ations between the accumulation of both social vulnerabili- ties and classical SES indicators can be found in Table S4 in the Appendix). A higher number of vulnerabilities was associated with a higher likelihood of having psychosocial problems in T0 and T1, where the OR increased with the number of vulnerabilities.

Children with one vulnerability (OR 1.33, 99% CI 1.07– 1.66) and two to four vulnerabilities (OR 1.42, 99% CI 1.00–2.06) were more likely to have internalising problems at T1. Similarly, children with one vulnerability (OR 1.23, 99% CI 1.03–1.48) and two to four vulnerabilities (OR 1.45, 99% CI 1.06–1.96) were more likely to have poorer well-being at T1.

For all models, raw ORs (model 0, data not shown) showed a higher effect of social vulnerabilities on psychosocial factors than in full adjustment models (model 2). Concerning the roles of covariates, ORs were just slightly attenuated when adding the lifestyle indicators to the models (model 1) and a greater effect was found when adding classical SES (model 2). Nevertheless, the overall results remained unaltered.

Discussion

The impact of low parental education, occupation and income on children's mental health is well established but the effect of other vulnerability indicators (such as children whose parents lack a social network, non-traditional fami- lies, children of migrant origin and children with unem- ployed parents) on psychosocial problems independently of SES and lifestyle indicators has not yet been analysed [26, 50]. We investigated the association between belonging to a vulnerable (vs non-vulnerable) group and psychosocial problems (poor well-being and internalising problems)

Table 3 Longitudinal associations between the changes in vulnerability from T0 (baseline) to T1 (follow-up) and well-being and internalising problems at follow-up (T1) (reference: normal) for the three models

	Well-being at T1 from KINDL						Internalising problems at T1 from SDQ					
	M1[a]			M2[b]			M1[a]			M2[b]		
	OR	99% CI	*P* value	OR	99% CI	*P* value	OR	99% CI	*P* value	OR	99% CI	*P* value
Social network[c]												
V–V (237)	1.61	1.08–2.38	**0.002**	1.57	1.06–2.33	**0.003**	2.05	1.31–3.21	**<0.001**	1.97	1.26–3.08	**<0.001**
NV–V (340)	1.97	1.42–2.72	**<0.001**	1.95	1.40–2.71	**<0.001**	1.47	0.98–2.19	0.013	1.44	0.96–2.15	0.021
V–NV (297)	1.18	0.82–1.71	0.238	1.15	0.80–1.67	0.318	1.36	0.88–2.10	0.064	1.30	0.84–2.01	0.122
NV–NV (5113)	1.00			1.00			1.00			1.00		
Family structure[d]												
V–V (798)	1.34	1.06–1.71	**0.002**	1.28	1.00–1.65	**0.010**	1.40	0.94–1.68	**0.002**	1.24	0.93–1.67	0.056
NV–V (347)	1.20	0.85–1.71	0.180	1.20	0.84–1.71	0.180	1.62	1.08–2.42	**0.002**	1.60	1.07–2.39	**0.003**
V–NV (303)	1.00	0.68–1.47	0.978	0.98	0.67–1.44	0.897	1.25	0.78–2.01	0.221	1.21	0.75–1.94	0.298
NV–NV (4539)	1.00			1.00			1.00			1.00		
Employment status												
V–V (107)	1.50	0.83–2.70	0.075	1.44	0.79–2.61	0.115	1.22	0.60–2.48	0.474	1.01	0.49–2.09	0.964
NV–V (370)	1.25	0.90–1.75	0.082	1.22	0.87–1.70	0.136	1.21	0.81–1.80	0.232	1.09	0.73–1.65	0.573
V–NV (180)	1.07	0.66–1.72	0.731	1.02	0.63–1.65	0.911	1.85	1.10–3.10	**0.002**	1.62	0.95–2.74	0.020
NV–NV (5330)	1.00			1.00			1.00			1.00		

Results from the logistic mixed-effects models: odds ratios (OR), 99% confidence intervals (CI) and p values are shown

Statistically significant results shown in bold font

All models include random effects (school/kindergarten, country) to account for the study design

KINDL KINDL Questionnaire for Measuring Health-Related Quality of Life in Children and Adolescents, *SDQ* Strengths and Difficulties Questionnaire, *V–V* Vulnerable at T0 and T1, *NV–V* Non-vulnerable at T0 and vulnerable at T1, *NV–NV* non-vulnerable at T0 and T1

[a] M1 at T1 was adjusted for baseline age, sex, study region (intervention vs control), well-being and internalising problems at T0 for KINDL and SDQ models, respectively, and lifestyle indicators: frequency of fruit and vegetable consumption, physical activity, total screen time and *z*-score of BMI (body mass index) by Cole and Lobstein [26]

[b] M2 at T1 was additionally adjusted for baseline classical SES indicators (education, income and occupation except for employment status model)

[c] Social network was assessed with the question how many persons they could rely on in case of need including their family: minimal (0–1 person) and strong (>2 persons)

[d] Family structure: If the child did not live with both his/her parents, the family was defined as a 'non-traditional family'

over a 2-year period in children aged 2–9 years old partici- pating in a European study. This research found that chil- dren whose parents had minimal social networks and chil- dren from non-traditional families had a higher likelihood of presenting psychosocial problems cross-sectionally and longitudinally compared to non-vulnerable groups.

The findings of our study are in line with previous research despite some differences. Several studies have explored the relationship between different socioeconomic and cultural factors and psychosocial problems [21, 49, 61]. A systematic review has shown that socioeconomically disadvantaged children were two to three times more likely to develop mental health problems [49].

In our study, migrant status was not significantly associ- ated with a higher risk of having psychosocial problems. This is in accordance with some investigations [42, 53, 58], although other studies found that migrant children fare worse compared to their native peers in relation to mental health [2, 35]. However, studies varied with the informants used and the characteristics of the migrant group and the host country.

Concerning social network, we found a statistically significant association between children whose parents reported to have a minimal social network with a higher risk of having psychosocial problems; which is in agree- ment with previous studies that associated parents' minimal social networks and children's behavioural disturbance [22, 51, 55]. Out of the four types of vulnerability investigated, small parental social network appeared to be the most important factor in predicting children's psychosocial prob- lems; specifically, when parents' social isolation persisted over time. As underlying mechanisms, parents who have a strong social network can act as role models for children in friendship patterns and may facilitate access routes to a

Table 4 Association between the accumulation of vulnerabilities at T0 and well-being and internalising problems at T0 and T1 (reference: normal)*

	Accumulation of vulnerability at T0											
	Well-being at T0 from KIND[a]			Internalising problems at T0 from SDQ[a]			Well-being at T1 from KIND[b]			Internalising problems at T1 from SDQ[b]		
	OR	99% CI	*P* value	OR	99% CI	*P* value	OR	99% CI	*P* value	OR	99% CI	*P* value
Number of vulnerabilities[c]												
2–4 vulnerabilities (410)	1.99	1.44–2.75	**<0.001**	1.51	1.07–2.13	**0.002**	1.45	1.06–1.96	**0.002**	1.42	1.00–2.06	**0.010**
1 vulnerability (1713)	1.40	1.14–1.72	**<0.001**	1.21	0.97–1.49	0.025	1.23	1.03–1.48	**0.003**	1.33	1.07–1.66	**0.001**
Non-vulnerable (3864)	1.00			1.00			1.00			1.00		

Results from the logistic linear mixed model: odds ratios (OR) and 99% confidence intervals (CI) are shown

Statistically significant results shown in bold font

KINDL KINDL Questionnaire for Measuring Health-Related Quality of Life in Children and Adolescents, *SDQ* Strengths and Difficulties Questionnaire

[a] Models at T0 were adjusted for baseline age, sex and lifestyle indicators: frequency of fruit and vegetable consumption, physical activity, total screen time, *z*-score of BMI by Cole and Lobstein [3] and classical SES indicators (education and income)

[b] Models at T1 were additionally adjusted for study region (intervention vs control)

[c] A total vulnerability score was calculated by adding up the scores (1 vs 0) of the four indicators (minimal social network, non-traditional family, migrant background, unemployed). Total vulnerability score ranges from 0 (the child has none of the four vulnerability indicators) to four (the child has all four vulnerability indicators)

wider community [14]. Therefore, children whose parents have strong social networks may learn social skills and expectations from their parents and furthermore allow them to have greater access to beneficial social relationships, i.e. a wider social circle [29]. Nevertheless, the social network reported might be confounded by parental psychosocial problems. After all, smaller social networks, fewer close relationships, and lower perceived adequacy of social sup- port have been linked to depressive symptoms [6] and psy- chosocial problems of the parents might influence psycho- social problems of the child due to the environmental and genetic sharing [37]. Regarding family structure, children from non-traditional families had a higher risk of having psychosocial problems than those children from traditional families. These results confirmed previous investigations that concluded children from traditional families had fewer socio-emotional and higher cognitive scores than those from non-traditional families [17, 56]. Recent research holds that it is predominantly the stability of the traditional family structure that gives it its advantage [59].

Concerning parental unemployment, we did not find a statistically significant association with children's psychosocial problems when controlling for classical SES indicators and lifestyle indicators. This finding partly con- tradicted the conclusions of Powdthavee and Vernoit [46] who found that parental job loss had a positive influence on young children's well-being; however, this association became either strongly negative or statistically insignificant depending on the age of the child and whether it is pater- nal or maternal unemployment [46]. Job loss could cause mental distress on the parent [13], which could have a neg- ative spillover effect on the child since unemployed parents can model despondency and despair as well as inhibit emo- tional warmth and incite erratic or punitive parenting prac- tices [9, 39].

Finally, compared with non-vulnerable groups, those of vulnerable groups adopt more obesogenic attitudes and tended to have lower SES than non-vulnerable groups [33, 34], this in turn is related to lower levels of well-being and internalising problems [27]. In part, this may be a result of the lower availability of resources vulnerable groups can have [60]. Our results showed that healthy lifestyle indi- cators (higher levels of weekly consumption of fruit and vegetables, lower levels of weekly screen time and higher levels of weekly physical activity) and lower SES were statistically significant related to higher well-being and-/ or lower internalising problems. However, when adding the lifestyle indicators to the models that studied the associa- tion between social vulnerabilities and psychosocial problems there was just a slight attenuation. Furthermore, when adjusting additionally for SES the attenuation was higher but the overall results remained unaltered. Consequently, these associations may be just partly explained by classical SES and lifestyle indicators.

Some limitations of this study should be acknowledged. Firstly, the IDEFICS study is not representative neither of the European population nor of the countries participat- ing since each survey centre covered a limited geographi- cal area within a country. Secondly, some groups (from the lowest or the highest SES) could be underestimated as

participation in this study was voluntary and usually these populations are less likely to take part in research. Like- wise, a selection bias cannot be precluded because some participants (with lower well-being score and more inter- nalising problems) did not complete all required informa- tion or did not continue the study at follow-up. A further limitation is the fact that, in order to reduce participants' burden, questionnaires did not include all subscales of the original KINDL and SDQ instruments restricting the interpretation to the studied dimensions. Finally, migrant origin and reasons for migration may differ significantly from one person to another and consequently some groups of migrants could be more vulnerable than others. How- ever, due to the small size of some migrant groups, no group differences were taken into account in the present investigation.

A special strength of the study is that to our knowl- edge, previous research has not investigated the associa- tion between vulnerabilities such as social network, family structure and unemployment status with psychosocial prob- lems in a longitudinal study. A large sample size including children from eight different countries following standard- ised procedures and using validated instruments is also astrength of our study.

Conclusions

The current study suggests associations between social vul- nerabilities and psychosocial problems (poor well-being and internalising problems), independent of family income, parental occupation, parental education and lifestyle indica- tors. Mainly having parents with minimal social networks and the lack of a traditional family structures were disad- vantageous. Interventions during the early years of a child's life may be needed to reduce inequalities and counteract negative effects on children's mental health. Therefore, pol- icy makers should implement measures to strengthen the social support for parents with a minimal social network.

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Author contributions The authors' contributions were as follows: II carried out the statistical analysis and drafted the manuscript along with NMCB designed the statistical analyses. KB, JMF-A, WG, RF, BT, and PR developed the measurement instruments; LR, SDH, MH, LAM, and TV supervised the national data collection authors read and critically reviewed the manuscript.

Compliance with ethical standards

Conflict of interest The authors declare that there are no conflicts of interest.

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Artículo IV [Paper IV]: Social vulnerabilities as determinants of overweight in 2-, 4- and 6-year-old Spanish children.

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ORIGINAL ARTICLE

Social vulnerability as a predictor of physical activity and screen time in European children

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Abstract
Objectives To examine associations between social vulnerabilities and meeting physical activity (PA) and screen time (ST) recommendations during a 2-year follow-up.
Methods 13,891 children aged 2.0 to \ 9.9 from eight European countries were assessed at baseline and 8482 children at follow-up. Children's sports club membership, PA and ST were collected via parental questionnaires. Moderate-to-vigorous physical activity (MVPA) was objectively assessed with accelerometers. Performing at least 1 h of MVPA daily and spending less than 2 h of ST defined physically active and non-sedentary children, respectively. Vulnerable groups were defined at baseline as children whose parents had minimal social networks, from non-traditional families, with migrant origin or with unemployed parents. Logistic mixed-effects analyses were performed adjusting for classical socioeconomic indicators. *Results* Children whose parents had minimal social net- works had a higher risk of non-compliance with PA rec- ommendations (subjectively assessed) at baseline. Migrants and children with unemployed parents had longer ST. All vulnerable groups were less likely to be sports club members.

Claudia Börnhorst and Luis A. Moreno contributed equally and share the last authorship.

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Conclusions Migrants and children with unemployed par- ents are at risk for excessive ST and all vulnerable groups have lower odds of being sports club members.

Keywords Vulnerable groups · Physical activity · Accelerometry · Screen time · Children · IDEFICS study

Abbreviations

PA	Physical activity
MVPA	Moderate to vigorous physical activity IDEFICS Identification and prevention of dietary- and lifestyle-induced health effects in children and infants
ST	Screen time
SES	Socio-economic status
T0	Baseline
T1	Follow-up after the intervention

Introduction

Regular physical activity (PA) during childhood is asso- ciated with improved musculoskeletal and cardiovascular health and lower adiposity (Janssen and Leblanc 2010; Strong et al. 2005). Insufficient PA and excessive screen time (ST) are independently associated with negative health outcomes (Ekelund et al. 2012). Therefore, increasing PA and decreasing sedentary time are public health priorities. Current guidelines for children aged 5–18 recommend at least 1 h of moderate-to-vigorous physical activity (MVPA) per day (World Health Organization 2010) and to limit ST to no more than 2 h a day (American Academy of Pediatrics 2001). Despite these benefits, many children do not meet the recommended level of PA or ST (Konstabel et al. 2014).

Socio-economic status (SES) is an important determi- nant of health in adults but results for children and ado- lescents are less consistent (Drenowatz et al. 2010). Some studies showed that youth from higher SES are more physically active than youth from lower SES (Hanson and Chen 2007) while one study in China reported that high SES was positively associated with insufficient PA (Wang et al. 2016). One reason for these differences may be that associations may vary by domain of PA. The association between SES and sport may be different to that for active transport, both of which contribute to overall PA. Regarding ST results also seem ambiguous (Pate et al. 2011). Similarly, studies vary according to the sedentary measure used. Some studies showed children from high SES groups spent more time on non-screen sedentary behaviours (such as sitting or lying down) and those from low SES spent more time in screen-based sedentary behaviours (e.g. watching TV). However, no significant differences between children from low and high SES backgrounds were found for total sedentary time (sum of non-screen sedentary behaviours and ST) (Klitsie et al. 2013). Using subjective and objective methods, Foley et al. (2011) showed that, children and adolescents in New Zealand from areas of lower deprivation (i.e., higher SES) accumulated more total sedentary time than those from higher deprivation.

Inconsistent findings could be partially due to differen- tial methods used to assess PA levels and sedentary time by e.g. subjective procedures such as questionnaires compared to objectives measures, such as accelerometers (Raudsepp and Viira 2008). Accelerometers are more accurate at assessing total time spent engaging in PA at different intensity levels and recording inactive time (Hagströmer et al. 2010). However, questionnaires are preferable to assess domains of PA (e.g. transport, sport, leisure) and sedentary-related behaviours (Atkin et al. 2012).

The majority of studies to date have focused on the relationship between classical SES indicators (such as income, education and occupation), PA and sedentary behaviours (Tandon et al. 2012) but other indicators of social vulnerability, such as children whose parents lack a social network, children from non-traditional families (the child does not live with both parents), migrant children or children with unemployed parents, are rarely explored in the literature. Social vulnerabilities can be defined as social (e.g. migrant) and economic (e.g. unemployment)

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situations that can increase the susceptibility to harm and that eventually amount to social disconnectedness (Hau- denhuyse et al. 2012). These social vulnerable groups tend to adopt unhealthier behaviours and to be less active compared to non-vulnerable groups (Hawkins et al. 2009; Labree et al. 2014).

We hypothesized that children from vulnerable groups would have lower levels of PA and higher levels of ST compared to non-vulnerable groups due to financial con- straints and negative experiences faced by vulnerable children. Some investigations reported that migrant chil- dren had lower levels of PA compared to native children as a result of the acculturation and a different body image perception (Labree et al. 2014). Non-traditional families could be at risk of being more inactive and of having lower sports participation levels because they might have lower modelling abilities and financial capacity compared to traditional families (Quarmby et al. 2011). Children with unemployed parents reported lower levels of PA and higher levels of ST compared to children with employed parents (Federico et al. 2009). Job loss raises TV-watching and since parents exert an impact on children, this may nega- tively affect children. Finally, we expect that children whose parents lack a social network could have a lower participation in PA and higher ST levels because of less access to resources and personal contact that could encourage activity levels.

To our knowledge no studies have examined a set of social vulnerabilities in the same population. Four vulner- able groups were investigated: children whose parents lack a social network; children from non-traditional families; migrant children and children with either one or both parents unemployed. This paper aims to explore (i) the cross-sectional and prospective associations between being a member (vs. non-member) of a vulnerable group at baseline and PA (reported and objectively assessed with accelerometers), sports club membership and ST, at two time points, in European children and (ii) the association of accumulated vulnerability (belonging to multiple vulnera- ble groups) with PA, sports club membership and ST at baseline. This will allow us to understand whether the disadvantages of socio-economic circumstances in Euro- pean children are associated with unhealthy activity behaviours.

Methods

Design and study population

IDEFICS is a multi-centre prospective cohort study, including a school- and community-based obesity preven- tion intervention in eight European countries (Belgium, Cyprus, Estonia, Germany, Hungary, Italy, Spain and Sweden). At baseline (T0), 16,228 children aged 2.0–9.9 years were examined from September 2007 to June 2008 (response rate 51%). The first follow-up (T1) took place 2 years later (September 2009–June 2010) when 11,038 children aged 4.0–11.9 years were re-examined. In all survey centres, recruitment was carried out at the community level. Parents of children eligible for inclusion were identified and recruited through local kindergartens and schools. The survey comprised anthropometrical measurements, examinations of children and parental self- completion questionnaires on lifestyle habits and dietary intakes of children. Standardised procedures were used by all survey centres. A detailed description is given by Ahrens et al. (2011).

Parents or legal guardians gave written informed con- sent for examinations and data collection for their children, while children expressed oral consent. Ethical approval was obtained from the research ethics authority of each participating centre.

Measurements

Physical activity and screen time assessed with a questionnaire

A parental questionnaire was used to collect a proxy measure of children's subjectively measured PA and ST (Burdette et al. 2004). Parents reported the total hours and minutes children spent playing outdoors during weekends and weekdays and the weekly duration their children spent doing sport in a sports club for a typical week in the pre- vious month. Reported PA was calculated as: [(hours playing outdoors on weekdays * 5) + (hours playing out- doors on weekend days * 2) + weekly sports participation]/7. Thereafter, participants were classified depending on whether they met the current PA guidelines of < 1 h/- day vs. ≥ 1 h/day (World Health Organization 2010). Parents also reported children's sport club membership (dichotomized into belonging or not belonging to a sport club).

Moreover, parents reported hours of TV/DVD/video viewing and computer/games-console use for weekdays and weekend days by their children. Response options were: not at all; < 0.5; < 1; 1 to < 2; 2 to < 3; and ≥ 3 h/day. Total ST per day was calculated as: (5 * weekday values + 2 * weekend values)/7. Partici- pants were divided into two groups depending on whether they met current ST guidelines of B 2 h/day vs. >2 h/day (American Academy of Pediatrics 2001).

Objectively measured MVPA

Children were instructed and asked to wear a uniaxial accelerometer (ActiGraph or ActiTrainer, ActiGraph, Pensacola, FL, USA) on a hip belt for at least 2 days including one weekend day and one-weekday (weekdays were weighted by five and weekend days by two and the sum was divided by seven). An average of 730 min of valid time was obtained in the final sample. To obtain compa- rable data despite differing valid times, adjusted MVPA was calculated by dividing raw minutes of MVPA by wear time and multiplying by 730 (Konstabel et al. 2014). Only children with a minimum duration of 8 h monitoring time per day were considered, where non-wear time was defined as at least 20 min of consecutive zeroes. The sampling epoch was set to 15 s but data were re-integrated into 60 s epochs for analysis. The duration of MVPA was deter- mined according to the cut-offs of Evenson (Evenson et al. 2008).

Classical SES indicators as possible confounder

Education parents indicated the highest level of education of both themselves and their partners. The particular response categories for each country were coded according to the International Standard Classification of Education (UNESCO Institute for Statistics 1997) and re-categorized into: low (ISCED level 0–2), medium (ISCED level 3–4) and high (ISCED level 5–6) educational levels (UNESCO 1997).

Income parents provided information on the monthly net income of the household after taxes and deductions responding to nine country-specific categories (1: lowest income category to 9: highest income category). The cat- egory cut-offs were country-specific according to a scheme based on the median equivalent income, thus guaranteeing comparability between countries. The result was organised into three categories: low (1–3), medium (4–6) and high (7–9) income.

Occupation parents indicated their occupational position with 18 possible options, which were later transformed into the three-class version of the European Socioeconomic Classification (ESeC): working class, intermediate and salaried (Harrison and Rose 2006).

For occupation and education, the highest level of either the mother or the father was considered for the purpose of the study.

Vulnerable groups as predictors

Four vulnerabilities (dichotomised as vulnerable vs. non-vulnerable) were defined as our main exposures using baseline information from parent-reported questionnaires:

Social network based on the Single Item Measure of Social Support developed by Blake and McKay (1986) parents were asked how many persons they could rely on in case of need including their family. A minimal social network (vulnerable group) was assessed if the parental answer on the question was either 'Nobody' or '1 person'. Further answer categories were '2–3 persons' and 'more than 3 persons' and were labelled as non-vulnerable (Bammann et al. 2013). This measure has been strongly associated with a composite social support index (Blake and McKay 1986).

Family structure If the child did not live with both his/ her parents, the family was defined as a 'non-traditional family' (including single-parent families, stepparent fami- lies, living with grandparents or foster parents or in an institution).

Origin of parents A migrant background (vulnerable group) was assumed if one or both parents were born in a country different from where the study took place.

Employment status If at least one of the parents was unemployed or living on social assistance or welfare, the child was considered as belonging to the vulnerable group. A total vulnerability score was calculated by adding up the numbers of vulnerabilities a child was exposed to. Six vulnerability indicators (minimal social network, non-tra- ditional family, migrant, unemployed, low-income and low-education) were considered. Occupation status was not included as it was highly correlated with employment status. The vulnerability score ranged from 0 (the child had no vulnerabilities) to 6 (the child had all six vulnerability indicators) and was divided into four categories (three to six vulnerabilities, two vulnerabilities, one vulnerability and no vulnerability).

Weight categories

Anthropometric measurements were assessed at T0 according to standardised procedures in all participating countries. Barefoot body height was measured to the nearest 0.1 cm by trained staff using a portable stadiometer (SECA 225). Body weight in kg was measured by a child- adapted version of electronic scale TANITA BC 420 SMA with the children weighted in a fasting state and wearing only light clothes. Body mass index (BMI) was calculated by dividing body weight in kilograms by squared body height in metres and then transformed into an age- and gender-specific *z*-score (Cole et al. 1998). Weight groups were categorised using age and gender-specific cut points according to the criteria of the International Obesity Task Force (Cole and Lobstein 2012).

Sample size

Two analysis datasets were defined, one for the subjective and one for the objective measurements. Regarding the subjective measurements, 13,891 children were included for the cross-sectional analysis and 8482 children for the longitudinal analysis after excluding children with missing values in any of the outcomes (see Fig. 1). Children lost to follow-up belonged more often to the minimal social net- work group (12.0% vs. 9.0%), to non-traditional families (25% vs. 18.4%,), migrants (16.5% vs. 12.8%) and unemployed parents (7.0% vs. 4.8%) than those included in the present study.

Concerning objective measurements, 9021 children had at least some valid accelerometer data at T0 but only 5892 children met the following quality requirements (Konstabel et al. 2014): having at least 8 h daily wearing time for at least 2 days (1 weekend day and 1 weekday) using 60 s epoch. After 2 years of follow-up, only 2285 children measured at both T0 and T1 met the accelerometer quality criteria and were included in the longitudinal analysis (see Fig. 2). Children lost to follow-up belonged more often to non-traditional families (21.3% vs. 16.2%) and had more often a migrant background (16.5% vs. 12.8%) than those who were finally included in this study.

Statistical analyses

Logistic mixed-effects models were used to assess the cross-sectional and longitudinal associations between the four exposures (social network, family structure, migrant origin and employment status) and each outcome (meeting

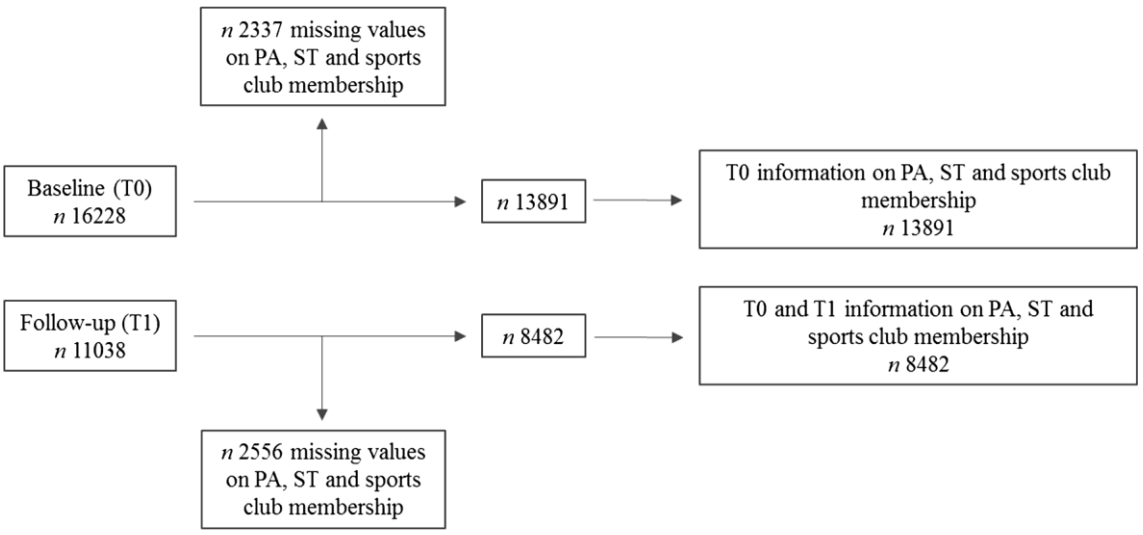

Fig. 1 Selection of the study sample for subjective measurements (parent-reported questionnaire). *T0* baseline, *T1* follow-up, *PA* physical activity, *ST* screen time

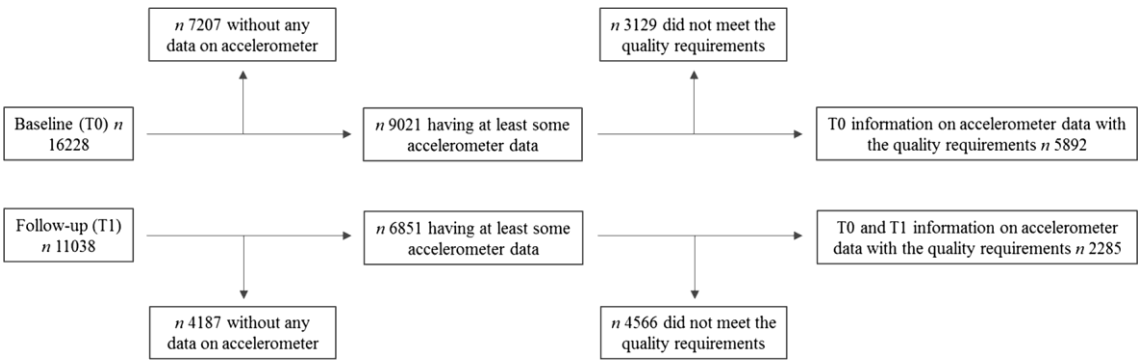

Fig. 2 Selection of the study sample for objective measurement (accelerometer). *T0* baseline, *T1* follow-up

recommendations for objectively and subjectively mea- sured PA and ST, sports club membership). The reference category used was the healthiest behaviour for each out- come (subjective PA ≥ 1 h, ST ≤ 2 h, sports club mem-
bership and objective MVPA ≥ 1 h), respectively. The cross-sectional models were adjusted for baseline age, gender, BMI z-score and classical SES indicators; the objectively measured PA (MVPA) model was additionally adjusted for season. The longitudinal analyses were again adjusted for baseline age, gender, BMI *z*-score and classi- cal SES indicators, but also for region (intervention versus control region) and baseline outcomes. A further analysis was conducted to estimate the accumulation of vulnera- bility at T0 and PA (subjectively and objectively assessed), sports club membership and ST. All models included a random kindergartens/school and a random country effect to account for the clustered study design.

Respondents with missing socioeconomic information may not be a random subset of population-based survey participants and excluding them may bias study results (Kim et al. 2007). Therefore, missing values of socioeco- nomic data were coded as a separate category.

Before model building, correlations among SES indi- cators were checked resulting in the exclusion of occupa- tion status in models with employment status as main exposure to avoid collinearity problems.

The significance level was set at 0.01 to account at least partially for multiple testing. The analyses were performed using the Statistical Package for the Social Sciences (ver- sion 22.0; SPSS, Inc.).

Results

Table 1 summarises the distributions of predictors and background variables for the three parent reported out- comes (reported PA, ST and sports club membership) at T0 and T1 (see Table S1). Older children presented a higher percentage of meeting PA recommendations than younger children (88.6 and 86.1%, respectively), exceed ST rec- ommendations (19.6 and 36.9%, respectively), and being a member of a sports club (27.1 and 58.5%, respectively). By sexes, males had a lower percentage of children report- ing ≥ 1 h of PA (87%) and sports club membership
(43.7%) than females (88 and 45%, respectively). By countries, Germany had the highest percentage of children being member of a sports club (58.3%) and Cyprus the lowest (38.5%).

Table 2 shows the distributions of predictors and back- ground variables for the objectively measured PA (MVPA) at T0 and T1. The percentage of children reporting ≥ 1 h of MVPA was lower than subjectively measured PA.

Children from vulnerable groups and with missing val- ues presented a lower percentage of meeting PA recom- mendations, a higher percentage of exceeding ST recommendations and a lower percentage as members of a sports club than non-vulnerable groups. Regarding T1, results were similar to T0 (see Table 1).

Table 3 and Table S2 present odds ratio (OR), 99% confidence interval (CI) and *p* values for the models assessing the cross-sectional and longitudinal associations between the four vulnerability indicators at T0 and the reported PA, ST and sports club membership at T0 and T1, respectively. Regarding T0, children whose parents had
minimal social networks (OR = 1.30, [99% CI 1.10–1.61]) were more likely not to reach PA recommendations. Migrants (OR = 1.32, [99% CI 1.17–1.48]) and children with unemployed parents (OR = 1.33, [99% CI 1.07–1.66]) were less likely to meet ST recommendation.
Those children whose parents had minimal social networks (OR 1.30, [99% CI 1.10–1.61]), non-traditional families
(OR = 1.15, [99% CI 1.01–1.31]), migrants (OR = 1.49, [99% CI 1.33–1.68]) and children with unemployed parents (OR = 1.34, [99% CI 1.06–1.70]) were less likely to belong to a sports club. After 2-year follow-up, associa- tions remained for non-traditional families and children
with unemployed parents who were less likely to belong to a sports club at T1.

Table 4 shows the models assessing cross-sectional and longitudinal associations between the four vulnerability indicators at T0 and MVPA at T0 and T1, respectively. No associations were found between any of the social vul- nerabilities and MVPA at T0 or T1.

Table S3 and S4 from supplementary material show the association between the accumulation of vulnerabilities and the four outcomes (reported and objectively assessed PA, ST and sports club membership) at T0. A higher number of vulnerabilities were not associated with a higher risk of non-compliance with PA recommendations (sub- jectively and objectively measured) but it was associated with a higher risk of non-compliance with ST recommen- dations, where the OR increased with the number of pre- sent vulnerabilities. Likewise, a greater number of vulnerabilities was associated with a lower likelihood of being a member of a sports club.

To estimate the change produced when including the classical SES indicators (full adjusted models), we added basic adjusted models (adjusted for baseline age, sex and BMI *z*-score) as supplementary material (see Table S5). ORs were greater when excluding classical SES compared to the full adjusted models. However, overall results remained unaltered.

Table 1 Description of the study population at T0, stratified by subjectively measured PA (divided into <1 h of reported PA and ≥ 1 of reported PA), ST (divided into < 2 h of ST and ≥ 2 of ST) and belonging to a sport club (yes or no)

Total	T0						
	N (%)	Reported PA[a]		ST[b]		Sports club[c]	
		<1 h	□ 1 h	> 2 h	≤ 2 h	No	Yes
	13,891 (100%)	%	%	%	%	%	%
Age groups (years)							
2 to \ 6	6270 (45.1)	13.9	86.1	19.6	80.4	72.9	27.1
6 to \ 10	7621 (54.9)	11.4	88.6	36.9	63.1	41.5	58.5
Gender of the child							
Male	7034 (50.6)	13.0	87.0	30.4	69.6	56.3	43.7
Female	6857 (49.4)	12.0	88.0	27.8	72.2	55.0	45.0
Country							
Italy	2062 (14.8)	20.0	80.0	33.1	66.9	59.4	40.6
Estonia	1548 (11.1)	12.7	87.3	44.3	55.7	50.0	50.0
Cyprus	1334 (9.6)	16.3	83.7	33.4	66.6	61.2	38.8
Belgium	1724 (12.4)	23.3	76.7	25.2	74.8	55.5	44.5
Sweden	1680 (12.1)	5.7	94.3	25.7	74.3	48.0	52.0
Germany	1790 (12.9)	9.8	90.2	22.5	77.5	41.7	58.3
Hungary	2377 (17.1)	5.9	94.1	28.6	71.4	72.1	27.9
Spain	1276 (9.9)	7.4	92.6	20.1	79.9	50.4	49.6
BMI categories							
Thinness	1576 (11.3)	13.0	87.0	23.8	76.2	64.5	35.5
Normal	9626 (69.3)	12.2	87.8	27.9	72.1	54.8	45.2
Overweight	1708 (12.3)	13.4	86.6	34.7	65.3	53.6	46.4
Obese	981 (7.1)	13.1	86.9	39.3	60.7	53.6	46.4
Social network[d]							
Missing	170 (1.2)	24.1	75.9	29.4	70.6	57.6	32.4
Minimal	1458 (10.5)	14.6	85.4	32.5	67.5	62.4	37.6
Strong	12,263 (88.3)	12.1	87.6	28.7	71.3	60.0	40.0
Family structure							
Missing	111 (8.0)	19.8	80.2	33.8	66.2	57.7	42.3
Non-traditional	2912 (21.0)	13.2	86.8	33.3	66.7	58.7	40.2
Traditional	10,868 (78.2)	12.3	87.7	27.8	72.2	54.5	45.5
Migrant status							
Missing	84 (0.6)	16.7	83.3	22.6	77.4	61.9	38.1
Migrant origin	1978 (14.2)	12.6	87.4	34.1	65.9	61.5	38.5
Native	11,829 (85.2)	12.5	87.5	28.3	71.4	54.6	45.4
Employment status							
Missing	182 (1.3)	15.9	84.1	36.3	63.7	66.5	33.5
Unemployed	782 (5.6)	13.2	86.8	35.4	64.6	67.0	33.0
Employed	12,927 (93.1)	12.5	87.5	28.6	71.4	54.8	45.2
Parental education							
Missing	96 (0.7)	20.8	79.2	32.3	67.7	66.7	33.3
Low	1112 (8.0)	12.2	87.8	39.7	60.3	70.9	29.1
Medium	6964 (50.1)	11.8	88.2	33.0	67.0	57.0	43.0
High	5719 (41.2)	13.4	86.6	22.1	77.9	50.9	49.1
Income							
Missing	921 (6.6)	17.4	83.3	22.6	77.4	61.9	38.1
Low	4743 (34.1)	12.6	87.4	34.1	65.9	61.5	38.5
Medium	3704 (26.7)	12.5	87.5	28.3	71.4	54.6	45.4
High	4523 (32.6)	11.0	89.0	25.8	74.2	50.0	50.0

Table 1 continued

Total	T0						
	N (%)	Reported PA[a]		ST[b]		Sports club[c]	
	13,891 (100%)	<1 h %	≥ 1 h %	>2 h %	≤ 2 h %	No %	Yes %
Parental occupation							
Missing	485 (3.5)	15.1	84.9	34.8	65.2	67.4	32.6
Working class	4603 (33.1)	12.0	88.0	35.2	64.8	65.3	34.7
Intermediate	4999 (36.0)	13.0	87.0	26.1	73.9	52.2	47.8
Salariat	3804 (27.4)	12.3	87.7	24.9	75.1	47.1	52.9

Study population: children from 8 European countries aged 2.0–9.9 years examined from September 2009–June 2010

T0 baseline, *PA* physical activity, *ST* screen time, *h* hour(s)

[a]Reported PA: sum of hours that children spent playing outdoors (weekdays and weekend days) and weekly participation in sport club activities

[b]Screen time: total number of hours usually spent watching TV, videos or DVD and playing on the computer or games console

[c]Sport club membership

[d]Social network was assessed with the question how many persons they could rely on in case of need including their family: minimal (0–1 person) and strong (> 2 persons)

Discussion

This paper investigated the association between PA (ob- jectively and subjectively assessed), sports club member- ship, ST and social vulnerabilities over a 2-year period in children aged 2.0–9.9 years participating in a large Euro- pean cohort study. Vulnerable children presented a higher risk of showing excessive ST cross-sectionally and tended to be less active at sports clubs cross-sectionally and lon- gitudinally, compared to non-vulnerable groups. Regarding PA, our results did not show a strong association with social vulnerability indicators. Only those children whose parents reported to have minimal social networks were found to be at higher risk of non-compliance with subjec- tively assessed PA recommendations.

Adjusting for classical SES indicators allowed investi- gation of whether the associations between social vulner- abilities and ST/PA were independent of classical SES indicators or whether only the classical SES indicators were finally relevant in the model. We observed that associations may be partly explained by classical SES variables but still independent of classical SES indicators. Therefore, belonging to a vulnerable group seems to be an independent factor of excessive ST and lower participation/activity at sports clubs. A greater effect of the vulnerabil- ities was observed in cross-sectional analyses as opposed to longitudinal analyses. Consequently, current vulnerability (at the time of outcome assessment) seems the most rele- vant one for children's PA and ST.

The findings of our study are in line with previous research (McMillan et al. 2015; Singhammer et al. 2015) despite some differences.

Regarding family structure, no significant associations were found between children from non-traditional families and PA or ST, which is in agreement with some studies (McMillan et al. 2015; Singhammer et al. 2015). However, other studies have reported that children from non-tradi- tional families accumulate more ST and a higher risk of not meeting PA recommendations as a result of differences in role modelling abilities and financial capacity (Bagley et al. 2006; Quarmby et al. 2011).

Concerning migrant status, we found statistical differ- ences between migrant children and exceeding ST recom- mendations at baseline. The acculturation in the host society acquiring Western lifestyle characterized by lower levels of PA and higher levels of sedentary behaviours and different body image perceptions maintained from the country of origin could be the reason of differences found between migrant and native children. However, no asso- ciation was found between migrant children and not meeting PA recommendations. Similar to our study, Puder et al. (2013) showed that migrant children had a signifi- cantly higher amount of ST compared with children born in the country of measurement. Contrary to what we observed, it was showed that PA levels in children were significantly lower among migrant children compared to children in the native population (Labree et al. 2014).

Children whose parents were unemployed were more likely to exceed ST recommendations at baseline compared

Table 2 Description of the study population, stratified by objectively measured PA (MVPA) at T0 and T1

Total	MVPA T0			MVPA T1		
	N (%) 5892 (100%)	<1 h %	≥ 1 h %	N (%) 2285 (100%)	<1 h %	≥ 1 h %
Age groups (years)						
2 to < 6	2471 (41.9)	87.6	12.4	993 (43.5)	75.6	24.4
6 to < 12	3421 (58.1)	77.9	22.1	1292 (56.5)	82.0	18.0
Country						
Italy	855 (14.5)	93.5	6.5	335 (14.7)	92.8	7.2
Estonia	931 (15.8)	81.5	18.5	565 (24.7)	81.2	18.8
Cyprus	402 (6.8)	92.0	8.0	83 (3.6)	94.0	6.0
Belgium	432 (7.3)	86.6	14.4	188 (8.2)	85.6	14.4
Sweden	486 (8.2)	73.5	26.5	61 (2.7)	80.3	19.7
Germany	913 (15.5)	71.7	28.3	177 (7.7)	74.0	26.0
Hungary	720 (12.2)	82.5	17.5	90 (3.9)	86.7	13.3
Spain	1153 (10.6)	80.3	19.7	786 (34.4)	69.2	30.8
BMI categories						
Thinness	597 (10.1)	85.1	14.9	226 (9.9)	75.7	24.3
Normal	4074 (69.1)	79.7	20.3	1603 (70.2)	81.3	18.7
Overweight	779 (13.2)	85.6	14.4	292 (12.8)	78.8	21.2
Obese	442 (7.5)	91.9	8.1	164 (7.2)	92.1	7.9
Social network[a]						
Missing	277 (4.7)	87.4	12.6	61 (2.6)	83.6	16.4
Minimal	640 (10.9)	82.0	18.0	278 (12.2)	81.3	18.7
Strong	4975 (84.4)	81.7	18.3	1946 (86.2)	78.8	21.2
Family structure						
Missing	247 (4.2)	89.1	10.9	50 (2.2)	88.0	12.0
Non-traditional family	1138 (19.3)	82.9	17.1	370 (16.2)	80.3	19.7
Traditional family	4507 (76.5)	81.4	18.6	1865 (81.6)	78.8	21.2
Migrant status						
Missing	126 (2.1)	82.5	17.5	34 (1.5)	82.4	17.6
Migrant origin	792 (13.4)	82.8	17.2	237 (10.4)	84.8	15.2
Native	4974 (84.4)	81.8	18.2	2014 (88.1)	78.6	21.4
Employment status						
Missing	290 (4.9)	88.3	11.7	66 (2.9)	89.4	10.6
Unemployed	338 (5.7)	80.5	19.5	123 (5.4)	79.7	20.3
Employed	5264 (89.3)	81.7	18.3	2096 (91.7)	78.9	21.1
Parental education						
Missing	135 (2.3)	84.4	15.6	35 (1.5)	82.9	17.1
Low	507 (8.6)	82.6	17.4	146 (6.4)	80.8	19.2
Medium	3088 (52.4)	84.4	15.6	1263 (55.3)	80.0	20.0
High	2162 (36.7)	82.4	17.6	841 (36.8)	77.6	22.4
Income						
Missing	588 (10.0)	85.0	15.0	169 (7.4)	85.2	14.8
Low	1823 (30.9)	83.9	16.1	637 (27.9)	84.6	15.4
Medium	1550 (26.3)	79.7	20.3	625 (27.4)	75.0	25.0
High	2162 (36.6)	81.0	19.0	854 (37.4)	77.2	22.8
Parental occupation						
Missing	404 (6.9)	86.1	13.9	85 (3.7)	84.7	15.3
Working class	1881 (31.9)	82.3	17.7	683 (29.9)	81.7	18.3
Intermediate	2056 (34.9)	81.8	18.2	844 (36.9)		22.9

Table 2 continued

Total	MVPA T0			MVPA T1		
	N (%) 5892 (100%)	<1 h %	≥ 1 h %	N (%) 2285 (100%)	<1 h %	≥ 1 h %
Salariat	1551 (26.3)	80.8	19.2	673 (29.5)	78.8	21.2

Study population: children from 8 European countries aged 2.0–9.9 years examined at T0 from September 2007 to June 2008 and re-examined 2 years later (T1) from September 2009 to June 2010 when children aged 4.0–11.9 years

T0 baseline, *T1* follow-up, *MVPA* moderate to vigorous physical activity (objectively measured), *ST* screen time, *h* hour(s)

[a]Social network was assessed with the question how many persons they could rely on in case of need including their family: minimal (0–1 person) and strong (> 2 persons)

Table 3 Cross-sectional and longitudinal associations between social vulnerability indicators and the three reported outcomes (subjectively measured via questionnaires) for the adjusted models

	Outcome at T0[a,b]								
	Reported PA[d]			ST[e]			Sports club member[f]		
	OR	99% CI	*p* value	OR	99% CI	*p* value	OR	99% CI	*p* value
Social network[g]									
Missing	1.62	1.11–2.35	0.012	0.92	0.64–1.31	0.657	1.51	0.94–2.43	0.024
Minimal	1.30	1.10–1.61	0.002	1.05	0.92–1.19	0.436	1.23	1.09–1.47	0.001
Strong	1.00			1.00			1.00		
Family structure									
Missing	1.47	0.77–2.80	0.617	1.11	0.64–1.93	0.617	1.00	0.57–1.74	0.990
Non-traditional	0.97	0.84–1.19	0.952	1.00	0.88–1.13	0.921	1.15	1.01–1.31	0.007
Traditional	1.00			1.00			1.00		
Migrant status									
Missing	0.59	0.26–1.33	0.203	0.42	0.21–1.08	0.018	0.79	0.41–1.51	0.485
Migrant origin	1.00	0.85–1.17	0.971	1.32	1.17–1.48	< 0.001	1.49	1.33–1.68	< 0.001
Native	1.00			1.00			1.00		
Employment status									
Missing	1.12	0.58–2.17	0.663	1.15	0.79–1.86	0.456	1.00	0.60–1.65	0.950
Unemployed	1.23	0.97–1.66	0.076	1.33	1.07–1.66	0.001	1.34	1.06–1.70	0.001
Employed	1.00			1.00			1.00		

Results from the logistic mixed-effects models: odds ratios (OR), 99% confidence intervals (CI) and *p* values are shown. Study population: children from eight European countries aged 2.0–9.9 years examined at T0 from September 2007 to June 2008 and re-examined 2 years later (T1) from September 2009 to June 2010 when children aged 4.0–11.9 years

Bold indicates statistical significance

T0 baseline, *T1* follow-up, *PA* physical activity, *ST* screen time

[a]All models at T0 were adjusted for baseline age, gender, baseline classical SES indicators (education, income and occupation) and z-score of BMI by (Cole and Lobstein 2012)

[b]All models include random effects (school, country) to account for the study design

[c]Models at T1 were additionally adjusted for study region (intervention v. control) and baseline outcomes (reported PA, ST and sport club membership at T0, respectively)

[d]Reported PA: sum of hours that children spent playing outdoors (weekdays and weekend days) and weekly participation in sport club activities. Reference: Reported PA C 1 h

[e]Screen time: total number of hours usually spent watching TV, videos or DVD and playing on the computer or games console. Reference: ST B 2 h

[f]Sport club membership. Reference: yes

[g]Social network was assessed with the question how many persons they could rely on in case of need including their family: minimal (0–1 person) and strong (> 2 persons)

Table 4 Cross-sectional and longitudinal associations between vulnerabilities indicators and MVPA (objectively measured with accelerometers) at baseline and follow up for the adjusted models

	MVPA T0[a,b]			MVPA T1[b,c]		
	OR	99% CI	*p* value	OR	99% CI	*p* value
Social network[d]						
Missing	1.14	0.57–2.27	0.615	0.78	0.31–1.97	0.603
Minimal	0.90	0.66–1.23	0.401	1.30	0.92–1.83	0.133
Strong	1.00			1.00		
Family structure						
Missing	1.44	0.68–3.07	0.210	0.87	0.59–1.71	0.499
Non-traditional family	1.05	0.81–1.36	0.606	0.82	0.53–1.27	0.244
Traditional family	1.00			1.00		
Migrant status						
Missing	0.40	0.09–1.80	0.119	0.70	0.03–1.21	0.783
Migrant origin	1.17	0.86–1.58	0.181	1.60	0.91–2.72	0.033
Native	1.00			1.00		
Employment status						
Missing	1.35	0.62–2.96	0.322	0.76	0.32–2.28	0.156
Unemployed	0.99	0.66–1.49	0.970	1.08	0.56–2.10	0.759
Employed	1.00			1.00		

Results from the logistic mixed-effects models: *p* values, odds ratios (OR) and 99% confidence intervals (CI) are shown

Study population: children from 8 European countries aged 2–9.9 years examined at T0 from September 2007 to June 2008 and re-examined 2 years later (T1) from September 2009 to June 2010 when children aged 4–11.9 years

T0 baseline, *T1* follow-up, *MVPA* moderate-to-vigorous physical activity

[a]Models at T0 were adjusted for baseline age, gender, season, baseline classical SES indicators (education, income and occupation) and z-score of BMI by (Cole and Lobstein 2012)

[b]All models include random effects (school, country) to account for the study design

[c]Models at T1 were additionally adjusted for study region (intervention vs. control) and MVPA at baseline

[d]Social network was assessed with the question how many persons they could rely on in case of need including their family: minimal (0–1 person) and strong (> 2 persons)

to non-unemployed parents. These conclusions were con- firmed by previous papers (Hawkins et al. 2009; van Rossem et al. 2012). Unemployed people are at a higher risk of depression and inactivity compared to employed people. Since parents are important role models for chil- dren this could lead to lower activity levels in children (Van Domelen et al. 2011). Nonetheless, our results did not show any association between children with unemployed parents and being at higher risk of not meeting PA rec- ommendations, like other investigations have demonstrated (Federico et al. 2009).

Children whose parents had minimal social networks had a higher risk of non-compliance with PA recommen- dations (subjectively assessed) at baseline but they did not show a higher risk of exceeding ST recommendations. Not only parents but their networks can influence children's behaviours. Therefore, children whose parents have large social networks could have a positive influence for performing higher levels of PA. To our knowledge, no studies have investigated the associations between parent's social network and children's PA and ST.

In line with previous studies, we found that all vulner- able groups were less likely to participate at sports clubs than children from non-vulnerable groups at baseline and follow-up (McMillan et al. 2016; Toftegaard-Støckel et al. 2010). These associations were rather weak for children from non-traditional families and higher for children with unemployed parents.

Some limitations of the present study should be acknowledged. First, the IDEFICS study is not represen- tative of the European population or of the participating countries. Each survey centre only covered a delimited geographic area within a country making extrapolation of the results difficult and only a sub-sample of the partici- pants wore an accelerometer. Furthermore, a selection bias cannot be precluded as the children lost to follow-up had

more social vulnerabilities at baseline and as voluntary participation might be less frequent from very high or very low SES families. Besides, since self-reported PA usually overestimates total PA compared to accelerometers, sub- jective PA data should be interpreted with caution. It is questionable how reliably the duration of outdoor-play and sports club membership capture total PA and how reliable the dichotomization of meeting the PA guidelines is according to self-reported PA. On the other side, accelerometers may underestimate the overall activity because they cannot accurately capture activities that are not step-based (such as swimming or cycling) (Colley et al. 2011). Therefore, MVPA may be diminished, which may partly explains the current results as associations would be attenuated. Moreover, valid data on accelerometers was considered when children had at least 2 days of recording time (including one weekend day and one-week day) with a minimum 8-h duration of monitoring time per day, which could be insufficient for a correct assessment of whether they meet the PA guidelines. Finally, even though we have controlled for several potential confounders, we cannot preclude unmeasured confounding e.g. through parents' health status, parents' mental health and other socio-cul- tural factors.

A particular strength of this study is that to our knowl- edge, no research has been done concerning the association of vulnerabilities such as social network, family structure and unemployment status with objectively and subjectively assessed PA and ST in children in a longitudinal study. Having two measures of PA (subjectively and objectively assessed) provide different information. For example, sports club participation usually requires regular payments and it has hence other barriers than playing on a play- ground. Accelerometers could register both activities but it could not distinguish these differences. The large sample size of eight countries following standardised procedures is also a strength.

Future studies may investigate children with a different country of origin and family structure in more depth to help identify children at higher risk of low PA and high ST. Moreover, more studies including both subjective and objective measures of PA levels and sedentary behaviours are needed to test different constructs which provide additional information and compare possible discrepancies in results to analyse the causes.

Conclusion

The results suggest a higher risk for excessive ST cross-sectionally in children with unemployed parents and migrants as well as lower odds of being a member in a sports club cross-sectionally and longitudinally in all vul- nerable groups independent of family income, parental occupation and parental education. However, no associa- tions were found between any of the social vulnerabilities and objectively assessed PA. Policy makers should focus on decreasing ST sedentary behaviours among vulnerable groups as well as on offering subsidised access to external exercise, fitness, sports clubs and facilities.

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Authors' contributions The authors' contributions were as follows: II carried out the statistical analysis and drafted the manuscript. CB designed the statistical analyses. KB, JMF-A, NM, LL, and OS, developed the measurement instruments; SDH, RF, LAM, AP, LAR, PR, and TV supervised the national data collection procedures. All authors read and critically reviewed the manuscript.

Compliance with ethical standards

Conflict of interest The authors declare that there are no conflicts of interest regarding this manuscript.

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Artículo V [Paper V]: Prospective associations between social vulnerabilities and children's weight status. Results from the IDEFICS study.

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Prospective associations between social vulnerabilities and children's weight status. Results from the IDEFICS study.

Running title: Social vulnerabilities and children's weight status

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Keywords: social vulnerabilities, obesity, underweight, children, migrants, lack of social support, family structure, socioeconomic status.

Abstract

Background/Objectives: In high-income countries, childhood obesity follows a clear socio-economic gradient with greater prevalence in children with lower socioeconomic status (SES). The extent to which the trend of other social vulnerabilities over time and the accumulation of these vulnerabilities can affect children's weight is still unknown.

Subjects/Methods: In the IDEFICS study, 8,624 children aged 2.0-9.9 years from eight European countries were examined at baseline and after 2-years. Sociodemographic variables, maternal body mass index (BMI) and lifestyle were reported by parents. Children were measured and classified as thin, normal weight and overweight/obese using the extended IOTF criteria. Four vulnerable groups were defined: children whose parents were migrants, children whose parents lack a social network, children from non-traditional families (children not living with both biological parents) and children with unemployed parents. Logistic mixed-effects models were used to study the association between vulnerabilities and children's weight at baseline and follow-up, temporal trend of vulnerabilities and children's weight and accumulation of vulnerabilities and children's weight. Models were adjusted for lifestyle, maternal BMI, parental education and income.

Results: Children whose parents lost their social support at follow-up were more likely to be thin than non-vulnerable children (OR=1.69, 99%CI=1.03-2.78). Children whose parents had a migrant background (OR=1.30, 99%CI 1.04-1.62), children from non-traditional families at both time points (OR=1.40, 99%CI 1.03-1.90) and whose parents were unemployed at baseline and follow-up (OR=2.03, 99%CI 1.03-3.99) were more likely to be overweight/obese compared to non-vulnerable children. Cross-sectionally, we did not find an association between parental lack of network, non-traditional family structure, or employment and children's weight status.

Conclusions: Policy actions are required to tackle inadequate weight loss and gain among vulnerable children (especially those exposed over the long term) since they are at a higher risk of thinness and overweight.

1. Introduction

Childhood obesity is a serious health problem worldwide(1). Overweight and obesity in children often tracks into adulthood, which results in a higher incidence of metabolic syndrome, cardiovascular diseases and several cancers(2). Despite the reported plateau in the prevalence rates of childhood obesity in some developed countries(3) this trend has not been shared by all socioeconomic groups(4). Obesity and its risk factors of unhealthy diet and insufficient physical activity show a clear socioeconomic gradient with an increased prevalence of obesity among children from low socioeconomic status (SES) compared to high SES(5). Consequently, socioeconomic inequalities in overweight and obesity have been widening in the last decade(6).

Apart from the classical low SES groups (low income, educational or occupational level), there are other socially vulnerable groups that have been identified in the literature as at higher risk of adopting unhealthy behaviours and therefore of having poorer health outcomes(7-9). These high risk conditions have not, however, been translated into greater research focus(10). Herein, social vulnerabilities can be defined as social (e.g. migrant) and economic (e.g. unemployment) situations that can increase the susceptibility to harm and that eventually amount to social disconnectedness(11). These social vulnerabilities go beyond the traditional concept of low socioeconomic groups. For example, a low occupational status might imply a financial hardship, but unemployment would also imply the loss of professional social circle or perception of control to change circumstances. Adjusting for parental education and income allow to assess the effect that social vulnerabilities have on weight status independent of classical socioeconomic indicators.

Specific social vulnerabilities (i.e. migrant status, lack of a traditional family structure, minimal social network and unemployment) have already been linked to obesity in children. A systematic review regarding overweight and obesity among children and adolescents from migrant and native origin within Europe found that, in most of the European countries, non-European migrant children were at higher risk for overweight and obesity compared to native children(12). Family structure has also been associated with childhood obesity. In particular children living with single mothers were more likely to have obesity than children living with two parents(13). Results with regard to children with unemployed parents are inconsistent depending on the study and the country analysed. For instance, Bulgarian children with unemployed parents were less likely to have overweight but the reverse was observed in Sweden(14). Finally, having parents with minimal social networks has been found to be an explanatory factor in childhood obesity through parental stress(15).

While it has been stated that social vulnerabilities tends to intensify the exposure to obesity-promoting influences(16) we are not aware of any other prospective studies that have investigated the extent to which the trend of social vulnerabilities over time and the accumulation of these vulnerabilities can affect children's weight.

Moreover, the relationship between social vulnerabilities and underweight status has been rarely explored in high and middle-income countries. While many of the studies have reported an association between low SES and social vulnerabilities and childhood obesity(17), one could argue that social vulnerabilities could be related with higher odds for both thinness and overweight/obesity. After all, social vulnerable groups might be at a higher risk of being malnourished because they could face not only the lack of food provision due to a lower level of income compared to non-vulnerable groups but also

increased stress levels that vulnerable groups undergo as a result of their vulnerability status.

Therefore, this study focuses on comparing socioeconomically vulnerable to non-vulnerable children regarding their weight status. We hypothesized that the above mentioned four vulnerable groups (children whose parents lack a social network, children not living with both biological parents -for simplicity, referred to as non-traditional families-, children of migrant origin and children with either one or both parents unemployed) would be associated with both thinness and overweight/obesity in children, independently of maternal BMI, lifestyle factors and classical SES indicators (parental education and income), and that there is a cumulative effect of the four vulnerabilities increasing the likelihood of children's unhealthy weight status.

More specifically, the present paper aimed to explore (i) the cross-sectional and prospective associations between social vulnerabilities and children's weight status in European children, (ii) the association between trend of vulnerabilities over 2-years and children's weight status at follow-up and (iii) the association of accumulated vulnerability with children's weight status at baseline and follow-up.

2. Materials and methods

Study population

The Identification and Prevention of Dietary-and Lifestyle-induced Health Effects in Children and Infants (IDEFICS) Study is a multi-centre prospective cohort study, including a school- and community-based obesity prevention intervention(18) in eight European countries (Belgium, Cyprus, Estonia, Germany, Hungary, Italy, Spain and Sweden) (see http://www.isrctn.com/ISRCTN62310987 for trial registry information).

For comprehensive information about IDEFICS, a detailed description can be obtained by Ahrens et al.(19). In brief, 16,229 children aged 2.0-9.9 years participated from September 2007 to June 2008 in the baseline survey (T0) and fulfilled the inclusion criteria of the IDEFICS study. The follow-up (T1) took place two years later (September 2009-June 2010) applying the same standardised assessments where 11,041 children aged 4–11 years were re-examined. During the surveys, comprehensive information on lifestyle, medical history and dietary intake was collected supplemented by physical examinations, biomarker collections, fitness tests and accelerometer measurements.

Definition of vulnerable groups

We defined four social vulnerabilities at baseline as our exposures. One of these vulnerabilities (migrant background) is stable over time, while the other three (social network, family structure and employment status) can potentially change over the 2-year study period. Information was obtained from parental questionnaires.

Social network: If the parental answer to 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’, a minimal social network (vulnerable group) was assumed. Further answer categories were ‘2 to 3 persons’ and ‘More than 3 persons’ and were labeled as non-vulnerable(7, 20, 21).

Family structure: When the child was living with both his/her biological parents the family was defined as a ‘traditional family’(22) versus ‘non-traditional family’ that included single-parent families, stepparent families, living with grandparents, other relatives or adults, foster parents or in an institution.

Origin of the parents: A migrant background (vulnerable group) was assumed if one or both parents were born in a country (European or non-European) different from where the study took place.

Employment status: If at least one of the parents was unemployed or living on social assistance or welfare the child was considered as belonging to the vulnerable group(23).

We calculated a total vulnerability score by adding up the numbers of social vulnerabilities a child was exposed to where the abovementioned four vulnerability indicators (minimal social network, non-traditional family, migrant, unemployed) were considered. The vulnerability score ranged from 0 (the child had no vulnerability) to 4 (the child had all four vulnerability indicators) and was divided into three categories (two to four vulnerabilities, one vulnerability and no vulnerability).

Maternal BMI assessed at baseline:

Mothers reported their weight and height and we calculated maternal BMI by dividing mother's body weight in kilograms by mother's body height in metres squared.

Lifestyle assessed at baseline:

Fruit and vegetable consumption was obtained using the food frequency section of the so-called Children's Eating Habits Questionnaire-Food Frequency Questionnaire (CEHQ-FFQ)(24). This FFQ is a self-administered validated screening tool where parents reported usual at-home-consumption frequencies of 42 food items of the previous four weeks. To have a healthy diet indicator we summed the reported weekly intake frequencies of fresh fruits, raw and cooked vegetables.

Physical activity: Parents reported the total weekly hours the children spent playing outdoors and children´s participation in sports club activities in the previous month.

Physical activity per week was calculated with this formula: [(hours playing outdoors on weekdays × 5) + (hours playing outdoors on weekend days × 2) + weekly hours in sports participation].

Screen time: Parents reported the daily screen time spent on audio-visual media (TV, video, DVD, computer, game console) by the children for a typical weekday and weekend day. Total screen time per week was obtained as: (5 × weekday + 2 ×weekend).

Weight categories

Anthropometric measurements were assessed at T0 according to standardised procedures in all participating countries. Barefoot body height was measured to the nearest 0.1 cm by trained staff using a portable stadiometer (SECA 225). Body weight in kg was measured by a child-adapted version of electronic scale TANITA BC-420 SMA with the children weighted in a fasting state and wearing only light clothes(25). BMI was calculated by dividing body weight in kilograms by squared body height in metres and children were classified as 1) thin, 2) normal weight and 3) overweight (including obese children) using the extended IOTF criteria by Cole et al. (2012)(26).

Classical SES indicators

Education: parents were asked to indicate the highest level of education of both themselves and their partners. The response categories for each country were coded according to the International Standard Classification of Education (ISCED 1997) and re-categorised into three categories: low (ISCED level 0-2), medium (ISCED level 3-4) and high (ISCED level 5-6)(27). The highest level of either the mother or the father was taken into account.

Income: parents also provided information on the monthly net income of the household after taxes and deductions responding to nine country-specific categories (1: from the lowest category to 9: the highest category). The category cut-offs were designed to be country-specific according to a fixed scheme based on the median equivalent income, thus guaranteeing comparability between countries(20). The results were organised into three categories: low (1-3), medium (4-6) and high income (7-9).

As respondents with missing socio-economic information may not be a random subset of population-based survey participants, and excluding records with missing income information from analyses may bias study results(28) missing values in socio-economic variables and vulnerability indicators were coded as a separate category.

After excluding children with missing values in lifestyle factors at baseline, the present analysis finally included 8,624 children (50.7% boys) (see also Figure 1).

Parents or legal guardians gave written informed consent for examinations and data collection for their children, while children expressed oral consent. Ethical approval was obtained from the research ethics authority of each participating centre.

Statistical analyses

Multinomial mixed-effects models were used to assess the cross-sectional and prospective associations between the four dichotomised exposures (social network, family structure, migrant origin and employment status) and children's weight status (thin, normal weight and overweight/obese; reference category: normal weight). All models included a random kindergarten/school and a random country effect to account for the clustered study design.

One cross-sectional and three prospective analyses were conducted. In the cross-sectional analysis, for each exposure assessed at T0, a model was estimated to assess the associations with children's weight status at T0. In the first prospective analysis, we related each exposure at T0 with children's weight status at T1. In the second prospective analysis, temporal trend of vulnerability from T0 to T1 (vulnerable at T0 and T1, vulnerable at T0 and non-vulnerable at T1, non-vulnerable at T0 and vulnerable at T1 and non-vulnerable at T0 and T1) was related to children´s weight status at T1. Since migrant status does not change between baseline and follow-up the patterns of vulnerability were assessed for only three of the vulnerable groups considered here. Finally, one more analysis was conducted to estimate the association between the accumulation of vulnerabilities at T0 and children's weight status at T0 and T1.

All models were adjusted for baseline age, sex, maternal BMI and lifestyle factors (frequency of fruit and vegetable consumption, physical activity and total screen time) and classical SES indicators (parental education and income) for each outcome/exposure (Figure 2).

In each country, children were recruited from distinct communities serving as intervention and control regions. Therefore, for prospective analyses, a variable indicating intervention status (yes vs. no) was added and models were additionally adjusted for baseline outcome values (children's weight status at T0).

Before model building, correlations among classical SES indicators were checked ranging from 0.42 (between parental education and income) to 0.04 (between migrant status and education). The largest correlation was found between occupation and income such that parental occupation was not included in the models together with the other SES indicators to avoid collinearity problems.

Furthermore, sensitivity analyses were run to test the contribution of the different covariates (maternal BMI, lifestyle factors, parental education and income) (data not shown) and to assess the associations between social vulnerabilities and children's weight trajectories.

The significance level was set at 0.01 to account at least partially for multiple testing. The analyses were performed using the Statistical Package for the Social Sciences (version 22.0; SPSS, Inc.).

3. Results

Table 1 summarises the distributions of predictors and covariates by children's weight status at T0 and T1. For the continuous covariates, the mean and the standard deviation (SD) is shown. At T1, older children (27.1%) and females (23.5%) had a higher percentage of overweight and obesity than younger children (17.0%) and males (21.5%), respectively. In children whose parents had a high SES (parental education and income) the percentage of overweight was lower and the percentage of underweight higher. Children categorized as vulnerable and with missing on any of the social vulnerabilities studied showed a higher percentage of overweight and obesity compared to those categorized as non-vulnerable. About the number of vulnerabilities accumulated, children with 2-4 vulnerabilities or with missing information on any of the vulnerabilities had a higher percentage of overweight and obesity (30.1%) compared to those with no vulnerabilities (18.7%). The mean maternal BMI and total screen time was higher in the group of children with overweight and obesity compared to thin or normal weight children. Table S1 compares main characteristics of the study participants included in the present analyses (N=8,624) with those in the original sample

of 16,229 children at T0. In the original sample, prevalence of socio-economic variables and vulnerabilities were slightly higher.

Table 2 displays odds ratios (OR), 99% confidence intervals (CI) and p-values for the models assessing the cross-sectional and prospective associations between the four vulnerability indicators and children's weight status at baseline and follow-up, respectively. Children whose parents had a migrant background were more likely to be overweight/obese at T0 compared to non-migrant children (OR 1.30, 99%CI 1.04-1.62). Some other effect estimates pointed to the expected directions, though not reaching statistical significance: Children with unemployed parents at T1 seemed to be at a higher risk of being overweight/obese than children with employed parents (OR 1.45, 99%CI 0.95-2.21) and migrants seemed to be more likely to be thin compared to native children (OR 1.42, 99%CI 0.99-2.03).

Table 3 presents the results for the associations between trend of vulnerabilities over time and children's weight status at T1. Those children from non-traditional families at both time points were more likely to have overweight/obesity at T0 compared to those who were non-vulnerable at two time points (OR 1.40, 99% CI 1.03-1.90). Likewise, there was more than twice the likelihood of presenting overweight/obesity if parents were unemployed at two time points compared to children whose parents were employed at T0 and T1 (OR 2.03, 99% CI 1.03-3.99).

Children whose parents lost their social support at follow-up were more likely to be thin compared to children whose parents did not report to have a lack of social network at baseline and follow-up (OR 1.69, 99%CI 1.03-2.78). Despite the lack of statistical significance, a similar risk pattern of being overweight/obese was found in children who lost their traditional family structure at T1 compared to children of traditional families

(OR 1.45, 99%CI 0.97-2.16) and in children whose parents lack a social network at T0 and T1 (OR 1.31, 99% CI 0.80-2.15).

Table 4 shows the associations between the accumulation of the four social vulnerabilities assessed at baseline and children's weight status at T0 and T1. Although no statistically significant associations were observed, associations pointed to a higher risk of being overweight/obese in children with more vulnerabilities accumulated than children with no vulnerabilities (OR 1.33, 99% CI 0.91-1.94).

Sensitivity analyses

For cross-sectional analysis we calculated associations between social disadvantages and children's weight status using available information for the whole T0 population (N=12,217) irrespective whether the children participated at T1 or not. However, overall results remained unchanged (Table S2).

For all models, unadjusted ORs (Tables S3-S6) showed stronger associations between social vulnerabilities on children's weight status than the fully adjusted model. Concerning the roles of covariates, ORs were attenuated when adding the lifestyle factors, particularly sedentary behaviours (total screen time). The greatest attenuation was found when adding maternal BMI to the models. The adjustment for classical SES (parental education and income) only slightly attenuated the association but overall results remained unaltered.

In additional analyses we checked the associations between social vulnerabilities and weight trajectories of children. We found that children whose parents had a migrant background were more likely to remain overweight/obese after two years compared to non-migrant children (OR 1.29, 99%CI 1.02-1.64). Also, children from non-traditional

families had higher odds of changing their normal weight status to an overweight status two years later (OR 1.45, 99%CI 1.04-2.05). However, as social vulnerabilities turned out to be mainly related to the actual weight status, but not to changes in weight we focused on these results.

4. Discussion

In this European longitudinal study children from non-traditional families at both time points, children whose parents had a migrant background, and children whose parents were unemployed at two time points had a higher risk of having overweight/obesity compared to non-vulnerable groups. Consequently, mainly long-term adversities might affect weight status. Despite a lack of statistical significant result children who accumulate more vulnerabilities tended to show a higher risk of overweight/obesity and a slightly higher risk of underweight. Therefore, children's body weight was surprisingly resistant to an accumulation of multiple adversities, probably different adversities may act in different directions (i.e. lead to thinness or overweight) masking the potential effects of the single vulnerabilities. In general, effect sizes were rather small suggesting the factors leading to overweight are manifold with the vulnerabilities under investigation adding only a minor part. Also, we found that children whose parents lost their social support at follow-up were more likely to be thin compared to children whose parents did not report to have a lack of social network at baseline and follow-up. Our main interest was to investigate whether such vulnerabilities affect weight status independent of the classical SES parameters (parental education and income). The results of this study suggest that the association between social vulnerabilities and children's weight is partially explained by lifestyle factors (physical activity, screen time and fruit and vegetable consumption), maternal

BMI and classical SES indicators (parental education and income). By adding lifestyle factors, we checked whether the association is explained by mediation through lifestyle factors or whether it is actually a direct effect of vulnerabilities (following different pathways) on weight status. As the association attenuates, this indicates that part of the association is mediated through the lifestyle factors. Our findings are largely consistent with the existing evidence for an inverse association of SES and social vulnerabilities with childhood overweight and obesity in high-income countries (29-31).

Social network

Most of the previous studies have generally focused on the role that peers and parental support can have on childhood obesity(32, 33) but just a few have investigated the influence of parental social network on children's weight(15, 20). In our study, we did not find a statistically significant result between children whose parents reported to have a lack of social network at both time points and to have overweight or obesity compared to children whose parents have a strong social network, but results pointed to this expected direction. Gerald et al., observed a positive association between parents with minimal social networks and children's obesity(15); however, in that small study (N=77) the authors did not adjust for lifestyle factors or SES and therefore this result may reflect more the effects of low education and income rather than the lack of social support on childhood obesity. Besides, we found that children whose parents reported a loss of social network between T0 and T1 had higher odds of being thin than children whose parents did not report a minimal social network at baseline and at follow-up. A possible mechanism underlying this relationship might be that parents with minimal social networks experience more psychological distress and thus can give less attention to children's feeding practices(34), which could result in children with an inadequate

weight status (thin or overweight/obese) due to different mediating or susceptibility factors. These findings would be consistent with evidence that stressful exposures could be associated with both overweight and reduced weight gain and risk of being underweight as a consequence of the different impact that the stress of social vulnerabilities has on children(35).

Family structure

Consistent with previous studies we observed a positive relationship between belonging to a non-traditional family at two time points and childhood obesity(36-38). It has been suggested that single-parents are often under more stress which may negatively impact on children weight status and well-being. Using IDEFICS data a previous study demonstrated that a non-traditional family structure was a predictor for psychosomatic and emotional symptoms in children such as low emotional well-being and self-esteem of the child, emotional problems and frequent occurrence of headaches, stomach-aches or sickness over the last 6 months(39). Furthermore, although a non-traditional family structure is not associated with family economic hardship, in another study single-parent families were shown to be 1.8 times more likely to experience economic adversity, which also contributes to higher levels of stress(40). And both, parental stress and children's stress, have been related to child fast-food consumption and childhood obesity(17) which may explain the finding of our study.

Migrant background

Similar to previous studies we found that children whose parents had a migrant background were more likely to present overweight and obesity at baseline than native children. Migrant children seem to display a more sedentary way of life(41), adverse dietary patterns(7) and a shorter sleep duration(12) compared to native children. This

may be an effect of the process of acculturation when immigrants exchange their original attitudes and behaviours for those of the host culture(42) and the adaptation of some parts of the western style of life (e.g. decreased physical activity opportunities and increased availability of high-fat energy-dense foods)(43). Noteworthy, in the present study a migrant background (vulnerable group) was considered if one or both parents were born in a country different from where the study took place (Europeans or non-Europeans). Although having a migrant status could be a vulnerable situation per se, having a non-European background may require greater adaptation to culture, food and lifestyle. Consequently, children with a non-European background might be at a higher risk compared to children with a European background (9). However, due to small sample sizes this was not further distinguished in the present study.

Employment status

Finally, we observed that children whose parents were unemployed at two time points had more than double the likelihood of presenting overweight/obesity than children whose parents were not unemployed at baseline and follow-up. This in line with a previous observation that periods of unemployment may lead to an increased risk of overweight of the concerned children(44). On the other hand, other studies differentiating between paternal and maternal unemployment have shown different results. Some investigations indicated that mother's employment would negatively affect children's diet and weight status because of the decreased time mothers spend on cooking and due to the reduced supervision of meals(45, 46). Other studies have revealed heterogeneity in the associations between parental unemployment and childhood overweight and obesity depending on the country studied(14). Employment status was the strongest predictor of children's overweight and obesity independently of education and income. Having a job goes beyond the concept of earning a salary and

may impact on family and children's daily life and lifestyle, self-esteem, social life, and well-being(47). Unemployment affects social contacts, status and activity, which result in anxiety, distress and depression. Children may feel this leading potentially to worse lifestyle and mental health which may subsequently increase obesity risk(7-9, 48).

Accumulation of vulnerabilities

Contrary to our expectation, children who accumulated more vulnerabilities did not show a higher likelihood of having unhealthy weight status (either overweight/obese or thin). Nonetheless, the results still pointed to the expected direction and ORs increase with increasing numbers of vulnerabilities.

Strengths and limitations

These data and analyses are not without limitations. Firstly, as with all epidemiological studies a selection bias cannot be precluded as there were participants (mainly children whose parents had a lower SES, migrant background, non-traditional families and children with a higher BMI) who refused to participate in the baseline survey, did not respond to all study questions or did not continue to participate in the follow-up(49). As low SES and social vulnerabilities are known to be associated with childhood obesity the associations presented could be underestimated. It should be acknowledged that the associations between social vulnerabilities and overweight/thinness may differ among countries. However, estimation of country-specific effects was out of the scope of the present paper such that only country indicators were used to account for differences among countries.

Another limitation is reliance on self-reported measures (such as maternal weight and height), parental reports of children's diets, sleep and activity patterns, and other aspects

of energy balance that we were not able to measure that could be predisposing under- and over-weight in children).

Likewise, the heterogeneity of some groups of this study should be acknowledged. For example, migrant origin and reasons for migration may differ significantly from one person to another and therefore some groups of migrants could be more vulnerable than others. In the same line of thought, children from non-traditional families included single-parent families, stepparent families and living with other relatives or adults and these situations may provoke diverse responses in children. Notwithstanding, in the present investigation, no group differences could be taken into account due to the small size of some migrant groups, and some situations in the non-traditional families which may have attenuated our results.

The main strengths of this study are the large sample size, that enables even the detection of very small effect sizes, including children from eight different countries at different ages, the prospective design as well as the assessment of outcomes, exposures and various covariates following standardised procedures and using validated instruments. A special strength is that, to our knowledge, no previous research has analysed the association between different vulnerabilities -such as social network, family structure and unemployment status- and children weight in a prospective study including an analysis of the temporal trend of vulnerabilities at two time points and the accumulation of these social vulnerabilities.

Conclusion

Using data from a multicentre cohort of European children, this study found associations between certain social vulnerabilities and children's weight, independently of classical SES parameters (family income, parental education), maternal BMI and

lifestyle factors. Having a migrant background, the lack of a traditional family structure at baseline and follow-up and long-term parental unemployment were associated with childhood overweight/obesity. Thus, mainly vulnerabilities that persist over time might affect weight increase. On the other hand, children whose parents lost their social support at follow-up were found to be at a higher risk of being thin compared to children whose parents had a stronger social network at both times. Social vulnerabilities may affect weight status in two directions – i.e. increase the risk for thinness as well as for overweight. The potentially counteracting effects of different vulnerabilities may be the reason why no accumulation effect was found. Overall, these findings suggest that policy action is required to tackle inadequate weight gain (both underweight and overweight/obesity) among vulnerable children.

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Fig. 1. Final study sample.

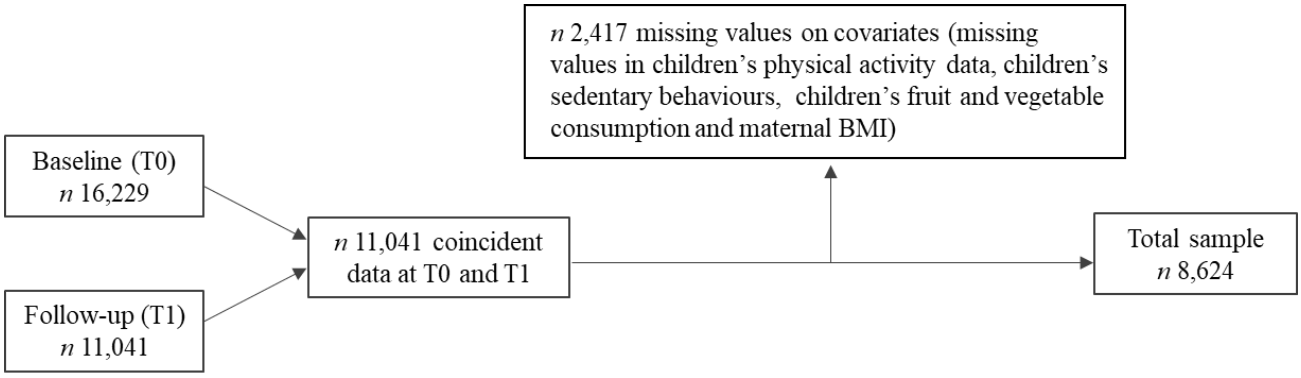

Fig. 2. Overview of the exposure (social vulnerabilities), outcome (children´s weight status) and potential mediators in our manuscript.

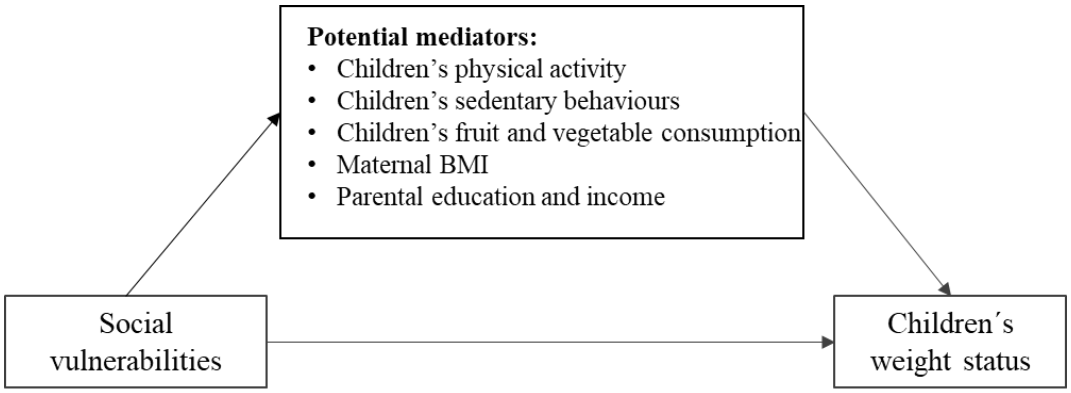

Table 1. Description of the study population, stratified by children's weight (overweight/non-overweight) at baseline (T0) and follow-up (T1). Number of participants and percentages are shown for categorical variables and median for the continuous variables.

Total 8624 (100%)	N (%)						
Categorical variables at baseline		**Children's weight at T0**			**Children's weight at T1**		
Age groups		Thin	Normal	Overweight/ obese	Thin	Normal	Overweight/ obese
2.0-6.0 years	3923 (45.5%)	14.3	73.6	12.1	12.0	71.0	17.0
6.0-9.9 years	4701 (54.5%)	9.3	68.5	22.4	8.7	64.2	27.1
Sex of the child							
Male	4375 (50.7%)	11.4	72.2	16.5	9.8	68.7	21.5
Female	4249 (49.3%)	11.8	69.2	19.0	10.5	65.9	23.5
Country							
Italy	1219 (14.1%)	4.9	52.5	42.6	3.4	45.2	51.4
Estonia	1081 (12.5%)	11.3	75.3	13.4	12.0	72.2	15.8
Cyprus	977 (11.3%)	12.1	66.0	21.9	8.2	62.1	29.7
Belgium	1025 (11.9%)	14.6	78.6	6.7	12.1	78.0	9.9
Sweden	1316 (15.3%)	12.6	77.5	10.1	11.0	77.2	11.8
Germany	907 (10.5%)	11.4	76.2	12.5	11.9	71.8	16.3
Hungary	1052 (12.2%)	18.0	69.4	12.6	18.1	63.6	18.3
Spain	1047 (12.1%)	8.5	72.2	19.3	5.6	70.0	24.4
CLASSICAL SOCIO-ECONOMIC INDICATORS							
Income							
Low	2519 (29.2%)	10.5	63.4	26.1	8.9	59.0	32.1
Medium	2323 (26.9%)	12.1	72.9	14.9	10.4	70.2	19.4
High	2990 (34.7%)	12.2	75.9	12.0	11.8	72.8	15.4
Missing	792 (9.2%)	10.9	68.2	21.0	7.6	64.6	27.8
Education (ISCED)							
Low	431 (5%)	6.7	58.0	35.3	5.1	51.0	43.9
Medium	3572 (41.4%)	10.8	67.9	21.3	9.0	63.7	27.2
High	4518 (52.4%)	12.6	74.4	13.0	11.5	72.0	16.5
Missing	103 (1.2%)	11.7	62.1	26.2	12.6	57.3	30.1
VULNERABILITIES							
Social network[a]							
Minimal	750 (8.7%)	9.3	71.0	19.6	8.9	64.9	26.1
Strong	7506 (87.0%)	11.7	70.8	17.5	10.4	67.7	21.9
Missing	368 (4.3%)	13.0	68.2	18.8	7.6	64.9	27.4
Family structure[b]							
Non-traditional family	1504 (17.4%)	11.3	65.8	22.9	10.4	60.9	28.7
Traditional family	6783 (78.7%)	11.6	72.0	16.3	10.4	69.0	20.6
Missing	337 (3.9%)	11.0	65.9	23.1	5.3	62.6	32.0
Migrant status							
Migrant origin	1156 (13.4%)	11.2	65.4	23.4	10.6	61.0	28.5
Native	7427 (86.2%)	11.6	71.5	16.8	10.1	68.4	21.5
Missing	41 (0.5%)	14.6	69.0	19.5	17.1	58.5	24.4
Employment status							
Unemployed	583 (6.8%)	12.3	64.1	23.6	8.6	59.0	32.4
Non-unemployed	7609 (88.2%)	11.6	71.6	16.8	10.5	68.3	21.2
Missing	432 (5.0%)	11.1	64.0	24.9	7.2	60.7	32.1
Patterns of social network evolution							
V-V	300 (3.5%)	11.3	69.7	19.0	9.0	63.3	27.7
V-NV	387 (4.5%)	8.0	72.0	19.9	8.8	66.4	24.8
NV-V	447 (5.2%)	11.9	64.4	23.8	13.4	58.2	28.9
NV-NV	6577 (76.3%)	11.5	71.0	17.4	10.0	68.0	22.0
Missing	913 (10.6%)	13.1	71.9	15.2	10.8	68.9	20.3
Patterns of family structure evolution							
V-V	1002 (11.6%)	11.7	68.9	19.5	11.0	62.6	26.4
V-NV	380 (4.4%)	10.8	55.8	33.4	9.2	52.9	37.9
NV-V	468 (5.4%)	9.8	67.9	22.2	6.4	62.6	31.0
NV-NV	5930 (68.4)	11.8	72.0	16.2	10.5	69.3	20.3
Missing	844 (9.8%)	11.1	72.2	16.7	9.7	68.6	21.7
Patterns of employment evolution							
V-V	140 (1.6%)	15.0	59.3	25.7	8.6	53.6	37.9
V-NV	226 (2.6%)	11.5	64.6	23.9	8.8	58.8	32.3
NV-V	452 (5.2%)	11.5	69.0	19.5	9.1	66.2	24.8
NV-NV	6510 (75.5%)	11.7	71.1	16.6	10.5	68.3	21.1
Missing	1296 (15.1%)	10.6	68.6	20.8	9.3	65.7	25.1
Number of vulnerabilities[c]							
2-4 vulnerabilities	615 (7.1%)	10.9	65.7	23.4	9.9	60.0	30.1
1 vulnerability	2250 (26.1%)	11.2	67.8	20.9	10.3	63.2	26.5
0 vulnerabilities	5048 (58.5%)	11.7	73.6	14.7	10.4	70.9	18.7
Missing	711 (8.2%)	12.2	64.0	23.8	8.3	61.7	30.0
CONTINUOUS VARIABLES (MEAN, SD)							
Fruit-vegetables [times/week]	18.2 (11.3)	18.3 (11.0)	18.2 (11.0)	18.1 (12.4)	18.0 (11.2)	18.5 (11.0)	17.8 (12.3)
Physical Activity [h/week]	17.7 (10.7)	17.2 (11.2)	17.6 (10.3)	18.2 (11.7)	17.3 (10.4)	17.6 (10.5)	18.0 (11.3)
Total screen time [h/week]	11.5 (6.9)	10.6 (6.7)	11.3 (6.7)	13.0 (7.7)	10.5 (6.5)	11.2 (6.8)	12.9 (7.4)
Maternal BMI	23.8 (4.2)	22.7 (3.6)	23.5 (4.0)	25.5 (4.8)	22.5 (3.6)	23.4 (3.9)	25.6 (4.8)

SD Standard Deviation, *V-V* Vulnerable at T0 and T1, *NV-V* Non-vulnerable at T0 and Vulnerable at T1, *NV-NV* Non-vulnerable at T0 and T1.
[a] Social network was assessed with the question how many persons they could rely on in case of need: minimal (0-1 person) and strong (2 persons).
[b] Family structure: If the child did not live with both biological parents, the family was defined as a 'non-traditional family'.
[c] A total vulnerability score was calculated by adding up the scores (1 vs 0) of the four indicators (minimal social network, non-traditional family, migrant background, unemployed). Total vulnerability score ranges from 0 (the child has none of the four vulnerability indicators) to four (the child has all four vulnerability indicators).

Table 2. Associations between vulnerability indicators at baseline and children's weight status at T0 (baseline) and T1 (follow-up) (reference: normal weight).

Results from the multinomial mixed-effects models: odds ratios (OR), 99% confidence intervals (CI) and p-values are shown*.

	CHILDREN'S WEIGHT STATUS AT T0[a]						CHILDREN'S WEIGHT STATUS AT T1[b]					
	Overweight vs Normal weight			Thin vs Normal weight			Overweight vs Normal weight			Thin vs Normal weight		
	OR	99% CI	P-value	OR	99% CI	P-value	OR	99% CI	P-value	OR	99% CI	P-value
Social network[c]												
Strong	1.00	(reference)		1.00	(reference)		1.00	(reference		1.00	(reference)	
Minimal	0.88	0.67-1.16	0.235	0.78	0.55-1.11	0.068	1.06	0.76-1.47	0.662	1.00	0.65-1.56	0.966
Missing	0.86	0.53-1.40	0.419	1.19	0.69-2.03	0.405	1.14	0.63-2.02	0.575	0.55	0.28-1.42	0.148
Family structure[d]												
Traditional	1.00	(reference)		1.00	(reference)		1.00	(reference)		1.00	(reference)	
Non-traditional	1.13	0.92-1.39	0.134	1.05	0.82-1.36	0.587	1.17	0.90-1.51	0.122	1.13	0.81-1.56	0.350
Missing	1.16	0.72-1.88	0.414	0.88	0.56-1.88	0.913	1.21	0.67-2.19	0.394	0.44	0.17-1.17	0.031
Migrant status												
Native	1.00	(reference)		1.00	(reference)		1.00	(reference)		1.00	(reference)	
Migrant origin	1.30	1.04-1.62	**0.003**	1.13	0.85-1.49	0.277	1.14	0.85-1.52	0.239	1.42	0.99-2.03	0.011
Missing	1.11	0.34-3.66	0.825	1.02	0.27-3.90	0.959	1.66	0.53-5.22	0.250	1.79	0.35-9.10	0.356
Employment status												
Non-unemployed	1.00	(reference)		1.00	(reference)		1.00	(reference)		1.00	(reference)	
Unemployed	1.07	0.76-1.52	0.598	1.25	0.82-1.91	0.167	1.45	0.95-2.21	0.023	0.80	0.45-1.46	0.350
Missing	1.17	0.81-1.70	0.263	1,13	0.70-1.83	0.497	1.14	0.71-1.81	0.476	0.67	0.33-1.37	0.670

* All models include random effects (school/kindergarten, country) to account for the study design.

[a] Models at T0 were adjusted for baseline age, sex and lifestyle indicators: frequency of fruit and vegetable consumption, physical activity, total screen time and maternal BMI (Body Mass Index) and baseline classical SES indicators (parental education and income).

[b] Models at T1 were additionally adjusted for study region (intervention v. control) and children's weight status at T0.

[c] Social network was assessed with the question how many persons they could rely on in case of need including their family: minimal (0-1 person) and strong (>2 persons).

[d] Family structure: If the child did not live with both his/her parents, the family was defined as a 'non-traditional family'.

Table 3. Longitudinal associations between patterns of vulnerability from T0 (baseline) to T1 (follow-up) and children's weight status at follow-up (T1)
(reference: normal weight) for the three models. Results from the multinomial mixed-effects models: odds ratios (OR), 99% confidence intervals (CI) and p-values are shown.

	CHILDREN'S WEIGHT STATUS AT T1[a]					
Vulnerability patterns over time	**Overweight vs Normal weight**			**Thin vs Normal weight**		
	OR	**99% CI**	**P-value**	**OR**	**99% CI**	**P-value**
Social network[b]						
NV-NV	1.00	(reference)		1.00	(reference)	
V-V	1.31	0.80-2.15	0.160	0.92	0.47-1.81	0.755
V-NV	0.82	0.52-1.30	0.275	1.20	0.65-2.19	0.435
NV-V	0.99	0.65-1.53	0.982	1.69	1.03-2.78	**0.006**
Missing	0.85	0.60-1.23	0.260	0.95	0.63-1.42	0.743
Family structure[c]						
NV-NV	1.00	(reference)		1.00	(reference)	
V-V	1.40	1.03-1.90	**0.004**	1.10	0.75-1.60	0.527
V-NV	1.04	0.64-1.57	0.984	1.23	0.65-2.31	0.406
NV-V	1.45	0.97-2.16	0.017	0.58	0.31-1.08	0.026
Missing	0.91	0.63-1.32	0.498	0.90	0.58-1.39	0.534
Employment status						
NV-NV	1.00	(reference)		1.00	(reference)	
V-V	2.03	1.03-3.99	**0.007**	0.76	0.28-2.07	0.479
V-NV	1.31	0.74-2.32	0.220	0.92	0.41-1.97	0.718
NV-V	0.92	0.59-1.42	0.617	0.85	0.49-1.49	0.477
Missing	0.79	0.58-1.07	0.042	0.95	0.65-1.38	0.709

V-V Vulnerable at T0 and T1, *V-NV V*ulnerable at T0 and Non-vulnerable at T1, *NV-V* Non-vulnerable at T0 and Vulnerable at T1, *NV-NV* Non-vulnerable at T0 and T1

Statistically significant results shown in bold font.

All models include random effects (school/ kindergarten, country) to account for the study design.

[a] Models at T1 were adjusted for baseline age, sex and lifestyle indicators: frequency of fruit and vegetable consumption, physical activity, total screen time, maternal BMI, baseline classical SES indicators (parental education and income), study region (intervention v. control) and children's weight status at T0.

[b] Social network was assessed with the question how many persons they could rely on in case of need including their family: minimal (0-1 person) and strong (>2 persons).

[c] Family structure: If the child did not live with both his/her parents, the family was defined as a 'non-traditional family'.

Table 4. Association between the accumulation of vulnerabilities at T0 and children´s weight status at T0 and T1 (reference: normal weight)*. Results from the multinomial mixed-effects models: odds ratios (OR) and 99% confidence intervals (CI) are shown.

	ACCUMULATION OF VULNERABILITY AT T0											
	CHILDREN'S WEIGHT STATUS AT T0[a]						CHILDREN'S WEIGHT STATUS AT T1[b]					
	Overweight vs Normal weig			Thin vs Normal weight			Overweight vs Normal weight			Thin vs No		
Number of vulnerabilities at T0[c]	**OR**	**99% CI**	**P-value**	**OR**	**99% CI**	**P-value**	**OR**	**99% CI**	**P-value**	**OR**	**99% CI**	**P-value**
Non-vulnerable	1.00	(reference)		1.00	(reference)		1.00	(reference)		1.00	(reference)	
2-4 vulnerabilities	1.20	0.88-1.62	0.128	1.08	0.74-1.59	0.601	1.33	0.91-1.94	0.051	1.27	0.78-2.09	0.204
1 vulnerability	1.13	0.94-1.37	0.089	1.07	0.86-1.34	0.415	1.16	0.92-1.47	0.097	1.14	0.86-1.52	0.222
Missing	1.27	0.91-1.78	0.068	1.30	0.87-1.95	0.089	1.07	0.70-1.64	0.672	0.79	0.44-1.42	0.310

[a] Models at T0 were adjusted for baseline age, sex and lifestyle indicators: frequency of fruit and vegetable consumption, physical activity, total screen time, maternal BMI and classical SES indicators (education and income).
[b] Models at T1 were additionally adjusted for study region (intervention v. control) and children's weight status at T0.
[c] A total vulnerability score was calculated by adding up the scores (1 vs 0) of the four indicators (minimal social network, non-traditional family, migrant background, unemployed). Total vulnerability score ranges from 0 (the child has none of the four vulnerability indicators) to four (the child has all four vulnerability indicators).

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Artículo VI [Paper VI]: Associations between socially disadvantaged groups and metabolic syndrome in European children. Results from the IDEFICS study.

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Prospective associations between socioeconomically disadvantaged groups and metabolic syndrome risk in European children. results from the IDEFICS study.

Running title: Disadvantaged groups and metabolic syndrome

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Abstract

OBJECTIVE Socioeconomic disadvantages during childhood are hypothesised to have negative implications for health. We aimed to investigate the association between socioeconomic disadvantages and children's total metabolic syndrome (MetS) score at baseline and follow-up and the extent to which socioeconomic disadvantages over time and the accumulation of these socioeconomic disadvantages can affect children's MetS risk.

METHODS The two-year longitudinal IDEFICS study included 2,401 European children (aged 2.0-9.9) with complete information of the 16,229 participating at baseline. Sociodemographic variables, psychosocial factors and lifestyle were proxy-reported via questionnaires. Socioeconomically disadvantaged groups included children from families with low income, low education, migrant origin, unemployed parents, parents who lacked a social network, and from non-traditional families. MetS risk score was calculated as the sum of z-scores of waist circumference, blood pressure, lipids and insulin resistance. Linear mixed-effects models were used to study the association between social disadvantages and MetS risk. Models were adjusted for sex, age, well-being and lifestyle (fruit and vegetables consumption, physical activity, screen time).

RESULTS At both time points, children from low-income families (0.20 [0.03-0.37]); β estimate and 99% confidence interval), children from non-traditional families (0.14 [0.02-0.26]), children whose parents were unemployed (0.31 [0.05-0.57]) and children who accumulated more than 3 disadvantages (0.21 [0.04-0.37]) showed a higher MetS score compared to non-socioeconomically disadvantaged groups.

CONCLUSION Children from socioeconomically disadvantaged families are at high metabolic risk independently of diet, physical activity, sedentary behaviours and well-being. Interventions focusing on these socioeconomically disadvantaged groups should be developed to tackle health disparities.

Introduction

Cardiovascular diseases are the most common cause of death in adults worldwide[1]. Risk factors for cardiovascular diseases and diabetes include abdominal obesity, hypertension, insulin resistance (IR), elevated triglycerides (TG) and reduced high-density lipoprotein cholesterol (HDL-C) tending to cluster as the metabolic syndrome (MetS)[2]. MetS affects over 24.3% of European adults with a higher occurrence in Southern than in Northern Europe[3]. According to a study conducted in European children aged 2.0-10.9, prevalence of MetS was 5.5%[4]. Although this percentage is lower in children than in adults, increasing rates of childhood obesity and sedentary lifestyle during the last decades could be associated with an increased prevalence of MetS in children and adolescents in the future[5].

Socioeconomic status (SES) is one of the main determinants of MetS in children and adults[6]. SES (often measured by determining education, occupation and income) is inversely associated with obesity and diabetes, both linked to MetS. Children and adults with low SES are more likely to have a poor diet, low levels of physical activity (PA) and high levels of sedentary behaviours and therefore, they show higher rates of obesity and diabetes than children and adults with high SES[7]. Higher SES in childhood has been associated with a lower risk for MetS more than 30 years later in adulthood independently of cardiometabolic risk factors in childhood and participants' SES in adulthood[8]. These results emphasize that obesity and MetS tracks into adulthood[9].

Despite some studies have analyzed the impact of low SES on MetS[6], there are other under-researched disadvantages in early life[10]. Additionally, most studies did not consider relevant information on mental health and lifestyle or focused on adults. Socioeconomic disadvantages are defined here as family and socioeconomic exposures negatively affecting children through behavioral, mental health and biological factors.

Socioeconomic disadvantages in children have been linked with unhealthy lifestyles, higher levels of obesity and a poorer well-being compared to non-socioeconomically disadvantaged groups[11-14].

In this study we used the general term socioeconomically disadvantaged groups, which included two low SES groups (children from families with low income and low education) and four social vulnerable groups (children whose parents were migrants, children whose parents lacked a social network, children from non-traditional families and children with unemployed parents).

Despite a vast literature have investigated the association between parental socioeconomic status and children's lifestyle and obesity very few studies have studied the impact that parental socioeconomic disadvantages can have on children MetS risk. Paediatric MetS is a contentious topic due to the difficultness in finding an accurate and useful definition beyond obesity itself could offered. Prospective studies are needed to understand whether social disadvantages during childhood can have early consequences. Using longitudinal data these results would help to identify children at a higher risk of developing cardiovascular diseases in adulthood.

This prospective study aimed to investigate the association of 1) the six above-mentioned socioeconomic disadvantages and children's total MetS score at baseline and follow-up; 2) socioeconomic disadvantages over time and children's total MetS score at follow-up and 3) accumulation of these socioeconomic disadvantages and children's total MetS score at baseline and follow-up, in a large cohort of European children.

Materials and methods

Study population

The Identification and Prevention of Dietary-and Lifestyle-induced Health Effects in Children and Infants (IDEFICS) study is a multi-centre prospective cohort study, including a school- and community-based obesity prevention intervention[15] in eight European countries (Belgium, Cyprus, Estonia, Germany, Hungary, Italy, Spain and Sweden). For comprehensive information about IDEFICS, a detailed description is given in Ahrens et al.[16]. In the baseline survey (T0), 16,229 children aged 2.0-9.9 participated from September 2007 to June 2008. Follow-up (T1) took place two years later (September 2009-June 2010) applying same standardised assessments where 11,041 children aged 4.0–11.9 were re-examined. Parents or legal guardians gave written informed consent for examinations and data collection for their children, while children expressed oral consent. Ethical approval was obtained from the research ethics authority of each participating centre.

Socioeconomically disadvantaged groups

The following information was obtained from parental questionnaires.

Education: parents indicated their highest level of education. Response categories for each country were coded according to the International Standard Classification of Education (ISCED 1997) and re-categorised into three categories: low (ISCED level 0-2), medium (ISCED level 3-4) and high (ISCED level 5-6)[17]. The highest level of education of either the mother or the father was considered.

Income: parents provided information on household monthly net income responding to nine country-specific categories (from lowest category, 1, to highest category, 9).

Results were organised into three categories: low (1-3), medium (4-6) and high income (7-9).

Social network: a minimal social network was assumed if parental answer to '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'. A strong social network was defined when response was ≥2 persons.

Family structure: children from 'Traditional families' lived with both biological parents and 'non-traditional families' included single-parent families, stepparent families, living with grandparents, other relatives or adults, foster parents or in an institution.

Origin of parents: a migrant background was assumed if one or both parents were born in a country different from where study took place.

Employment status: children with unemployed parents were those with either the mother or the father being unemployed or living on social assistance or welfare.

We calculated a total score by adding up the number of socioeconomic disadvantages a child was exposed to (low education, low income, minimal social network, non-traditional family, migrant, unemployed). Score ranged from 0-6 and was divided into four categories (three to six disadvantages, two disadvantages, one disadvantage and no disadvantages).

Waist circumference

Waist circumference (WC) (cm) was measured in upright position with relaxed abdomen and feet together, midway between the lowest rib margin and the iliac crest to the nearest 0.1 cm with an inelastic tape (Seca 200).

Blood pressure

Blood pressure (mmHg) was measured with an electronic sphygmomanometer (Welch Allyn 4200B-E2, USA). This electronic device has been validated and it records accurately blood pressure[18]. Before taking a blood pressure measurement, children were asked to sit for at least 5 min. Two measurements were taken with 2 min interval in between. When first and second measurements differed by >5% a third measurement was taken. For statistical analyses, the average of the two measurements was used. In case of three measurements, the average of the two measurements with the smallest difference was used.

Blood collection for lipid and glucose homeostasis

Depending on participants' preferences venepuncture or capillary sampling were used to collect fasting blood. A more detailed description about blood sampling procedures can be found in Ahrens et al[4]. Assessment of blood glucose, HDL-C and TG was performed on site at each study center within 5 min of blood withdrawal by placing one drop of blood in the 'point-of-care' analyzer Cholestech LDX (Cholestech, Hayward, CA, USA). Blood samples were analysed using a luminescence immunoassay (AUTO-GA Immulite 2000, Germany) for insulin (µIU/ml). The homeostasis model assessment (HOMA)[19] was used as measure of IR with this formula: HOMA=fasting insulin (µIU/ml)×fasting glucose (mg/ dl)/405.

Metabolic syndrome score

MetS score, developed by Ahrens et al.[4], was calculated as the sum of sex- and age-specific z-scores of WC, HOMA-IR index, mean of z-scores of diastolic and systolic blood pressure (SBP, DBP) and mean of z-score of HDL cholesterol multiplied by -1 and z-score of triglycerides (TG). A higher score suggests a higher metabolic risk.

Covariate information

Child sex, age, country and information on children´s well-being and lifestyle factors was collected using proxy-reported questionnaires during baseline survey.

Children's well-being score

A well-being score was calculated based on questions on emotional well-being, self-esteem, family relations and social contacts[20] adopted from KINDL®[14]. This score ranged from 12–48 with higher values indicating a better well-being[21].

Lifestyle indicators

Fruits and vegetables consumption was obtained using the food frequency section of Children's Eating Habits Questionnaire[22]. This questionnaire is a validated screening tool where parents reported usual at-home consumption frequencies of 42 food items of the previous four weeks. To have a healthy diet indicator we summed reported weekly intake frequencies of fresh fruits, raw and cooked vegetables.

Physical activity: Parents reported weekly hours children spent playing outdoors and participating in sports club activities in the previous month.

Screen time (ST): Parents reported daily ST their children spent on audio-visual media (TV, video, DVD, computer, game console) for a typical weekday and weekend day.

As respondents with missing socio-economic information may not be a random subset of population-based survey participants and excluding records with missing income information from analyses may bias study results[23], missing values in socio-economic variables and vulnerability indicators were coded as a separate category.

After excluding children with missing values in MetS score at baseline or follow-up, well-being score and any lifestyle indicators at baseline, this analysis finally included 2,401 children (52.4% boys) (Supplemental Figure S1).

Statistical analyses

For descriptive purposes, children were divided in two categories: at risk of MetS ($\geq 90^{th}$ percentile of MetS score) versus not at risk ($<90^{th}$ percentile of MetS score).

Linear mixed-effects models were used to assess cross-sectional and prospective associations between the six disadvantaged groups and MetS score. All models included a random kindergarten/school and a random country effect to account for the clustered study design.

One cross-sectional and three prospective analyses were conducted. For each exposure assessed at T0, a model was estimated to evaluate associations with children's MetS score at T0. In prospective analyses, we related 1) each exposure at T0 with children's MetS at T1; 2) socioeconomic disadvantages over time (disadvantaged at T0 and T1, disadvantaged at T0 and non-disadvantaged at T1, non-disadvantaged at T0 and disadvantaged at T1 and non-disadvantaged at T0 and T1) and children´s MetS score at T1 and 3) accumulation of socioeconomic disadvantages at T0 and children's MetS score at T0 and T1. Since migrant status does not change between baseline and follow-up, patterns of socioeconomic disadvantages were investigated for the other disadvantaged groups only.

All models were adjusted for baseline age, sex, children's well-being score and lifestyle factors (frequency of fruit and vegetable consumption, PA and total ST). Social vulnerabilities were also adjusted for parental education and income to assess the effect

independent of classical SES indicators. For prospective analyses, a variable indicating intervention versus control region was added and models were additionally adjusted for baseline outcome values (children's MetS at T0).

Before model building, correlations among socioeconomic disadvantages were checked ranging from r=0.01 to r=0.47. The largest correlation was found between occupation and income (r=0.47) such that parental occupation was not included in the models together with the other socioeconomic disadvantages to avoid collinearity problems.

Significance level was set at $p<0.01$ to account at least partially for multiple testing. Analyses were performed using the Statistical Package for the Social Sciences (version 22.0; SPSS).

3. Results

Table 1 summarises distributions of predictors and covariates stratified by children's MetS risk at T0 and T1. At T1, older children, males, children with socioeconomic disadvantages or with missing information on socioeconomic disadvantages studied (except for parental education) had a higher percentage of MetS risk than their counterparts without socioeconomic disadvantages. Children at risk for MetS had lower fruit and vegetables consumption, lower well-being score and higher ST compared to those not at risk, while mean PA was lower at T1 only.

Table 2 presents β estimates (β), 99% confidence intervals (CI) and p-values for models assessing cross-sectional and prospective associations between six socioeconomically disadvantaged groups and children's MetS score at baseline and follow-up, respectively. At T0, in models with basic adjustment, children from low-income families (β 0.17 [99%CI 0.01-0.31]) and children from families with a low (β 0.28 [99%CI 0.04-0.52])

and medium (β 0.17 [99%CI 0.06-0.28]) parental education showed a significantly higher MetS score compared to the corresponding non-socioeconomically disadvantaged groups. In fully-adjusted models (additionally adjusted for well-being score and lifestyle factors) β estimates were attenuated rendering them statistically insignificant (except for children from families with medium education).

Table 3 displays results for associations between patterns of socioeconomic disadvantages over time and children's MetS score at T1. In fully-adjusted models, children from non-traditional families at both time points (β 0.14 [99%CI 0.02-0.26]) and children with unemployed parents at baseline and follow-up (β 0.31 [99%CI 0.05-0.57]) had a significantly higher MetS score compared to children who were living with both biological parents and compared to children whose parents were employed at T0 and T1, respectively.

Despite the lack of statistical significance, results pointed to the expected direction for all socioeconomic disadvantages, i.e. MetS risk was higher in children showing disadvantaged patterns. A similar high risk of MetS at T1 was found in children with missing information on their family structure or parental social network compared to children of traditional families or strong social network parents.

Table 4 shows associations between accumulation of six socioeconomic disadvantages assessed at baseline and MetS score at T0 and T1. Children with 3 or more socioeconomic disadvantages accumulated had a significantly higher MetS score at T1 (β 0.21 [99%CI 0.04-0.37]) compared to children with less socioeconomic disadvantages. Results at T0 pointed to the same direction though not reaching statistical significance.

Sensitivity analyses

Role of covariates:

Unadjusted models showed stronger associations between socioeconomic disadvantages on children's MetS score than fully adjusted models. Concerning the roles of covariates, β estimates were attenuated when adding lifestyle factors and children's well-being. The greatest attenuation was found when adding ST to the models. Adjustment for classical SES (in models assessing the effect of social vulnerabilities) only slightly attenuated associations.

Individual components of MetS

Results of effects socioeconomic disadvantages can have on individual components of MetS [WC, BP (mean of SBP and DBP), blood lipids (mean of TG and inverse HDL levels) and IR (homeostasis model assessment, HOMA-IR)] can be found in supplementary material (Table S1-S3). Out of the social disadvantages investigated, parental education and employment status revealed the strongest associations with MetS components. Associations were mainly found for HOMA-IR, SBP and WC.

Discussion

This prospective study indicates early childhood socioeconomic disadvantages are associated with a higher metabolic risk in children. Particularly, children from non-traditional families at baseline and follow-up, children whose parents were unemployed at baseline and follow-up and children who accumulated more than 3 socioeconomic disadvantages showed a significantly higher MetS score compared to non-disadvantaged groups. These relations were independent of children's well-being score

and lifestyle factors (fruit and vegetables consumption, PA, ST), although adjustment for lifestyle factors attenuated associations. Children from low-educated and low-income families at baseline also had a higher metabolic risk at T0. However, these results were no longer significant after adjusting for children's well-being score and lifestyle factors. This suggests education and income act as causes-of-causes, i.e. SES seems to impact on well-being and lifestyle which further affects the metabolic risk.

While some studies have investigated the effect that early socioeconomic disadvantages can have on childhood MetS, to our knowledge the effect that the patterns of disadvantages over time and the accumulation of disadvantages can have on MetS risk score and every single component of the metabolic risk have not yet investigated. Our analyses allowed to envisage the consequences that early socioeconomic disadvantages can have in the future. While MetS risk score is higher in children from low-income families, non-traditional families, with unemployed parents and in case of three or more disadvantages, HOMA-IR seemed to be the component most affected by these disadvantages. These results highlight the importance that early interventions could have preventing diabetes type 2 and cardiometabolic diseases on these specific groups.

Possible mechanisms

Some theories have sought to explain the reasons why MetS risk is more common among socioeconomically disadvantaged groups i.e. due to mental health, biological and behavioural factors.

Stress over time has been linked to obesity and MetS[24]. Disadvantaged groups might be more exposed to chronic stress due to, among others, social isolation, financial constraints and lack of social support, which could result in negative parental cognitions, behaviors and a stressful context in children's lives. Stress can produce

short-term adaptive changes in metabolism turning into maladaptive when organism is under long-term stress[25]. Chronic stress increases the activity of hypothalamic-pituitary-adrenal axis and sympathetic nervous system, which activate central pathways that stimulate the release of glucocorticoids (i.e. cortisol) and catecholamines. Excessive and sustained cortisol secretion has been associated with all components of MetS, potentially via an acute inflammatory immune response[26,27].

Another possible explanation on how socioeconomic disadvantages may increase the risk of MetS is its association with unhealthy lifestyle behaviours including overeating, consumption of energy-dense foods, higher sedentary behaviours and lower levels of PA[11-13].

Socioeconomic status: parental education and income

Our results are consistent with previous literature indicating an inverse relationship between SES and MetS in developed and developing countries[28, 29]. Nevertheless, most studies assessing the risk factors of MetS have been conducted in adults[28-30] and only a few in children[31]. In a Canadian study, participants aged 10-18 from households with the highest SES had the lowest prevalence of one or more MetS risk factors[31]. Another study concluded lower SES in childhood could be associated with an increased risk of MetS, impaired fasting glucose and type 2 diabetes in adulthood[8]. According to this 31-year follow-up study, disadvantages in early life have negative future consequences on health. These studies have not considered key variables such as ST and well-being proven to have a potentially mediating role. In our study, associations were attenuated after adjusting for lifestyle indicators and children´s well-being, above all regarding education and income. Children from low-educated and low-income families are more likely to live in more deprived neighborhoods with lower availability of fresh products, more fast-food outlets and few recreational opportunities

resulting in poorer lifestyles and well-being, supporting the role of these variables as causes-of-causes[32].

Social network

A low social network of parents has been found to be negatively related to different obesity-related lifestyles in children[12-14]. Children of parents with low social networks were more likely to show an eating pattern characterized by a high consumption of snacks and fast food, lower levels of PA, higher levels of ST and more psychosocial problems than children whose parents reported to have a stronger social network. Contrary to our expectations, social network was not a relevant predictor of MetS risk but results pointed to the expected direction.

We are not aware of any papers investigating association of parent's social network and children's MetS but in adults, several studies have indicated MetS risk was higher in individuals with a lower social support, irrespective of SES[24].

Family structure

Our results showed children with a non-traditional family structure and those children whose parents did not offer any information regarding this question had a higher MetS score compared to children who were living with both biological parents. Previous investigations indicated children from non-traditional families had more psychosocial problems than children from traditional families[14, 33]. Parents in non-traditional families might have lower levels of organization, less emphasis on active-recreational pursuits and less cohesion than traditional families, which might be disruptive for children and cause higher levels of stress[34]. Moreover, risk factors of MetS such as physical inactivity and obesity seemed to be different in traditional and non-traditional

families. Indeed, children from non-traditional families are less likely to participate in organized sports[35] and have higher levels of overweight/obesity[36].

Migrant background

Some studies have focused on the impact that migrant status or some ethnicities could have on the risk of MetS, showing a higher prevalence of MetS in migrants than in natives[37]. Children with a migrant background may be at a higher risk of MetS as they have low-quality diets, higher levels of ST, more psychosocial problems and higher levels of obesity than native peers[11-14]. Despite previous findings, our results did not suggest an increased risk of MetS in migrant children. Additionally, specific ethnicity including genetic factors might influence perceived stressors and behavior, which was not assessed in this study[11].

Employment status

Children with unemployed parents at baseline and two-years later had a higher risk of MetS than children whose parents were employed at both time points. This was the strongest predictor of a higher MetS in children independently of education and income. Having a job goes beyond the notion of earning a salary affecting family and children's daily life and lifestyle, self-esteem, social life, and well-being[38]. We believe this is the first work investigating the relationship between parental employment status and risk of MetS in children. Nevertheless, consistent with our results, one study in adults found the OR for MetS was two times higher in those unemployed compared to employed subjects[39]. Unemployment entails anxiety, distress, depression and a decrease in activity in adults[38] that might be felt by children and may worsen their lifestyle factors and mental health and subsequently their MetS risk[12-14].

Accumulation of socioeconomic disadvantages

Our findings revealed children who accumulated 3 to 6 socioeconomic disadvantages were at a higher risk of MetS than children with no disadvantages and this effect seemed to be stronger after two years. Several studies have reported a dose-response relationship between number of socioeconomic disadvantages and increased risk for cardiometabolic diseases[40], which is consistent with our result.

Strengths and limitations

We acknowledge this study has limitations. The final sample was limited to available data at baseline and follow-up, which reduced the sample included in these analyses. Moreover, children excluded from the analysis were more likely to belong to socioeconomically disadvantages groups and to be overweight/obese than children included in the analysis. Since a substantial proportion of children did not participate in the study or were excluded from the final analysis a selection bias in this study cannot be precluded and therefore, results should be interpreted with caution. Finally, important information on health determinants such as quantity of salt and sugar intake, alcohol habits, smoking and illicit drugs was not considered in the present study that could affect our results.

Major strengths of this study include: prospective design, large sample of European children of different ages including repeated blood collections; consideration of lifestyle factors and psychosocial well-being of children as mediators; standardized covariate assessment and the use of a continuous MetS risk score based on newly derived reference values. To our knowledge, no other prospective investigation has studied the impact of a set of socioeconomic disadvantages in children on the total MetS risk score.

Conclusion

Early life exposure to socioeconomic disadvantages, particularly, living in low-educated families, having a non-traditional family structure and parental unemployment, are associated with higher MetS risk during childhood. Lifestyle factors and children's well-being are significant mediators attenuating the association between socioeconomic disadvantages and metabolic risk. Despite the independent effect of socioeconomic disadvantages on MetS, socioeconomic disadvantages can be seen as causes-of-causes because they seem to influence children's well-being and lifestyle, which further affect metabolic risk. These results highlight the importance of focusing on children of socioeconomically disadvantaged groups in order to decrease prevalence of MetS and health inequalities in adulthood.

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Table 1. Description of the study population, stratified by children's metabolic syndrome risk score (Mets) (at risk/not at risk) at baseline (T0) and follow-up (T1). Number of participants and percentages are shown for categorical variables and mean for the continuous variables.

		MetS risk score at T0		MetS risk score at T1	
Total 2401 (100%)					
Categorical variables at baseline					
Age groups		At risk	Not at risk	At risk	Not at risk
2.0-6.0 years	853 (35.5%)	9.8	90.2	9.3	90.7
6.0-9.9 years	1548 (64.5%)	10.1	89.9	10.7	89.3
Sex of the child					
Male	1257 (52.4%)	10.3	89.7	10.7	89.3
Female	1144 (47.6%)	9.7	90.3	9.5	90.5
Country					
Italy	343 (14.3%)	22.4	77.6	23.9	76.1
Estonia	304 (12.7%)	9.9	90.1	6.2	93.8
Belgium	99 (4.1%)	6.1	93.9	5.1	94.9
Sweden	416 (17.3%)	2.6	97.4	3.4	96.6
Germany	201 (8.4%)	3.5	96.5	2.0	98.0
Hungary	552 (23%)	12.7	87.3	14.3	85.7
Spain	486 (20.2%)	8.0	92.0	8.4	91.6
SOCIOECONOMIC DISADVANTAGES					
Parental income					
Low	634 (26.4%)	17.0	83.0	17.4	82.6
Medium	696 (29.0%)	8.2	91.8	8.6	91.4
High	974 (40.6%)	6.9	93.1	6.3	93.7
Missing	97 (4.0%)	8.2	91.8	13.4	86.6
Parental education (ISCED)					
Low	134 (5.6%)	22.4	77.6	22.4	77.6
Medium	1037(43.2%)	12.5	87.5	13.3	86.7
High	1227 (51.1%)	6.5	93.5	6.2	93.8
Missing	3 (0.1%)	0.0	100.0	0.0	100.0
Social network[a]					
Minimal	257 (10.7%)	10.9	89.1	13.2	86.8
Strong	2130 (88.7%)	9.9	90.1	9.8	90.2
Missing	14 (0.6%)	14.3	85.7	14.3	85.7
Family structure[b]					
Non-traditional family	414 (17.2%)	11.4	88.6	13.3	86.7
Traditional family	1973 (82.2%)	9.8	90.2	9.5	90.5
Missing	14 (0.6%)	0.0	100.0	14.3	85.7
Migrant status					
Migrant origin	235 (9.8%)	8.9	91.1	10.6	84.4
Native	2160 (90.0%)	10.1	89.9	10.1	89.9
Missing	6 (0.2%)	0.0	100.0	16.7	83.3
Employment status					
Unemployed	130 (5.4%)	12.3	87.7	13.8	86.2
Non-unemployed	2228 (92.8%)	9.6	90.4	9.8	90.2
Missing	43 (1.8%)	20.9	79.1	16.3	83.7
Patterns of parental income					
D-D	384 (16.0%)	16.7	83.3	17.2	82.8
D-ND	158 (6.6%)	14.6	85.4	11.4	88.6
ND-D	116 (4.8%)	15.5	84.5	12.1	87.9
ND-ND	1388 (57.8%)	6.8	93.2	6.8	93.2
Missing	355 (14.8%)	11.5	88.5	14.6	85.4
Patterns of parental education					
D-D	111 (4.6%)	20.7	79.3	19.8	80.2
D-ND	35 (4.5%)	25.7	74.3	28.6	71.4
ND-ND	2094 (87.2%)	9.0	91.0	9.1	90.9
Missing	161 (6.7%)	11.8	88.2	13.7	86.3
Patterns of social network					
D-D	106 (4.4%)	8.5	91.5	11.3	88.7
D-ND	131 (5.5%)	12.2	87.8	14.5	85.5
ND-D	131 (5.5%)	10.7	89.3	9.9	90.1
ND-ND	1858 (77.4%)	9.8	90.2	9.5	90.5
Missing	175 (7.3%)	10.9	89.1	13.1	86.9
Patterns of family structure					
D-D	266 (11.1%)	10.2	89.8	13.5	86.5
D-ND	107 (4.5%)	12.1	87.9	12.1	87.9
ND-D	102 (4.2%)	15.7	81.4	18.6	81.4
ND-ND	1757 (73.2%)	9.4	90.6	8.8	91.2
Missing	169 (7.0%)	10.7	89.3	13.0	87.0

Patterns of employment					
D-D	47 (2%)	14.9	85.1	17.0	83.0
D-ND	65 (2.7%)	10.8	89.2	10.8	89.2
ND-D	156 (6.5%)	14.7	85.3	12.2	87.8
ND-ND	1885 (78.5%)	8.8	91.2	9.2	90.8
Missing	248 (10.3%)	14.9	85.1	14.9	85.1
Number of socioeconomic disadvantages[c]					
3-6 disadvantages	138 (5.7%)	18.1	81.9	21.7	79.3
2 disadvantages	273 (11.4%)	12.5	87.5	11.4	88.6
1 disadvantage	571 (23.8%)	12.6	87.4	11.6	88.4
0 disadvantages	1172 (48.8%)	6.9	93.1	6.7	93.3
Missing	247 (10.3%)	11.3	88.7	15.8	84.2
CONTINUOUS VARIABLES (MEAN, SD)					
Fruit-vegetables [times/week]	18.0 (10.8)	17.3 (10.7)	18.1 (12.4)	17.2 (11.4)	18.1 (10.8)
Physical Activity [h/week]	18.5 (10.2)	18.5 (11.3)	18.5 (10.0)	19.4 (12.6)	18.4 (9.9)
Total screen time [h/week]	11.6 (6.9)	13.1 (8.6)	11.4 (6.7)	13.5 (8.4)	11.4 (6.7)
Well-being score[d]	40.1 (4.4)	39.4 (4.6)	40.2 (4.4)	39.2 (4.6)	40.2 (4.5)

SD Standard Deviation, *D-D* Disadvantaged at T0 and T1, *ND-D* Non-Disadvantaged at T0 and Disadvantaged at T1, *ND-ND* Non-Disadvantaged at T0 and T1.

[a] Social network was assessed with the question how many persons they could rely on in case of need: minimal (0-1 person) and strong (2 persons).

[b] Family structure: If the child did not live with both biological parents, the family was defined as a 'non-traditional family'.

[c] A total score was calculated by adding up the scores (1 vs 0) of the six disadvantages (low education, low income, minimal social network, non-traditional family, migrant background, unemployed). Total score ranges from 0 (the child has none of the six disadvantages) to six (the child has all six disadvantages).

[d] The range of the well-being score was 12–48, the higher values indicating better well-being.

Table 2. Associations between socioeconomic disadvantages at baseline and children's metabolic syndrome risk score (MetS) at T0 (baseline) and T1 (follow-up). Results from linear mixed-effects models: β estimates, 99% confidence intervals (CI) and p-values are shown.

	METS RISK SCORE AT T0						METS RISK SCORE AT T1					
	Basic Adjustment[a]			Full Adjustment[b]			Basic Adjustment[c]			Full Adjustment[d]		
	β	**99% CI**	**p-value**	**β**	**99% CI**	**p-value**	**β**	**99% CI**	**p-value**	**β**	**99% CI**	**p-value**
Parental education												
High (Reference)	0.00			0.00			0.00			0.00		
Low	0.28	0.04-0.52	**0.002**	0.24	-0.03-0.48	0.011	0.15	-0.02-0.32	0.021	0.13	-0.04-0.30	0.050
Medium	0.17	0.06-0.28	**0.000**	0.15	0.04-0.26	**0.000**	0.07	-0.09-0.15	0.022	0.06	-0.02-0.14	0.059
Missing	-0.08	-1.54-1.37	0.878	-0.19	-1.66-1.28	0.734	-0.48	-1.53-0.57	0.237	-0.55	-1.61-0.51	0.179
Parental income												
High (Reference)	0.00			0.00			0.00			0.00		
Low	0.17	0.01-0.31	**0.004**	0.14	-0.01-0.29	0.017	0.06	-0.04-0.16	0.166	0.05	-0.03-0.48	0.251
Medium	0.09	-0.03-0.21	0.072	0.07	-0.05-0.20	0.142	0.01	-0.07-0.10	0.706	0.01	0.04-0.26	0.827
Missing	0.05	-0.26-0.27	0.958	-0.04	-0.30-0.21	0.917	-0.01	-0.20-0.17	0.805	-0.02	-0.21-0.17	0.741
Social network[e,f]												
Strong (Reference)	0.00						0.00			0.00		
Minimal	-0.03	-0.25-0.20	0.724	-0.12	-0.29-0.04	0.057	0.07	-0.06-0.18	0.131	0.07	-0.04-0.19	0.129
Missing	0.37	-0.02-0.76	0.015	0.12	-0.54-0.79	0.630	-0.05	-0.53-0.43	0.781	0.03	-0.51-0.43	0.816
Family structure[e,g]												
Traditional (Reference)	0.00						0.00					
Non-traditional	-0.05	-0.18-0.09	0.365	-0.05	-0.19-.0.08	0.315	0.10	-0.00-0.20	0.010	0.10	-0.00-.0.20	0.013
Missing	-0.15	-0.81-0.50	0.539	-0.16	-0.82-0.49	0.518	0.23	-0.23-0.70	0.196	0.23	-0.23-0.70	0.202
Migrant status[e]												
Native (Reference)	0.00						0.00			0.00		
Migrant origin	0.02	-0.15-0.19	0.779	0.01	-0.17-0.18	0.969	0.00	-0.14-0.14	0.670	-0.02	-0.15-0.10	0.583
Missing	0.24	-0.76-1.24	0.534	0.27	-0.73-1.27	0.483	0.34	-0.38-1.05	0.226	0.36	-0.35-1.08	0.190
Employment status[e]												
Employed (Reference)	0.00			0.00			0.00			0.00		
Unemployed	-0.03	-0.25-0.20	0.724	-0.03	-0.26-0.20	0.705	0.12	-0.04-0.28	0.063	0.12	0.06-1.95	0.051
Missing	0.37	-0.02-0.76	0.015	0.35	-0.03-0.74	0.020	0.06	-0.21-0.34	0.566	0.06	-0.22-0.34	0.590

Statistically significant results considering 99% CI are shown in bold font.
All models include random effects (school/kindergarten, country) to account for the study design.
[a] Basic models at T0 were adjusted for baseline age and sex.
[b] Full models at T0 were additionally adjusted for well-being score and lifestyle indicators (frequency of fruit and vegetable consumption, physical activity, total screen time) at baseline.
[c] Basic models at T1 were adjusted for baseline age, sex, study region (intervention v. control) and children's metabolic risk syndrome score at T0.
[d] Full models at T1 were additionally adjusted for well-being score and lifestyle indicators: frequency of fruit and vegetable consumption, physical activity, total screen time and well-being score at baseline.
[e] Additionally adjusted for classical SES indicators (parental education and income) in basic and full models at T0 and T1.
[f] Social network was assessed with the question how many persons they could rely on in case of need including their family: minimal (0-1 person) and strong (>2 persons).
[g] Family structure: If the child did not live with both his/her parents, the family was defined as a 'non-traditional family'.

Table 3. Longitudinal associations between patterns of socioeconomic disadvantages from T0 (baseline) to T1 (follow-up) and children's metabolic syndrome (MetS) risk score at T1. Results from linear mixed-effects models: β estimates, 99% confidence intervals (CI) and p-values are shown.

SOCIOECONOMIC DISADVANTAGES OVER TIME	METS RISK SCORE AT T1[a]		
Parental income	**β**	**99% CI**	**p-value**
ND-ND (Reference)	0.00		
D-D	0.06	-0.07-0.18	0.248
D-ND	-0.07	-0.22-0.08	0.252
ND-D	0.11	-0.06-0.28	0.112
Missing	0.05	-0.06-0.16	0.271
Parental education			
ND-ND (Reference)	0.00		
D-D	0.07	-0.11-0.25	0.342
D-ND	0.28	-0.02-0.58	0.016
Missing	0.05	-0.09-0.20	0.366
Social network[b,c]			
ND-ND (Reference)	0.00		
D-D	0.10	-0.08-0.28	0.152
D-ND	0.05	-0.10-0.21	0.395
ND-D	-0.01	-0.17-0.15	0.851
Missing	0.10	-0.04-0.25	0.071
Family structure[b,d]			
ND-ND (Reference)	0.00		
D-D	0.14	0.02-0.26	**0.002**
D-ND	0.05	-0.13-0.22	0.510
ND-D	0.08	-0.10-0.26	0.252
Missing	0.12	-0.03-0.27	0.035
Employment status[b]			
ND-ND (Reference)	0.00		
D-D	0.31	0.05-0.57	**0.002**
D-ND	0.01	-0.21-0.23	0.916
ND-D	0.02	-0.12-0.17	0.692
Missing	0.05	-0.07-0.17	0.308

D-D Disadvantaged at T0 and T1, *D-ND* Disadvantaged at T0 and Non-Disadvantaged at T1, *ND-D* Non-Disadvantaged at T0 and Disadvantaged at T1, *ND-ND* Non-Disadvantaged at T0 and T1.
Statistically significant results considering 99% CI are shown in bold font.
All models include random effects (school/kindergarten and country) to account for the study design.
[a] Models were adjusted for baseline age, sex, study region (intervention v. control), children's metabolic risk syndrome at baseline, well-being score and lifestyle indicators at baseline: frequency of fruit and vegetable consumption, physical activity and total screen time.
[b] Additionally adjusted for classical SES indicators (parental education and income).
[c] Social network was assessed with the question how many persons they could rely on in case of need including their family: minimal (0-1 person) and strong (>2 persons).
[d] Family structure: If the child did not live with both his/her parents, the family was defined as a 'non-traditional family'.

Table 4. Association between the accumulation of socioeconomic disadvantages at T0 and children´s metabolic syndrome (MetS) risk score at T0 and T1. Results from the linear mixed-effects models: β estimates, 99% confidence intervals (CI) and p-values are shown.

ACCUMULATION OF SOCIOECONOMIC DISADVANTAGES AT T0	METS RISK SCORE AT T0[a]			METS RISK SCORE AT T1[b]		
	β	**99% CI**	**p-value**	**β**	**99% CI**	**p-value**
Number of socioeconomic disadvantages at T0[c]						
0 disadvantages (Reference)	0.00			0.00		
3-6 disadvantages	0.18	-0.05-0.41	0.052	0.21	0.04-0.37	**0.001**
2 disadvantages	-0.10	-0.28-0.07	0.128	0.02	-0.10-0.15	0.668
1 disadvantage	0.01	-0.11-0.14	0.770	0.03	-0.05-0.12	0.358
Missing	0.05	-0.12-0.22	0.474	0.08	-0.04-0.21	0.091

All models include random effects (school/kindergarten and country) to account for the study design.
Statistically significant results considering 99% CI are shown in bold font.
[a] Models at T0 were adjusted for baseline age, sex, well-being score and lifestyle indicators: frequency of fruit and vegetable consumption, physical activity, total screen time and well-being score at baseline.
[b] Models at T1 were additionally adjusted for study region (intervention v. control) and children's metabolic risk syndrome at T0.
[c] A total score was calculated by adding up the scores (1 vs 0) of the six disadvantages (low education, low income, minimal social network, non-traditional family, migrant background, unemployed). Total score ranges from 0 (the child has none of the six disadvantages) to six (the child has all six disadvantages).

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5. Discusión

Las desventajas socioeconómicas generan elevados niveles de estrés en los padres, por motivos tan diversos como el desempleo, el aislamiento social, dificultades económicas o la falta de integración en la sociedad, entre otros. El estrés de los padres es experimentado por los menores de manera que, a través de los roles parenterales, podría provocar respuestas desadaptativas en los niños[101]. El estrés crónico altera principalmente a las hormonas cortisol, adrenalina y glucagón, perjudicando al sistema inmunitario, endocrinológico y vascular, entre otros. Estas hormonas, con efecto catabólico, aumentarían la tensión arterial, los niveles de glucosa en sangre, los ácidos grasos libres en sangre o la frecuencia cardíaca.

Como consecuencia de esa vulnerabilidad, los padres presentan mayores niveles de estrés, lo cual conlleva prestar una peor atención a sus hijos. Los niños tendrían por tanto unos estilos de vida menos saludables (más sedentarismo, menos actividad física y una alimentación de peor calidad) con consecuencias negativas para su salud (sobrepeso, obesidad y síndrome metabólico)[79].

A continuación, se muestra el marco conceptual final elaborado a partir de los resultados obtenidos en la presente Tesis Doctoral (Figura 2). Para terminar, se abordan los posibles mecanismos subyacentes a cada una de estas relaciones.

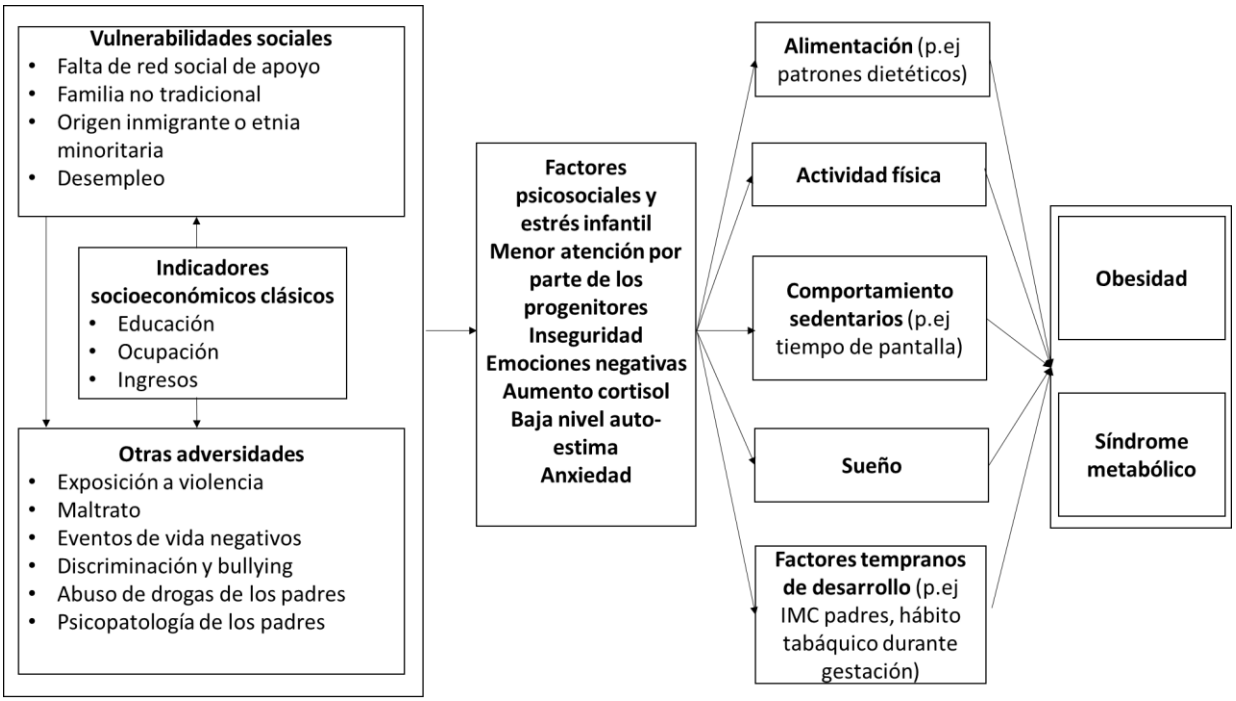

Figura 2. Marco conceptual final. Fuente: Elaboración propia.

Si se compara el marco conceptual elaborado a partir de las hipótesis planteadas al principio de la Tesis Doctoral se puede comprobar que tras el análisis de los datos obtenidos las relaciones establecidas han cambiado. Concretamente, las vulnerabilidades sociales, el bajo nivel socioeconómico y otras adversidades parecen afectar negativamente a los factores de riesgo de la obesidad y síndrome metabólico (patrón de alimentación no saludable, falta de actividad física, niveles altos de sedentarismo, escasez de sueño y factores tempranos de riesgo (como el sobrepeso y la obesidad de los progenitores entre otros) a través de mecanismos psicosociales y de una menor o peor atención a los niños que provocan un ambiente obesogénico en el que ellos habitan. Por ejemplo, los niños de familias monoparentales suelen disfrutar de menos tiempo o de una menor calidad con sus padres ya que a menudo la crianza individual no cuenta con la flexibilidad que puede ofrecer una familia nuclear. Las redes sociales de apoyo y los ingresos de las familias monoparentales suelen estar asimismo

más aminorados, haciendo que estas familias se enfrenten a más problemas que las familias nucleares.

La obesidad y el síndrome metabólico infantil son enfermedades multicausales; a pesar de ello, la presente Tesis Doctoral únicamente se ha centrado en determinadas asociaciones. Existen, por tanto, otros factores no analizados que podría contribuir a ese ambiente obesogénico. Por ejemplo, otros estudios han explicado que estos niños de familias más vulnerables suelen residir en barrios con un menor acceso a espacios verdes para hacer actividad física o establecimiento con una ´mayor concentración de restaurantes de comida rápida y menor acceso a frutas y verduras frescas lo que contribuiría a ese mayor riesgo observado[102, 103].

5.1. Vulnerabilidades sociales y patrones dietéticos

El primer artículo de la Tesis doctoral estudió la asociación entre las vulnerabilidades sociales y los patrones dietéticos, durante dos años de seguimiento. Se utilizó el análisis de conglomerados de K-medias basados en la frecuencia relativa de consumo de alimentos, para establecer grupos de participantes con patrones dietéticos similares entre sí y distintos de los del resto de participantes, desarrollado previamente por Fernández-Alvira y colaboradores[42]. Tras los análisis, los niños europeos se dividieron en tres grupos: los niños cuyo patrón característico fue el patrón procesado, caracterizado por una mayor frecuencia de consumo de aperitivos y comida rápida y menor frecuencia de consumo de verduras y productos integrales; el segundo patrón, denominado “dulce”, se caracterizó por un 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. Entre los grupos

vulnerables descritos (niños con un origen inmigrante, niños con algún progenitor desempleado, niños cuyos padres carecían de una red social de apoyo y familias monoparentales), los niños cuyos padres tenían una red social de apoyo escasa y un origen inmigrante, tenían mayores probabilidades de ser agrupados en el patrón "procesado" y menores posibilidades en comparación con los niños cuyos padres tenían una red social alta y los hijos de no inmigrantes, respectivamente. Estos resultados son coincidentes con la literatura previa, que ha mostrado un cambio de los hábitos de alimentación de los inmigrantes cuando llegan a los países de acogida siendo más frecuente entre estos grupos incrementen el consumo de comidas procesadas que son altamente calóricas y que contienen altos niveles de grasas, azúcares y sal. Estos productos a menudo remplazan componentes saludables de la dieta nativa tradicional como las frutas y verduras, frutos secos y cereales debido a la aculturación y la adopción del estilo de vida occidental[104, 105]. En cuanto a la asociación entre la red social de apoyo de los progenitores y los patrones dietéticos de los niños no parecen existir apenas estudios que hayan valorado investigado esta posible relación sin embargo sí se ha mostrado que niveles más bajos de contacto con los amigos están relacionados con un menor consumo de frutas y verduras, sobre todo en hombres[106].

Además, este resultado tuvo un efecto acumulativo cuando se sumaron el número de vulnerabilidades socioeconómicas, de manera que los niños que acumularon más de tres vulnerabilidades tenían un 78% más de posibilidades de consumir un patrón "procesado", en comparación con aquellos niños que no tenían vulnerabilidades en ambos momentos temporales (al inicio del estudio y dos años después). El ajuste por educación, ocupación e ingresos de los padres permitió concluir que existía un efecto independiente de estas vulnerabilidades sociales sobre los patrones dietéticos, no

explicado por el nivel socioeconómico, aunque tal y como se esperó, las asociaciones fueron más débiles cuando te ajusto por estos indicadores clásicos.

Existió además un factor protector en aquellos hogares en los que uno de los progenitores era amo o ama de casa y los niños tenían menos posibilidades de comer un patrón procesado en comparación con uno saludable.

Diversas investigaciones han analizado los diferentes patrones dietéticos en niños y adolescentes, aunque los estudios han mostrado un número variable de patrones (normalmente de 2 a 7), siendo el patrón saludable y el procesado u occidental el que se repetía mayoritariamente[107-109].

De manera similar a los resultados derivados del artículo I de la presente Tesis Doctoral, estudios previos han observado la relación entre un menor nivel socioeconómico y un patrón dietético no saludable, caracterizado por un consumo alto en grasas, bajo en frutas y verduras y altamente calórico[42, 109, 110]. Aunque existen estudios que han valorado la asociación entre distintas desventajas sociales en niños y el consumo de alimentos individuales, apenas existe literatura que haya valorado la calidad de la dieta de forma global independientemente del nivel socioeconómico. No obstante, de forma consistente con nuestros resultados, se ha señalado que los niños de familias inmigrantes en Europa tienen un consumo de alimentos de origen procesado superior al de los niños nativos[111]. La falta de red social de apoyo en los padres puede resultar también en patrones no saludables tal y como se ha demostrado en el estudio EPIC[106]. Contrariamente a lo esperado, no se encontró una mayor probabilidad de mostrar patrones menos saludables en niños con algún progenitor desempleado o niños de familias monoparentales, a pesar de que el estrés derivado de estas situaciones podría

dar lugar a ambientes más desfavorables, tal y como han mostrado algunos estudios[50, 112].

5.2. Vulnerabilidades sociales, actividad física y comportamientos sedentarios

Después de analizar los patrones dietéticos en niños pertenecientes a familias socialmente vulnerables, el objetivo del artículo II fue el estudio de los niveles de actividad física medidos objetivamente, a través de acelerómetros y subjetivamente a través de cuestionarios (divididos entre aquellos que cumplían las recomendaciones de al menos una hora de actividad física al día y los que no cumplían esta recomendación), así como de tiempo de pantalla a través de cuestionarios (divididos entre aquellos que cumplían con la recomendación de tener menos de dos horas de pantalla y los que no). Muchos de los estudios que han analizado la actividad física y el comportamiento sedentario de los niños se han basado en datos reportados por los padres a través de cuestionarios. Los resultados de nuestro estudio mostraron que los niños de origen inmigrante y de padres desempleados tenían más posibilidades de exceder el máximo recomendado de dos horas de tiempo de pantalla al día. Además, los niños cuyos padres declararon tener una red social escasa también tenían mayores probabilidades de no cumplir con las recomendaciones de actividad física, aunque esta asociación solo fue significativa cuando se utilizaron cuestionarios para su medición. Cuando la actividad física fue medida a través de acelerómetros, aunque los resultados no fueron estadísticamente significativos, se encontró este mismo patrón de riesgo para los niños de padres con una red social de apoyo escasa (coincidente con los resultados de los cuestionarios) y para los niños de origen inmigrante. Además, todos los niños de familias socialmente vulnerables tuvieron menores posibilidades de pertenecer a un club deportivo en comparación con los niños de familias no vulnerables.

Estos resultados son coincidentes con la literatura, que establece menores niveles de actividad física y mayores niveles de sedentarismo en niños de familias con un nivel socioeconómico menor[113] e inmigrantes[114] y desempleadas[115]. Respecto a la estructura familiar, no se observó un mayor riesgo de incumplimiento de los niveles de actividad física o sedentarismo en nuestro estudio. La literatura ha mostrado al respecto resultados poco concluyentes, y los estudios se dividen entre aquellos que no han encontrado relaciones significativas[116, 117] y los que han encontrado menores niveles de actividad física y mayores niveles de sedentarismo en menores de familias no tradicionales[63, 118]. En relación a la falta de red social de apoyo en los padres y su repercusión en los niveles de actividad física y sedentarismo de sus hijos, no se encontraron estudios previos aunque sí hay estudios que han determinado una asociación negativa entre niveles de apoyo escasos y estilos de vida más inactivos y sedentarios[119].

5.3. Vulnerabilidades sociales y problemas psicosociales

Diversos estudios han relacionado un bajo nivel socioeconómico familiar con un mayor número de problemas psicosociales en niños, que incluso se pueden mantener hasta la adultez[120]. Concretamente, estos niños manifiestan más problemas de comportamiento y emocionales que los niños de alto nivel socioeconómico[121]. Las diferencias en el acceso a recursos materiales y sociales y el estrés derivado de dichas condiciones, tanto en padres como en los menores, se han esgrimido como mecanismos para explicar la relación entre un nivel socioeconómico más bajo y el bienestar mental del niño.

El objetivo de nuestro estudio fue analizar otras desventajas socioeconómicas además de las propiamente clásicas, e investigar el efecto de las vulnerabilidades

sociales independientemente de la educación, la ocupación, los ingresos y de los estilos de vida de estos grupos. Las vulnerabilidades sociales parecen tener un impacto especialmente acusado en la salud mental de los niños. De hecho, de entre todas las vulnerabilidades estudiadas, tan solo la condición de inmigrante no estuvo relacionada con problemas psicosociales. La falta de red social de apoyo, la estructura familiar no tradicional y el desempleo de los padres sí tuvieron efectos negativos en la salud mental de los menores.

La estructura familiar parece ser un factor fundamental para la salud psicológica del niño. Tanto los que vivían en familias no tradicionales en ambos momentos del análisis, como aquellos que perdían su condición de familia tradicional en el momento del seguimiento tenían más riesgo de presentar problemas psicosociales. Estos resultados confirman los derivados de investigaciones previas, que hipotetizan que es la propia estabilidad de la estructura familiar la que concedería protección ante dichos problemas[122-124].

En nuestro estudio, el riesgo más alto para tener problemas psicosociales (incluidos la falta de bienestar mental y los problemas internalizados) se observó en aquellos niños que se encontraban inicialmente en una familia tradicional (viviendo con ambos progenitores) y dos años después dejaron de vivir en una familia tradicional y aquellos menores cuyos padres declararon tener una red social de apoyo escasa en ambos puntos temporales.

El efecto del desempleo sobre la salud mental del niño, aún importante, parece reflejar las consecuencias negativas derivadas de un nivel bajo de ingresos. Así, en los modelos en los que se ajustó por el nivel socioeconómico, el riesgo de sufrir problemas psicosociales se vio significativamente reducido.

La falta de red social de apoyo de los padres volvió a ser un factor fundamental en la salud y estilos de vida del niño, y fue el factor más estrechamente relacionado con los problemas psicosociales de los niños, sobre todo cuando esa falta de red social persistió en el tiempo. Los padres que tienen una amplia red social de apoyo pueden actuar como modelos de los niños, facilitar además el acceso a una comunidad más grande y acceder a relaciones sociales más beneficiosas[125, 126].

5.4. Vulnerabilidades sociales, obesidad infantil y síndrome metabólico

La infancia y la niñez temprana es el periodo en el que los humanos son más vulnerables y dependen mayormente de la alimentación externa (incluyendo el amamantamiento), la seguridad y el apoyo que les provean, ya que los niños aún no han adquirido mecanismos de protección adecuados como la resilencia, auto-estima, independencia[127]. Las familias con bajo nivel socioeconómico y con vulnerabilidades sociales a menudo no solo tienen limitaciones económicas, sino que a menudo tienen una falta de cohesión, una baja conciencia sobre la importancia de los estilos de vida, problemas de salud mental y baja estima lo que resulta en un ambiente hostil e inseguro para los niños. Como resultado estos niños más vulnerables tienen tasas de obesidad más altas y un estrés crónico (con niveles de cortisol elevados) y de inflamación crónica que hacen que estos grupos de niños tengan un mayor riesgo cardiovascular y por tanto de síndrome metabólico en comparación con los niños de familias no vulnerables. Los artículos IV, V y VI tuvieron como objetivo explorar la relación entre las desventajas sociales y el riesgo de obesidad y síndrome metabólico. Concretamente en el artículo IV se observó la relación entre el origen inmigrante o etnia minoritaria de los padres y el sobrepeso/obesidad en niños españoles de 2, 4 y 6 años. Tras ajustar los análisis por el IMC de los padres, nivel socioeconómico, y por distintos factores tempranos prenatales,

perinatales y postnatales relacionados con la obesidad infantil, se encontró que los menores de etnia gitana y aquellos de origen latinoamericano tenían un riesgo de sobrepeso u obesidad cuatro y tres veces mayor, respectivamente, que los menores con ambos progenitores de origen español no gitanos. Entre las posibles causas que la literatura ha esgrimido para explicar estas diferencias están la exposición de estos grupos vulnerables a entornos obesogénicos caracterizados por bajos niveles de actividad física, patrones de alimentación con elevada densidad energética y un estilo de vida sedentario, comparados con los grupos no vulnerables[60, 128]. Estos grupos generalmente viven en barrios con una mayor densidad de establecimientos de comida rápida, menor disponibilidad de frutas y verduras frescas y de espacios seguros para la realización de la actividad física[129].

De forma similar, en el artículo V se valoró la asociación entre las vulnerabilidades sociales y el peso en los niños europeos. Los niños tenían una probabilidad mayor de sobrepeso u obesidad si sus padres tenían un origen inmigrante, si los niños vivían en familias no tradicionales y si tenían algún progenitor desempleado. Este efecto fue más acusado en aquellas situaciones de vulnerabilidad mantenida en el tiempo, es decir, el riesgo era mayor para aquellos niños cuyos padres mantenían esa posición de desempleo o ese carácter de familia no tradicional. No obstante, en este artículo se observó que los niños cuyos padres perdieron su falta de red social al seguimiento tuvieron también problemas de bajo peso. Es decir, las vulnerabilidades parecen poner en mayor riesgo de sobrepeso u obesidad a los niños, aunque también se dan las situaciones contrarias en los que los niños puedan estar en una situación de bajo peso.

El síndrome metabólico está muy relacionado con la presencia de sobrepeso y obesidad[22]. Aunque en la actualidad no existe un consenso sobre la definición del síndrome metabólico en niños, independientemente de la definición usada, la prevalencia del síndrome metabólico es alta entre los niños obesos prepuberales y púberes[130]. Los cambios experimentados en los estilos de vida en las etapas infanto-juveniles ha incrementado el riesgo de presentar cada uno de los componentes del síndrome metabólico: obesidad de predominio abdominal, hipertensión, resistencia a la insulina u otras anomalías del metabolismo de la glucosa, hipertrigliceridemia y niveles bajos de lipoproteínas de alta densidad. Nuestros resultados confirmaron que los niños con desventajas sociales (particularmente aquellos niños con un nivel socioeconómico bajo, una estructura familiar no tradicional y de padres desempleados) presentaban un mayor riesgo de tener síndrome metabólico, en comparación con aquellos sin desventajas. Uno de los factores que parece mediar todas estas relaciones es el estrés derivado de estas situaciones más desfavorables, y han sido diversos artículos los que han relacionado el estrés mantenido a lo largo del tiempo con la obesidad y el síndrome metabólico[131-133]. Los grupos desfavorecidos podrían estar más expuestos al estrés crónico debido, entre otros, a su aislamiento social, limitaciones financieras y falta de apoyo social, lo que podría dar lugar a sentimientos negativos en los padres, comportamientos y afectos y un contexto estresante en la vida de los niños. El estrés puede producir cambios adaptativos a corto plazo en el metabolismo, convirtiéndose en inadaptados cuando el organismo está bajo estrés a largo plazo[131]. Entre las razones específicas que han intentado explicar por qué el síndrome metabólico es más común entre los grupos socioeconómicamente desfavorecidos se han basado por tanto en factores de salud mental, biológicos y de comportamiento[102, 131, 134]. Las desventajas

socioeconómicas incrementan el riesgo de alteraciones del ánimo y de la ansiedad, factores de salud mental que incrementan la morbilidad y mortalidad cardiovascular. Las desventajas socioeconómicas también pueden trastornar muchos de los sistemas biológicos del cuerpo alterando el sistema inmune, metabólico, neuroendocrino y sistema nervio autónomo. Por último, las desventajas socioeconómicas se relacionan con factores de comportamiento adversos que incrementan la enfermedad cardiovascular como el hábito tabáquico, inactividad física, consumo de alimentos altamente energético).

5.5. Implicaciones para la salud pública

La obesidad infantil sigue siendo uno de los principales problemas de salud pública. Aunque en las últimas décadas la prevalencia de obesidad infantil se ha estabilizado en algunos países, sus niveles siguen siendo alarmantemente altos. Además, estas tendencias positivas parecen estar enmascarando una creciente desigualdad en los niveles de obesidad entre los niños de nivel socioeconómico más alto y aquellos de nivel más bajo y con mayores vulnerabilidades acumuladas[135, 136]. Frederick y colaboradores observaron que hasta el año 2002 las tasas de obesidad se incrementaron de forma similar en todos los niños. Sin embargo, después de ese año, la obesidad ha experimentado un decrecimiento entre los niños de mayor nivel socioeconómico mientras que la obesidad ha seguido aumentando en aquellos grupos con más desventajas socioeconómicas[136]. Los resultados de la presente Tesis Doctoral han confirmado que los niños con mayores desventajas socioeconómicas presentan peores estilos de vida (dieta, actividad física y sedentarismo), problemas psicosociales, obesidad y riesgo de síndrome metabólico comparado con los niños de mayor nivel socioeconómico.

Los resultados obtenidos (artículo I, II, III, IV, V, VI) parecen indicar que las familias con desventajas socioeconómicas soportan mayores niveles de estrés, que a su vez transmiten a sus hijos, traduciéndose probablemente en una peor atención de los padres a sus hijos, repercutiendo negativamente en sus estilos de vida y en su salud. Esto sería coincidente con un estudio que mostraba que el tiempo de pantalla de los padres parecía modelar en mayor medida el tiempo de pantalla de los niños frente a la actividad física, que no presenta la misma relación[61].

La relación entre el sobrepeso y los problemas psicosociales se ha mostrado en diferentes estudios. La obesidad y los desórdenes mentales son condiciones comórbidas tanto en adultos como en menores. La mayoría de las investigaciones han establecido una relación bidireccional entre la obesidad y los problemas psicosociales; es decir, la obesidad aumentaría el riesgo de un bienestar psicosocial pobre, y los problemas psicosociales infantiles aumentarían el riesgo de desarrollar obesidad en el futuro[137]. En el artículo III de la presente tesis doctoral, los niños que tenían sobrepeso u obesidad mostraban un mayor porcentaje de problemas internalizados y de bajo bienestar mental en comparación con los niños que tenían un peso normal, lo que es coincidente con los resultados de previas investigaciones[138]. No obstante, cabe recordar que el objetivo del presente estudio fue relacionar las vulnerabilidades sociales con el riesgo de sufrir problemas psicosociales, aunque se observase un mayor porcentaje de personas con vulnerabilidades sociales con obesidad y con problemas psicosociales. Asimismo, los resultados de artículo III tampoco permiten establecer el orden en la causalidad de estas relaciones, es decir si es la vulnerabilidad social la que daría lugar a la obesidad y después a los problemas psicosociales, o la vulnerabilidad social daría lugar a los problemas psicosociales y posteriormente a la obesidad.

La alimentación, la actividad física y los problemas psicosociales son esenciales para entender el desequilibrio energético que se da en los niños con sobrepeso u obesidad. En el artículo V y VI de la presente Tesis Doctoral los niños socioeconómicamente vulnerables mostraron mayores problemas de peso (tanto de bajo peso como de sobrepeso u obesidad, sobre todo).

Además, en el artículo VII, en línea con nuestra hipótesis, los niños con desventajas socioeconómicas también mostraron una mayor puntuación en el riesgo de síndrome metabólico, comparado con los niños sin desventajas, fruto probablemente de mayores niveles de estrés y de unos peores estilos de vida.

En una revisión sistemática, se sugirió que las intervenciones que tienen como objetivo prevenir, reducir o controlar la obesidad no aumentan las desigualdades[139]. Para los niños, hubo mayor evidencia de efectividad para las intervenciones especialmente dirigidas a la escuela y al entorno[139]. Concretamente, las intervenciones tempranas dirigidas a niños de nivel socioeconómico más bajo, con el fin de mejorar la calidad de la dieta a través del incremento en el conocimiento nutricional y la disponibilidad de comida saludable en el colegio, son de especial relevancia[140].

Teniendo en cuenta estos resultados y los expuestos en la presente Tesis Doctoral, las intervenciones de salud pública deberían prestar una especial atención a los niños de familias con mayores desventajas socioeconómicas, de manera que se puedan reducir las desigualdades existentes en salud, especialmente en el exceso de peso. Las intervenciones en la primera infancia, como la educación dirigida a los niños y programas de apoyo de los padres, tienen impactos positivos en la salud y ayuda a abordar las desventajas socioeconómicas y las disparidades de salud. Debido a su potencial para mejorar resultados en padres e hijos, y para producir beneficios de salud

y socioeconómicos en el tiempo, estas intervenciones pueden producir un considerable retorno de la inversión[141]. No obstante, la mayoría de las intervenciones de salud dependen sin embargo de la participación voluntaria de los individuos, por lo que aquellos en situación más vulnerable pueden enfrentarse a mayores impedimentos. Se ha observado que los esfuerzos que conlleva la prevención a menudo atraen a aquellas personas que menos lo necesitan y por el contrario suele fallar en aquellas con una situación menos ventajosa, las cuales suelen experimentar más barreras para llevar a cabo la intervención. Entre las barreras que se han reportado se suelen incluir una falta de flexibilidad para dedicar tiempo fuera del trabajo, o transporte, la alienación o el fatalismo[142]. Es por ello que son necesarias las iniciativas que incluyan medidas preventivas específicas para cada uno de los grupos vulnerables, con el objetivo de evitar que las políticas públicas incrementen más las desigualdades de salud existentes entre los grupos en situación más ventajosa y aquellos con mayor vulnerabilidad[143]. Según diversos estudios mejorar el acceso a una educación de alta calidad parece una de las mejores herramientas para reducir las desigualdades[144].

6. Aportaciones principales de la tesis doctoral

Existen multitud de estudios que han mostrado una fuerte asociación entre los indicadores socioeconómicos clásicos familiares (educación, ocupación e ingresos) y los estilos de vida y salud infantiles. No obstante, existen otros indicadores de carácter social, que han sido raramente estudiados, como son la cantidad de las redes sociales de apoyo, el tipo de estructura familiar, el desempleo y el origen geográfico de los padres, y cuyo efecto se había asociado principalmente al derivado de la educación o los ingresos familias. La presente Tesis Doctoral ha investigado el posible efecto que estos indicadores sociales tienen independientemente de la educación y de los ingresos de los padres. Los resultados obtenidos han mostrado que existe una vulnerabilidad social que no puede explicarse por el nivel socioeconómico de los padres y que afecta negativamente a los estilos de vida de los niños desde una temprana edad, registrando estos niños mayores niveles de sedentarismo, menores niveles de actividad física, siguen una dieta menos saludable y, por esto, mayores niveles de obesidad y mayor riesgo de riesgo de síndrome metabólico. La perspectiva longitudinal de nuestros estudios ha permitido observar que el efecto negativo de estas vulnerabilidades en los niños se acentúa a lo largo del tiempo, siendo aquellos niños con una vulnerabilidad mantenida en el tiempo aquellos con unos peores niveles de salud física y mental. Además, los artículos incluidos en esta Tesis han observado un patrón acumulativo de vulnerabilidad siguiendo el número de desventajas socioeconómicas. Es decir, el efecto negativo que tenían estas desventajas en las relaciones estudiadas (dieta, ejercicio y sedentarismo, bienestar mental, obesidad y síndrome metabólico) era mayor cuando en el mismo niño se acumulaban varias de estas desventajas. Es destacable asimismo el papel de la falta de red social de apoyo como indicador de vulnerabilidad en los niños

siendo éste el predictor más importante en las asociaciones investigadas. Aunque han sido varios artículos los que han estudiado la relación entre la falta de red de apoyo y los estilos de vida y salud no existen apenas estudios que hayan investigado la repercusión que tienen la falta de redes de apoyo de los padres en los estilos de vida, salud mental y resultados de salud de los niños como la obesidad y el síndrome metabólico[145]. A continuación, se explican las principales contribuciones de cada uno de los artículos incluidos en la Tesis Doctoral:

Artículo I. Las vulnerabilidades sociales condicionan negativamente la alimentación de los niños. Particularmente, aquellos cuyos padres declararon tener una red social de apoyo escasa y los niños con padres inmigrantes mostraron más frecuentemente una alimentación caracterizada por un alto consumo de aperitivos y comida rápida (patrón que denominamos como procesado). Además, a mayor número de desventajas sociales, mayor fue la probabilidad de tener un patrón de alimentación no saludable. De hecho, aquellos niños con tres o más desventajas sociales tuvieron casi un 80% más de posibilidades de seguir este patrón procesado. Por otro lado, aquellos niños cuyos padres (madre o padre) estaban de baja maternal/paternal o eran amos de casa tenían mayores posibilidades de tener un patrón saludable (caracterizado por un alto consumo de frutas y verduras) existiendo por tanto un efecto protector.

Artículo II. Los niños con vulnerabilidades sociales mostraron menores niveles de actividad física y mayores niveles de sedentarismo en comparación con los niños sin vulnerabilidad. Los cuestionarios reflejaron que los menores cuyos padres tenían una red social de apoyo escasa tenían menores niveles de actividad física en comparación con los niños cuyos padres tenían una red social más amplia. La actividad física valorada de forma objetiva con acelerómetros no mostró diferencias estadísticamente

significativas entre grupos, pero de acuerdo con resultados previamente publicados, los niños cuyos padres tenían una red social de apoyo escasa, tendieron a mostrar menores niveles de actividad física, al igual que los menores de origen inmigrante. Respecto a los comportamientos sedentarios, los menores con un origen inmigrante y los niños con padres desempleados declararon más horas de tiempo de pantalla que los menores nativos y con padres empleados.

Artículo III. Las vulnerabilidades sociales en los niños predijeron los problemas psicosociales (problemas internalizados y falta de bienestar mental). La falta de red social de apoyo de los padres, una estructura familiar no tradicional (concretamente la pérdida de esa estructura tradicional familiar) y el desempleo de los padres estuvieron relacionados con mayores problemas psicosociales. De nuevo, una red social de apoyo escasa por parte de los padres fue el factor más importante para entender los problemas psicosociales en los menores. El origen inmigrante fue la única vulnerabilidad social no relacionada con un mayor riesgo de sufrir problemas psicosociales.

Artículo IV. En Aragón casi uno de cada tres niños tiene sobrepeso u obesidad a la edad de seis años. Los niños de etnia gitana tuvieron un riesgo cuatro veces superior de presentar sobrepeso u obesidad comparado con los niños españoles de etnia no gitana. Los niños de origen Latinoamericano también presentaron el doble de probabilidades de tener sobrepeso u obesidad en comparación con los niños españoles de etnia no gitana.

Artículo V. Los niños europeos con vulnerabilidades sociales presentaron mayores problemas de peso (sobre todo de sobrepeso u obesidad, aunque también asociados a problemas de bajo peso) que aquellos sin vulnerabilidad. Las desventajas sociales como no vivir con ambos progenitores o el desempleo de alguno de ellos, estuvo asociado con un mayor riesgo de sobrepeso u obesidad en comparación con los menores que vivían

con su padre y su madre y tenían un empleo. Los hijos de los padres que declararon tener una red social de apoyo extensa al inicio del estudio pero que perdieron la misma dos años más tarde tenían además un 70% más de riesgo de tener una situación de bajo peso.

Artículo VI. Las desventajas socioeconómicas tempranas (que incluyen las vulnerabilidades sociales y un bajo nivel socioeconómico) tuvieron un efecto negativo en el riesgo de síndrome metabólico. Los niños de familias con un bajo nivel de ingresos, de familias no tradicionales y de padres desempleados mostraron mayores puntuaciones en el riesgo de presentar síndrome metabólico en comparación con los grupos sin desventajas socioeconómicas. Asimismo, los menores con tres o más desventajas socioeconómicas mostraron tener un mayor riesgo de síndrome metabólico. La edad, el sexo, el bienestar mental y los estilos de vida (consumo de frutas y verduras, actividad física, tiempo de pantalla) explicaron solo parcialmente estas diferencias.

La prevención de la obesidad infantil es clave para la prevención futura de la obesidad y los problemas y enfermedades asociadas, como la diabetes tipo 2, problemas musculo-esqueléticos, alteraciones del sueño, hipertensión, síndrome metabólico o problemas psicosociales, entre otros. Estas enfermedades están asociadas a la mayoría de las muertes en los países desarrollados y su prevención supone evitar mayores costes futuros tanto directos como indirectos derivados del tratamiento médico.

En cuanto a las repercusiones prácticas que se pueden extraer de estos resultados se sugiere que las intervenciones a nivel de salud deberían tener más en cuenta las diversidades étnicas, sociales y económicas para crear políticas eficaces que lograran la reducción de las desigualdades manifiestas en la salud de los niños. Así, un desafío futuro es trabajar sobre los hábitos de alimentación y los entornos de los niños con

vulnerabilidades acumuladas, para hacer que los que crecen en entornos desfavorecidos tengan estilos de vida más saludables, que les ayuden a disminuir los niveles de obesidad y las consecuencias negativas derivadas de la misma. Igualmente, y para contrarrestar los efectos negativos que las vulnerabilidades sociales conllevan en la salud mental de los niños, las políticas sociosanitarias deberían implementar medidas para fortalecer el apoyo social de los padres que carecen de una red social adecuada.

Los resultados de esta Tesis Doctoral han mostrado que las desventajas socioeconómicas de los padres tienen un gran impacto en los niños y sus consecuencias negativas pueden ser mostradas en edades muy tempranas con un efecto acumulativo que incrementa a lo largo de los años, señalándose la importancia de combatir las desigualdades en las etapas más precoces de la vida.

6. Main thesis contributions

There are many studies that have shown strong associations between classical socioeconomic indicators (education, occupation and income) and children's lifestyles and health. However, there are other indicators of a social nature that have been rarely studied, such as the quantity of social support networks, the type of family structure, unemployment and the geographical origin of the parents, and its effects have been mainly associated with the derivative of education or family income. This Doctoral Thesis has investigated the potential effects of these social indicators on …regardless of education and income of parents. The results of this thesis have shown that there are social vulnerabilities that cannot be explained by the socioeconomic level of the parents but that still negatively affects the lifestyles of children. From an early age, these children show higher levels of sedentary lifestyle, lower? levels of physical activity, follow a less healthy diet and, therefore, exhibit higher levels of obesity and an increased risk of metabolic syndrome. The longitudinal nature of our studies enabled us to establish that the negative effect of these vulnerabilities in children is accentuated over time. In addition, the articles included in this Thesis have found a cumulative effect of vulnerability in that sense that children's unhealthy behaviours accumulate with the accumulation of socioeconomic disadvantages. The role of lack of a social support network as an indicator of vulnerability in children is noteworthy, being this the most important predictor in the associations investigated. Although there have been several articles that have studied the relationship between the lack of a support network and lifestyles and health in adult populations? there are hardly any studies that have investigated the impact of the lack of support networks of parents on lifestyles, mental health and health outcomes such as obesity and metabolic syndrome in children[(145)]. In

summary, the main contributions of each of the articles included in the Doctoral Thesis are:

Paper I. Social vulnerabilities negatively impact on children's diet. Particularly, children whose parents reported to have a small social network and children of migrants had a diet characterized by a high consumption of snacks and fast food (a dietary pattern we called "processed"). In addition, the greater the number of socioeconomic disadvantages, the greater the child's chance of having an unhealthy dietary pattern. In fact, those children with three or more socioeconomic disadvantages were almost 80% more likely to show this processed pattern. On the other hand, children whose parents (mother or father) were on parental leave or were housemakers were more likely to have a healthy dietary pattern (characterized by a high consumption of fruits and vegetables), suggesting a protective effect.

Paper II. Children from some vulnerable groups had lower levels of physical activity and higher levels of sedentary behaviours (screen time) compared to children without any vulnerability. Particularly, children whose parents had a low social network were found to be less physically active compared to children whose parents had a wider social network when considered self-reported PA data. Surprisingly, no such association was observed when using objectively measured physical activity data but results still pointed to the expected direction. In fact, children whose parents had a low social network showed lower levels of self-reported? physical activity which was also true for children of migrant origin. Regarding sedentary behaviour, especially parents with a migrant background and unemployed reported that their children had more hours of screen time than native children and employed parents.

Paper III. Social vulnerabilities in children predicted psychosocial problems (internalized problems and lack of mental well-being): The lack of a social network for parents, a non-traditional family structure (specifically the loss of that traditional family structure) and unemployment of parents were related to greater psychosocial problems. Again, low social network was the most determining factor in predicting psychosocial problems in children. Having a migrant origin was the only social vulnerability considered here not related to an increased risk of suffering from psychosocial problems.

Paper IV. In the Spanish region of Aragon almost one in three children at the age of six years are overweight or obese. However, in our study, Roma children were four times more likely to be overweight or obese than non-Roma Spanish children. Similarly, children with a Latin American origin had twice the chances of being overweight or obese compared to non-Roma Spanish children.

Paper V. European children with social vulnerabilities were at higher risk for weight problems (especially problems of overweight or obesity but also problems of underweight) than those without any vulnerability. Social vulnerabilities such as not living with both biological parents or unemployment of either the mother or father was associated with an increased risk of overweight or obesity compared to children who lived with both parents and whose parents were employed, respectively. Children of parents who reported to have an extensive social network at the beginning of the study but who lost this social network two years later an increased risk of approx. 70% of being underweight.

Paper VI. Early socioeconomic disadvantages (which include social vulnerabilities and low socioeconomic status) have a negative effect on the metabolic risk in children.

Children from low-income families, children living in non-traditional families and children from unemployed parents showed higher risk scores for metabolic syndrome compared to groups without socioeconomic disadvantages. Likewise, children with three or more socioeconomic disadvantages showed an increased risk of metabolic syndrome. Confounders such as age, sex, well-being and lifestyles (fruit and vegetable consumption, physical activity and screen time) only partially explained these differences.

The prevention of childhood obesity is a key strategy to prevent future obesity and associated problems and diseases, such as type 2 diabetes, musculoskeletal problems, sleep disturbances, hypertension, metabolic syndrome or psychosocial problems, among others. These diseases are associated with the majority of deaths in developed countries and their prevention means avoiding future direct and indirect costs derived from medical treatment.

Regarding the practical implications that can be extracted from these results, it is suggested that interventions at the health level should take into account ethnic, social, and economic diversities in order to create effective policies to reduce the growing health gap between children from disadvantaged non-disadvantaged groups. Thus, a future challenge is to work on diets and environments of children with accumulated vulnerabilities, to make those who grow up in disadvantaged environments have healthier lifestyles, which help them to reduce the levels of obesity and the negative consequences derived of the same. Likewise, and to counteract the negative effects that social vulnerabilities have on the mental health of children, socio-health policies should implement measures to strengthen the social support of parents who lack an adequate social network. We have also shown that parental disadvantages have a great impact on

children, and its negative consequences can be displayed at early ages with a cumulative effect that increases over the years, pointing out the importance of tackling inequalities and the importance of acting at early ages.

7. Conclusiones

Artículo I. Los niños cuyos padres dispusieron de una red social de apoyo escasa y los niños de origen inmigrante mostraron con mayor frecuencia un alto consumo de aperitivos y de comida rápida. Las vulnerabilidades sociales tuvieron un efecto acumulativo negativo en la alimentación de los niños y a mayor número de desventajas sociales, mayor fue el riesgo del niño de tener un patrón dietético poco saludable. Estar de permiso por paternidad o ser amo de casa tuvo un efecto protector en la dieta de los niños.

Artículo II. Los niños de padres con una red social de apoyo escasa mostraron niveles más bajos de actividad física en comparación con los niños de padres con una red social más amplia. Los niños de origen inmigrante y los niños de padres desempleados informaron de más horas de pantalla que los niños nativos y los padres empleados. Todos los niños de grupos vulnerables tuvieron menos probabilidades de pertenecer a un club deportivo.

Artículo III. Las vulnerabilidades sociales predijeron más problemas psicosociales en los niños. La falta de una red social de apoyo en los padres, una estructura familiar no tradicional (particularmente el perder esa estructura familiar tradicional) y el desempleo de los padres se relacionó con mayores problemas psicosociales.

Artículo IV. Existe una disparidad en la prevalencia de la obesidad infantil entre diferentes grupos raciales y étnicos en Aragón, España. Los niños romaníes tuvieron cuatro veces más probabilidades de tener sobrepeso u obesidad que los niños españoles no romaníes y los niños con un origen latinoamericano tuvieron el doble de

posibilidades de tener sobrepeso u obesidad en comparación con los niños españoles no romaníes.

Artículo V. No vivir con ambos padres biológicos o el desempleo de la madre o el padre, se asoció con un mayor riesgo de sobrepeso u obesidad infantil. Por otro lado, los hijos de padres que informaron tener un amplio apoyo social al comienzo del estudio pero que perdieron ese apoyo social dos años después tuvieron más probabilidades de tener bajo peso.

Artículo VI. Los niños de familias de bajos ingresos, los niños que viven en familias no tradicionales, los niños de padres desempleados y los niños con tres o más desventajas socioeconómicas mostraron puntuaciones más altas en el riesgo de sufrir síndrome metabólico en comparación con los grupos sin desventajas socioeconómicas.

En conclusión, las desventajas socioeconómicas tempranas pueden causar efectos relevantes en el estilo de vida de los niños y, por consiguiente, en su salud. En particular, las desventajas socioeconómicas mantenidas a lo largo del tiempo y las familias con más de tres desventajas acumuladas son las más expuestas a futuros problemas de salud y psicosociales. Aquellos niños que pasaron de una situación vulnerable a una situación no vulnerable tuvieron un menor riesgo de obesidad y síndrome metabólico que los niños que mantuvieron su situación de vulnerabilidad a lo largo del tiempo. Estos resultados muestran que políticas públicas adecuadas dirigidas a familias en situación vulnerable llevadas a cabo a edades tempranas pueden mejorar la situación de los niños y revertir los resultados negativos de salud.

7. Conclusions

Paper I. Children whose parents reported to have a small social network and migrants had a diet characterized by a high consumption of snacks and fast food. Social vulnerabilities had a cumulative negative effect on children´s diet and the greater the number of socioeconomic disadvantages, the greater the child's chance of having an unhealthy dietary pattern. Being on parental leave or being housemakers had a protective effect on children´s diet.

Paper II. Children whose parents had a low social network showed lower levels of physical activity compared to children whose parents had a wider social network. Parents with a migrant background and unemployed parents reported that their children spent more hours of screen time than native children and children of employed parents, respectively. Children from vulnerable groups were in general less likely to be member of a sports club.

Paper III. Social vulnerabilities predicted more psychosocial problems in children. The lack of a social network of parents, a non-traditional family structure (specifically the loss of that traditional family structure) and unemployment of parents were related to greater psychosocial problems.

Paper IV. There is a disparity in the prevalence of childhood obesity between different racial and ethnic groups in? Aragon, Spain. Roma children were four times more likely to be overweight or obese than non-Roma Spanish children. Children with a Latin American origin had twice the chances of being overweight or obese compared to non-Roma Spanish children.

Paper V. Not living with both biological parents or unemployment of either the mother or father, was associated with an increased risk of childhood overweight or obesity. On the other hand, children of parents who reported to have an extensive social network at the beginning of the study but who lost this social network two years later were more likely to be underweight.

Paper VI. Children from low-income families, children living in non-traditional families, children from unemployed parents and children with three or more socioeconomic disadvantages showed a higher metabolic risk score compared to groups without socioeconomic disadvantages.

In conclusion, early socioeconomic disadvantages can cause relevant effects in children's lifestyle and consequently in health. Most notably, socioeconomic disadvantages maintained over time and families with more than three disadvantages accumulated are those more exposed to future health and psychosocial problems. Those children that changed their situation from a vulnerable to a non-vulnerable situation had a lower risk of obesity and metabolic syndrome than children who kept their vulnerable situation over the time. These results show that adequate policy actions at early ages can improve children's situation and reverse negative health outcomes.

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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 áreas temáticas correspondientes.

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

Artículos publicados o aceptados [Published or accepted manuscripts]:

	Revista [Journal]	**Factor de Impacto [Impact factor]**
Artículo I	British Journal of Nutrition	3,706
Ranking in 2016 ISI JCR: 20/81 (Nutrition and Dietetics)		
Artículo II	International Journal of Public Health	2,327
Ranking in 2016 ISI JCR: 32/157 (Public, Environmental and Occupational Health)		
Artículo III	European Child and Adolescent Psychiatry	3,295
Ranking in 2016 ISI JCR: 12/121 (Pediatrics) 48/142 (Psychiatry)		
Artículo IV	European Journal of Public Health	2,431
Ranking in 2016 ISI JCR: 28/157 (Public, Environmental and Occupational Health)		

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Paciencia, disponibilidad y humildad son cualidades personificadas en la figura de Luis Moreno, líder nato de este bonito proyecto, GENUD. Gracias por haberme ayudado a ser mejor en mi trabajo, gracias por tus contestaciones inmediatas a mis correos y mensajes, gracias por tu amabilidad y predisposición, gracias por tus buenos consejos. Solo te puedo decir una cosa Luis, GRACIAS.

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Anexos [Annexes]

Para obtener una información más precisa de la metodología llevada a cabo en el estudio IDEFICS se adjunta el siguiente artículo:

- 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 SOBRE INFORMACIÓN

SOCIOECÓNOMICA

General information

1. How many persons live permanently in the household where your child usually lives?

Number of persons (adults and children): |__|__| persons.
Number of persons below 18 years: |__|__| person(s).

2. Who does your child live with most of the time?
Please tick the answer that applies most.

❍ 1 With his/her parents

❍ 2 With his/her mother

❍ 3 With his/her mother and her new partner

❍ 4 With his/her father

❍ 5 With his/her father and his new partner

❍ 6 Half of the time with his/her mother and the other half with his/her father

❍ 7 With his/her grandparents or other relatives

❍ 8 With foster parents or adoptive parents

❍ 9 In an institution e.g. orphanage

❍ 10 Elsewhere, please specify: _____

3. How many older and younger siblings does your child live with?
Count also half brothers and sisters / siblings in-law.

My child lives together with |___|___| older siblings.

My child lives together with |___|___| younger siblings.
My child lives together with |___|___| siblings of the same age.

❍ 0 My child does not live together with any siblings.

Socio-demographic information

The following questions will help us to compare the health of your child with that of other children with the same characteristics.

73. Does your child have the <*insert nationality*> citizenship?

❍ 1 Yes

❍ 2 No, please specify: _____

Does the mother of the child have the <*insert nationality*> citizenship?

❍ 1 Yes

❍ 2 No, please specify: _____

Does the father of the child have the <*insert nationality*> citizenship?

❍ 1 Yes

❍ 2 No, please specify: _____

74. Was your child born in <*insert country*> ?

❍ 1 Yes

❍ 2 No, please specify: _____

Was the mother of the child born in <*insert country*> ?

❍ 1 Yes

❍ 2 No, please specify: _____

Was the father of the child born in <*insert country*> ?

❍ 1 Yes

❍ 2 No, please specify: _____

75. In what language(s) do you usually speak with your child at home?

❍ 1 *<insert national language>*

❍ 2 Other language, please specify:

_____

76. What is the highest level of education you and your spouse/partner have?

Please indicate only one per person.

	Me	***Spouse/partner***
<Country-specific categories>	❍ 1	❍ 1
<Country-specific categories>	❍ 2	❍ 2
<Country-specific categories>	❍ 3	❍ 3
<Country-specific categories>	❍ 4	❍ 4
...	❍ 5	❍ 5
No graduation (yet)	❍ 8	❍ 8
Unknown	❍ 9	❍ 9

77. What is the highest level of professional qualification you and your spouse/partner have?

Please indicate only one per person.

	Me	***Spouse/partner***
<Country-specific categories>	❍ 1	❍ 1
<Country-specific categories>	❍ 2	❍ 2
<Country-specific categories>	❍ 3	❍ 3
<Country-specific categories>	❍ 4	❍ 4
...	❍ 5	❍ 5
No training (yet)	❍ 8	❍ 8

	Me	*Spouse/partner*
Unknown	❍ 9	❍ 9

78. At the present time, which of the following does best describe your main occupational status and that of your spouse/partner?
Please indicate only one per person.

	Me	*Spouse/partner*
Full-time job (30 hrs. or more a week)	❍ 1	❍ 1
Part-time job (less than 30 hrs. a week)	❍ 2	❍ 2
Attend school or university	❍ 3	❍ 3
Homemaker	❍ 4	❍ 4
Retired (also early retirement)	❍ 5	❍ 5
Temporary company leave (e.g. maternity or paternity leave)	❍ 6	❍ 6
Unemployed, for less than one year	❍ 7	❍ 7
Unemployed, for a year or more	❍ 8	❍ 8
On welfare (social assistance)	❍ 9	❍ 9
Other, please specify: _____	❍ 10	❍ 10

79. In what occupational position are you and your spouse/partner presently occupied?

If you or your spouse/partner is no longer occupied or currently not occupied, please indicate the last occupational position.

	Me	***Spouse/partner***
Worker		
Non-skilled worker	❍ 1	❍ 1
Semi-skilled worker	❍ 2	❍ 2
Skilled worker, craftsman	❍ 3	❍ 3
Master craftsman, foreman	❍ 4	❍ 4
Employers and self-employed (including helping family members)		
Self-employed agriculturist, farmer	❍ 1	❍ 1
Self-employed, Freelancer	❍ 2	❍ 2
Employers with up to 9 employees	❍ 3	❍ 3
Employers with 10 and more employees	❍ 4	❍ 4
Helping family member	❍ 5	❍ 5
Employee		
Employee with simple tasks (e.g. salesperson, clerk)	❍ 1	❍ 1
Employee with qualified tasks (e.g. accounting clerk, dental assistant)	❍ 2	❍ 2
Employee with highly qualified tasks or management functions (e.g. scientist, department manager)	❍ 3	❍ 3
Employee with comprehensive executive functions (e.g. director, managing director, executive board)	❍ 4	❍ 4
Civil servant		
<*Country-specific categories*>	❍ 1	❍ 1
<*Country-specific categories*>	❍ 2	❍ 2
<*Country-specific categories*>	❍ 3	❍ 3
<*Country-specific categories*>	❍ 4	❍ 4

	Me	*Spouse/partner*
Never employed	❍ 7	❍ 7

80. What is your monthly household income, i.e. the net income that you (altogether) have after taxes and deductions?

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.

Under	*<Country-specific cut-points>*		❍ 1
<Country-specific cut-points>	up to under	*<Country-specific cut-points>*	❍ 2
<Country-specific cut-points>	up to under	*<Country-specific cut-points>*	❍ 3
<Country-specific cut-points>	up to under	*<Country-specific cut-points>*	❍ 6
...	...	*...*	..
<Country-specific cut-points>	up to under	*<Country-specific cut-points>*	❍ 11
<Country-specific cut-points>	up to under	*<Country-specific cut-points>*	❍ 12

CUESTIONARIO SOBRE BIENESTAR MENTAL

Health and Well-Being

47. Self-Esteem

During the last week…	***Not at all***	***Hardly ever***	***Sometimes***	***Often***	***All the time***
… my child was proud of him/herself.	❍ 0	❍ 1	❍ 2	❍ 3	❍ 4
… my child felt on top of the world.	❍ 0	❍ 1	❍ 2	❍ 3	❍ 4
… my child liked him/herself.	❍ 0	❍ 1	❍ 2	❍ 3	❍ 4
… my child had many good ideas.	❍ 0	❍ 1	❍ 2	❍ 3	❍ 4

48. Family

During the last week…	***Not at all***	***Hardly ever***	***Sometimes***	***Often***	***All the time***
… my child got on well with us as parents.	❍ 0	❍ 1	❍ 2	❍ 3	❍ 4
… my child felt fine at home.	❍ 0	❍ 1	❍ 2	❍ 3	❍ 4
… we had heated arguments at home.	❍ 0	❍ 1	❍ 2	❍ 3	❍ 4
… my child felt patronised by us.	❍ 0	❍ 1	❍ 2	❍ 3	❍ 4

49. Social Contacts

During the last week…	***Not at all***	***Hardly ever***	***Sometimes***	***Often***	***All the time***
… my child spent time with his/her friends.	❍ 0	❍ 1	❍ 2	❍ 3	❍ 4
… my child was liked by other children.	❍ 0	❍ 1	❍ 2	❍ 3	❍ 4

During the last week…	*Not at all*	*Hardly ever*	*Sometimes*	*Often*	*All the time*
… my child got along well with his/her friends.	❍ 0	❍ 1	❍ 2	❍ 3	❍ 4
… my child felt like he/she was different from others.	❍ 0	❍ 1	❍ 2	❍ 3	❍ 4

50. Physical well-being

During the last week…	*Not at all*	*Hardly ever*	*Sometimes*	*Often*	*All the time*
… my child felt ill.	❍ 0	❍ 1	❍ 2	❍ 3	❍ 4
… my child had belly- or headache.	❍ 0	❍ 1	❍ 2	❍ 3	❍ 4
… my child was tired and nervous.	❍ 0	❍ 1	❍ 2	❍ 3	❍ 4
… my child was strong and full of energy.	❍ 0	❍ 1	❍ 2	❍ 3	❍ 4

51. Emotional well-being

During the last week…	*Not at all*	*Hardly ever*	*Sometimes*	*Often*	*All the time*
… my child laughed and had lots of fun.	❍ 0	❍ 1	❍ 2	❍ 3	❍ 4
… my child did not feel much like doing anything.	❍ 0	❍ 1	❍ 2	❍ 3	❍ 4
… my child felt lonely.	❍ 0	❍ 1	❍ 2	❍ 3	❍ 4
… my chid was insecure or anxious.	❍ 0	❍ 1	❍ 2	❍ 3	❍ 4

53. To what extent do the following characterisations apply to your child?

Please give your answers on the basis of the child's behaviour **over the last six months.**

	Not true	***Somewhat true***	***Certainly true***
Considerate of other people's feelings	❍ 0	❍ 1	❍ 2
Restless, overactive, cannot stay still for long	❍ 0	❍ 1	❍ 2
Often complains of headaches, stomach-aches or sickness	❍ 0	❍ 1	❍ 2
Shares readily with other children (toys, etc.)	❍ 0	❍ 1	❍ 2
Often has temper tantrums or hot tempers	❍ 0	❍ 1	❍ 2
Rather solitary, tends to play alone	❍ 0	❍ 1	❍ 2
Generally obedient, usually does what adults request	❍ 0	❍ 1	❍ 2
Has many worries, often seems worried	❍ 0	❍ 1	❍ 2
Constantly fidgeting or squirming	❍ 0	❍ 1	❍ 2
Has at least one good friend	❍ 0	❍ 1	❍ 2
Often fights with other children or bullies them	❍ 0	❍ 1	❍ 2
Often unhappy, downhearted or tearful	❍ 0	❍ 1	❍ 2
Generally liked by other children	❍ 0	❍ 1	❍ 2
Easily distracted, concentration wanders	❍ 0	❍ 1	❍ 2
Nervous or clingy in new situations, easily loses confidence	❍ 0	❍ 1	❍ 2
Kind to younger children	❍ 0	❍ 1	❍ 2
Picked on or bullied by other children	❍ 0	❍ 1	❍ 2
Often volunteers to help others	❍ 0	❍ 1	❍ 2
Can be spiteful to others	❍ 0	❍ 1	❍ 2
Gets on better with adults than with other children	❍ 0	❍ 1	❍ 2
Has many fears, easily scared	❍ 0	❍ 1	❍ 2
Sees tasks through to the end, good attention span	❍ 0	❍ 1	❍ 2

CUESTIONARIO SOBRE ACTIVIDAD FÍSICA Y SEDENTARISMO

Leisure time activities and consumer behaviour

54. How much time does your child usually spend per day <u>at a park, playground, or outdoor recreation area</u> (e.g. swimming pool, zoo or amusement park)?

Please indicate for every timeframe. Include times while the child is at day care, kindergarten, preschool or school.

	0 minutes	***1-15 minutes***	***16-30 minutes***	***31-60 minutes***	***Over 60 minutes***
Wake-up time until noon	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5
Noon until 6 PM	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5
6 PM until bedtime	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5

55. Think for a moment about a typical weekday for your child in the last month. How much time would you say your child spends playing outdoors on a typical weekday?

|___|___| hours |___|___| minutes

56. Now think about a typical weekend day for your child in the last month. How much time would you say your child spends playing outdoors on a typical weekend day?

|___|___| hours |___|___| minutes

57. Is your child member in a sports club?

❍ 1 Yes

❍ 2 No

If yes: How much time does he/she spend doing sport in a sports club per week?

|___|___| hours |___|___| minutes

60. How long does your child usually watch TV / video / DVD per day?

	Not at all	***Less than 30 min. per day***	***Less than 1 hour per day***	***Approx. 1 – 2 hrs. per day***	***Approx. 2– 3 hrs. per day***	***More than 3 hours per day***
Weekdays	❍ 0	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5
Saturday/Sunday	❍ 0	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5

61. How long does your child usually sit at a computer per day?

	Not at all	***Less than 30 min. per day***	***Less than 1 hour per day***	***Approx. 1 – 2 hrs. per day***	***Approx. 2– 3 hrs. per day***	***More than 3 hours per day***
Weekdays	❍ 0	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5
Saturday/Sunday	❍ 0	❍ 1	❍ 2	❍ 3	❍ 4	❍ 5

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