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

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CONFLICT OF INTERESTS

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ABSTRACT

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

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

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

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

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INTRODUCTION

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

Besides from being associated with higher all-cause mortality (7), childhood obesity was shown to lead to a lower educational attainment in later life in men (8). This association

remained stable also after adjustment for intelligence level and SES. Moreover, obesity is associated with developmental delays already at a very young age (9).

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

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

METHODS

IDEFICS is a multi-centre population-based intervention study on childhood obesity that is carried out in selected regions of eight European countries comprising Belgium, Cyprus, Estonia, Germany, Hungary, Italy, Spain and Sweden. The study was set up in pre- and primary school settings in a control and an intervention region in each of these countries. Two major cross-sectional surveys (baseline and follow-up) were conducted in pre-schools and primary school classes (1st and 2nd grades at baseline). The baseline survey (September 2007 - May 2008) reached a response proportion of 51% (ranging from 41% to 66% in the

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single countries) and included 16.220 children aged 2 to 9 years. The general design of the IDEFICS study has been described elsewhere (14, 15). The present study only includes children for whom full information on the investigated socioeconomic factors is available. This holds true for 11,994 children (50.9 % boys, 49.1 % girls). A brief description of the study regions can be found in the appendix of this paper. It should be noted that the study regions are not representative on a national level.

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

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

Socioeconomic factors: micro level

Different information on the direct social environment of the children stems from the IDEFICS baseline survey data. The three traditional SES indicators education, occupation and income of the parents were assessed as follows: The *parental educational level* was assessed

employing two questions: "What is the highest level of education you and your spouse/ partner have?" and "What is the highest level of professional qualification you and your spouse/ partner have?". The country-specific answer categories for these two questions were re-coded according to the International Standard Classification of Education (ISCED97, (16)).

The *parental level of occupation position* was assessed by the following question: "In what occupational position are you and your spouse/ partner presently occupied?" which had to be answered by 18 given categories for each parent. Apart from the group of civil servants, the questionnaire categories were the same for all eight countries. For this paper, the 5-classes version of the European Socioeconomic Classification (ESeC), a modified Erikson-Goldthorpe-Portocarero Schema, was employed on the categories for describing the occupational position (17).

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

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

Socioeconomic factors: macro level

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

The *Human Development Index (HDI)* of the United Nations is a composite statistical index that describes the human development of countries (20). The components that went into the calculation of the 2008 index were: life expectancy, literacy, school participation and gross domestic product. All countries participating in the IDEFICS survey belong to the top group denoted "very high human development countries".

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

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

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

Statistical methods

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

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

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

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

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

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

Ethical issues

All applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during this research. Approval by the appropriate Ethics Committees was obtained by each of the eight centres doing the field work. Study children did not undergo any procedure before both they and their parents had given consent for examinations, collection of samples, subsequent analysis and storage of personal data and collected samples. Study subjects and their parents could consent to single components of the study while abstaining from others.

RESULTS

Basic characteristics of the participating countries can be found in Table 1. The IDEFICS sample consists of eight different countries in Europe that are quite heterogeneous. These comprise five long-standing member states from different regions (one Scandinavian country (Sweden); two from Western Europe (Belgium, Germany); two Mediterranean countries (Italy, Spain) and three countries that entered the European Union in 2004 (Cyprus, Estonia,

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Hungary). This heterogeneity is reflected by several of the investigated macro-level indicators as e.g. the mean equivalized disposable income that is in Hungary and Estonia less than 50% of the other countries, the HDI that is, albeit on a high level, lower in the new Member States compared to the older members. The Gini coefficient is moderate (ranging from 24.0 in Sweden to 31.3 in Spain) in all countries. Childhood poverty is highest in the Mediterranean countries and lowest in Sweden. Formal child care is especially low in Germany. The unemployment rate ranges from 3.6% in Cyprus to 11.3% in Spain.

>>>> Include Table 1 about here

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

In comparison with the national income statistics displayed in Table 1, it can be seen that the survey participants from Belgium and Italy and especially from Cyprus and Germany are below the average national level and the survey participants from Spain, Sweden, Hungary and Estonia are above the average national level. This comparably low socioeconomic status in the German and Italian samples is also reflected in a high proportion of parents with an ISCED level of 2 and lower and also with a low proportion of parents in a high occupational position. Contrastingly, the participating children from Cyprus and Sweden come from families with the highest educational level and occupational position. The proportion of vulnerable groups highly varies between centres: 4.2% of the children in the Hungarian sample have a migrant background as opposed to 31.3% of the children with migrant background in Germany. Unemployment proportions range from 1.3% in the Estonian sample to 11.4% in the German sample. One parent families are especially rare in the Italian

sample (2.2%), and a small social network is most often reported in Hungary (15.5%), Italy

(13.5%) and Spain (16.8%) samples and least often in Sweden (3.2%).

>>>> Include Table 2 about here

The overweight (including obesity) prevalence ranges from 7.5% in the Belgium sample to

42.0% in the Italian sample (Table 3), the obesity prevalence ranged from 1.9% in Belgium

and Sweden to 19.9% in Italy (data not shown). The age-adjusted prevalence odds ratios

(POR) for the traditional SES indicators show two distinct patterns for the different centres

for overweight/obesity. In the majority of the centres an SES gradient for overweight/obesity

can be observed for the additive SES indicator and for all or most of the three single

components (Belgium, Estonia, Germany, Spain and Sweden). The second group of countries

(Cyprus, Hungary and Italy) does not show this SES gradient for overweight/obesity with

PORs for SES close to 1.0.

Even more heterogeneity between centres is observed for the association between other

micro-level socioeconomic factors and overweight/obesity (Table 3). A migrant background

is statistically significantly associated with a higher prevalence of overweight/obesity in

Belgium (POR=2.3, 95%CI=1.23-3.70) and Germany (POR=1.7, 95%CI=1.31-2.27), shows only

weak association in Cyprus and Sweden and no association in the other centres.

Unemployment of parents shows an elevated POR for children's overweight/obesity in

Belgium (POR=2.5, 95%CI=1.15-5.62), Estonia (POR=1.6, n.s.), Germany (POR=1.4, n.s.) and

Sweden (POR=2.0, n.s.), a negative association with children's overweight/obesity in Cyprus

(POR=0.3, n.s.), and only weak or no association in Hungary, Italy and Spain. Children from

one parent families have a higher prevalence of overweight/obesity only in Belgium

(POR=1.7, n.s.), Cyprus (POR=1.4, n.s.), Spain (POR=1.6, n.s.) and Sweden (POR=2.1, 95%CI=1.21-3.56), with no association in the other centres. A small social network is statistically significantly associated with a higher prevalence of overweight/obesity in Germany (POR=1.9, 95%CI=1.19-2.98), Belgium (POR=1.7, n.s.) and Sweden (POR=1.4, n.s.), not associated with the overweight/obesity prevalence in Hungary and Italy and associated with a lower prevalence of overweight/obesity in Cyprus (POR=0.6, n.s.), Estonia (POR=0.6, 95%CI=0.41-0.94) and Spain (POR=0.6, 95%CI=0.41-0.94). Similar results were obtained for obesity alone (data not shown).

>>>> Include Table 3 about here

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

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>>>> Include Figure1a-d about here

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

>>>> Include Table 4 about here

DISCUSSION

This paper investigated the association of different socioeconomic factors with the prevalence of childhood overweight and obesity in eight different European regions. Regarding the classical SES indicators, we found an inverse gradient for overweight and for obesity in five of the eight investigated centres (Sweden, Belgium, Spain, Estonia and Germany) and no association in the Cypriot, Hungarian and Italian centre. Within all five centres with an inverse SES gradient, the parental occupational position and parental education contributed more to the gradient than the equivalized household income. The

investigated association between other socioeconomic factors and overweight was not consistent. Having a migrant background or being from a one-parent family was linked with a higher prevalence of overweight and obesity only in selected centres and was not associated in other centres. For parental unemployment or a small social network, all kind of associations (positive, negative and no association) were found in the eight centres and no clear pattern could be found. Furthermore, we investigated factors on a country and on a centre-specific level that could possibly explain the differences concerning the SES gradient. Highest correlations were found with country-specific HDI and centre-specific mean income for both, the SES gradient of overweight including obesity and that of obesity alone.

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

or even across different continents. Here, the parental education poses probably the most promising alternative.

The association between other socioeconomic factors and childhood obesity has only rarely been the subject of study. Apart from an inverse SES gradient, Singh et al. (25) found in a US cohort a higher risk for overweight and obesity for children of unemployed households, with single mothers, with parents with low social capital, of selected ethnicities (Hispanics, non-Hispanic blacks and American Indians) and children of households where English was not the primary language. Bürgi et al. (26) found a small but statistically significant difference of the BMI of migrant of non-migrant parents in Swiss children and Will et al. (27) showed for a German pre-school sample a higher point prevalence of obesity in children of migrant parents as opposed to children of non-migrant parents. This might be due to social or genetic causes; the influence of race on childhood obesity was repeatedly shown in US studies.

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

report, and this may or may not have influenced results. Unfortunately, the validity of self-reported socioeconomic indicators is largely understudied.

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

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

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reflects the author's view and is provided as is.

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

	Belgium	Cyprus	Estonia	Germany	Hungary	Italy	Spain	Sweden
Mean equivalized disposable income per year								
Euros	19,986	18,935	6,333	21,086	4,827	17,734	14,583	21,805
Purchasing power standards (PPS)	18,606	21,555	8,635	20,738	7,237	17,307	15,707	18,865
Gini coefficient								
	27.5	28.0	30.9	30.2	25.2	31.0	31.3	24.0
Human Development Index (HDI) Source: United Nations Development Programme (http://hdr.undp.org)								
	0.865	0.807	0.816	0.885	0.804	0.850	0.861	0.885
Children (less than 16 yrs) below poverty line								
in %	16.7	13.2	17.1	14.7	19.5	24.6	24.1	12.3
Formal child care (>=30 hours)								
<3 years in %	23	18	16	9	5	16	16	31
3 years – minimum compulsory school age in %	74	43	84	36	57	72	45	64
Unemployment								
Unemployment rate 2008	7.0	3.6	5.5	7.5	7.8	6.7	11.3	6.2

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

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Table 2: Basic characteristics of included children: family level indicators

Country	Belgium	Cyprus	Estonia	Germany	Hungary	Italy	Spain	Sweden
Sample size	N=1,520	N=1,049	N=1,415	N=1,669	N=1,758	N=1,673	N=1,507	N=1,619
Age in yrs: mean (std)	5.6 (1.6)	6.2 (1.4)	5.9 (2.1)	6.1 (1.8)	6.3 (1.8)	6.2 (1.8)	5.7 (1.8)	5.7 (2.0)
Parental education								
ISCED 0-2 in %	3.2	3.0	1.8	35.4	2.3	19.0	7.8	1.2
ISCED 3-4 in %	49.1	36.0	83.3	48.8	51.4	61.2	38.1	27.7
ISCED 5-6 in %	47.7	61.0	14.9	15.8	46.3	19.8	54.1	71.0
Parental occupation								
Lower technical & routine occ. in %	11.4	12.1	18.2	23.9	22.5	27.8	11.0	11.0
Lower services & sales occ. in %	16.6	11.7	6.6	12.0	21.4	22.4	15.2	8.5
Small employers & self-employed in %	13.4	19.0	10.0	6.2	10.3	21.5	15.7	8.4
Intermediate employee in %	26.8	16.8	23.8	34.8	20.9	20.0	25.0	25.3
Salariat in %	31.0	39.6	41.3	20.9	24.3	7.1	31.7	45.5
Equivalized yearly household income								
In Euros: mean (std)	19,147 (6,898)	13,152 (9,381)	8,218 (4,819)	14,049 (6,789)	5,378 (2,380)	10,170 (4,652)	15,689 (6,159)	23,145 (7,301)
In PPS: mean (std)	18,685 (6,732)	14,972 (10,679)	11,206 (6,571)	13,817 (6,677)	8,063 (3,568)	9,468 (4,331)	16,900 (6,634)	20,024 (6,316)
SES								
Indicator: mean (std)	10.54 (2.83)	10.92 (2.63)	10.16 (2.84)	9.10 (3.38)	9.94 (3.32)	8.63 (2.97)	10.28 (2.88)	11.04 (2.79)
Vulnerable groups								
Migrant background	5.7	27.7	5.2	31.3	4.2	17.2	10.4	16.7
Unemployment	3.0	2.9	1.3	11.4	7.3	7.0	7.4	2.0
One parent family	8.6	9.6	9.6	13.7	14.6	2.2	7.3	6.1
Small social network	6.6	9.4	9.2	6.8	15.5	13.5	16.8	3.2

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

Country	Belgium	Cyprus	Estonia	Germany	Hungary	Italy	Spain	Sweden
Sample size	N=1,520	N=1,049	N=1,415	N=1,669	N=1,758	N=1,673	N=1,507	N=1,619
Overweight including obesity in %	7.5	24.6	13.6	15.0	15.2	42.0	19.7	10.3
Equivalized yearly household income								
In Euros/10,000	0.7 (0.54-0.97)	1.0 (0.83-1.13)	0.7 (0.49-0.97)	0.6 (0.50-0.79)	0.8 (0.47-1.43)	1.1 (0.88-1.34)	0.8 (0.64-1.02)	0.8 (0.60-0.95)
In PPS/10,000	0.7 (0.53-0.97)	1.0 (0.85-1.11)	0.8 (0.59-0.98)	0.6 (0.50-0.79)	0.9 (0.60-1.27)	1.1 (0.87-1.37)	0.8 (0.66-1.02)	0.7 (0.55-0.94)
Parental education								
ISCED 0-2	2.1 (0.84-5.20)	1.2 (0.52-2.58)	1.4 (0.44-4.56)	2.5 (1.54-3.93)	1.3 (0.55-3.04)	1.3 (0.95-1.79)	2.2 (1.37-3.60)	2.4 (0.77-7.17)
ISCED 3-4	1.5 (0.99-2.19)	1.1 (0.83-1.42)	1.3 (0.83-2.12)	1.5 (0.94-2.40)	1.2 (0.95-1.63)	1.0 (0.79-1.31)	1.6 (1.18-2.14)	1.2 (0.87-1.75)
ISCED 5-6	1.0 (Ref.)	1.0 (Ref.)	1.0 (Ref.)	1.0 (Ref.)	1.0 (Ref.)	1.0 (Ref.)	1.0 (Ref.)	1.0 (Ref.)
Parental occupation								
Lower technical & routine occ.	1.9 (1.07-3.45)	1.2 (0.73-1.83)	1.7 (1.12-2.58)	1.6 (1.05-2.49)	1.1 (0.78-1.63)	1.0 (0.64-1.47)	1.2 (0.73-1.91)	1.9 (1.14-3.04)
Lower services & sales occ.	1.1 (0.64-2.08)	1.2 (0.76-1.91)	1.0 (0.48-1.90)	2.1 (1.32-3.45)	0.9 (0.58-1.28)	0.8 (0.55-1.27)	1.2 (0.81-1.89)	1.5 (0.86-2.70)
Small employers & self-employed	1.0 (0.54-2.08)	1.3 (0.86-1.84)	0.9 (0.51-1.64)	1.4 (0.71-2.59)	0.8 (0.50-1.37)	0.9 (0.56-1.31)	1.1 (0.72-1.70)	1.7 (0.95-2.90)
Intermediate employee	1.0 (0.60-1.74)	0.8 (0.50-1.19)	1.3 (0.91-2.00)	1.3 (0.89-2.04)	0.9 (0.60-1.32)	0.7 (0.44-1.05)	1.1 (0.75-1.58)	1.2 (0.80-1.83)
Salariat	1.0 (Ref.)	1.0 (Ref.)	1.0 (Ref.)	1.0 (Ref.)	1.0 (Ref.)	1.0 (Ref.)	1.0 (Ref.)	1.0 (Ref.)
SES								
Additive indicator	0.91 (0.85-0.97)	0.99 (0.94-1.04)	0.94 (0.89-0.99)	0.91 (0.88-0.95)	0.99 (0.95-1.03)	0.99 (0.96-1.02)	0.94 (0.90-0.99)	0.92 (0.87-0.97)
Vulnerable groups								
Migrant background	2.3 (1.23-4.27)	1.3 (0.94-1.73)	1.1 (0.58-2.16)	1.7 (1.31-2.27)	1.0 (0.51-1.87)	1.0 (0.76-1.27)	1.0 (0.62-1.52)	1.3 (0.84-1.90)
Unemployed	2.5 (1.15-5.62)	0.3 (0.10-1.13)	1.6 (0.52-5.06)	1.4 (0.97-2.13)	0.7 (0.41-1.27)	1.3 (0.89-1.91)	1.0 (0.59-1.73)	2.0 (0.80-4.86)
One parent family	1.7 (0.93-2.95)	1.4 (0.86-2.14)	0.9 (0.51-1.51)	0.9 (0.59-1.32)	1.2 (0.81-1.67)	0.9 (0.43-1.73)	1.6 (0.99-2.63)	2.1 (1.21-3.56)
Small social network	1.7 (0.90-3.22)	0.6 (0.36-1.05)	0.6 (0.41-0.94)	1.9 (1.19-2.98)	0.9 (0.62-1.30)	0.9 (0.67-1.20)	0.6 (0.41-0.94)	1.4 (0.61-3.09)

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Table 4: Correlation of social indicators with SES gradient of overweight / obesity in all eight centres
Pearson's correlation coefficients of investigated indicators with beta estimates of SES on overweight / obesity

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

	POR
Sweden	0.44 (0.23-0.85)
Spain	0.69 (0.41-1.18)
Italy	1.07 (0.76-1.52)
Hungary	0.97 (0.61-1.55)
Germany	0.35 (0.21-0.58)
Estonia	0.66 (0.38-1.17)
Cyprus	1.01 (0.61-1.67)
Belgium	0.48 (0.24-0.95)
All	0.77 (0.65-0.91)

Dotted line: POR for all countries; solid line: POR=1.0
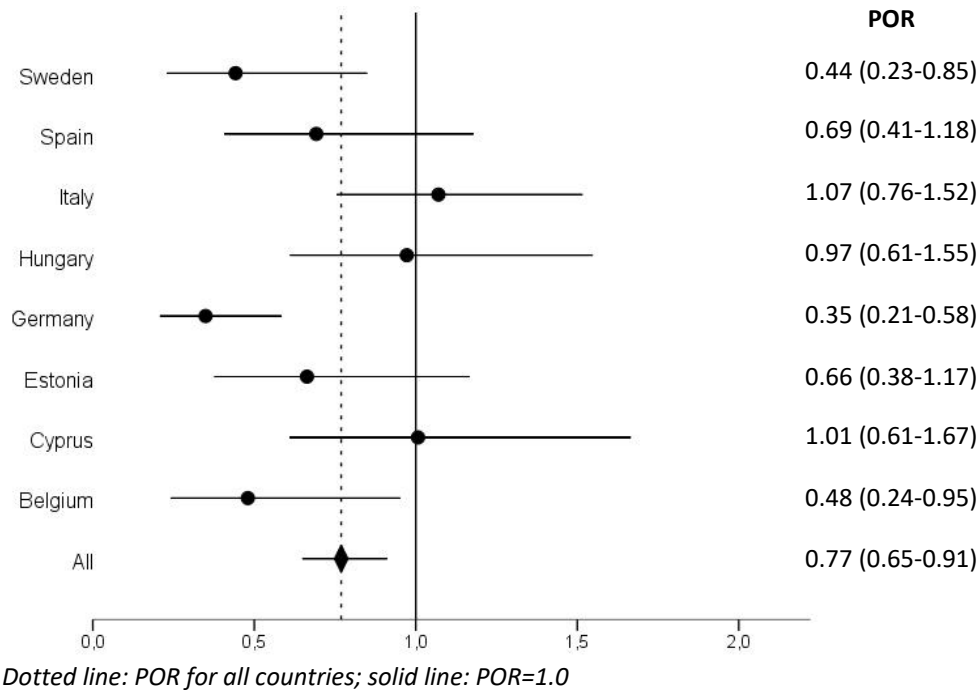
Figure 1a: SES indicator component: Household income
Prevalence odds ratios for overweight/obesity with 95% confidence interval

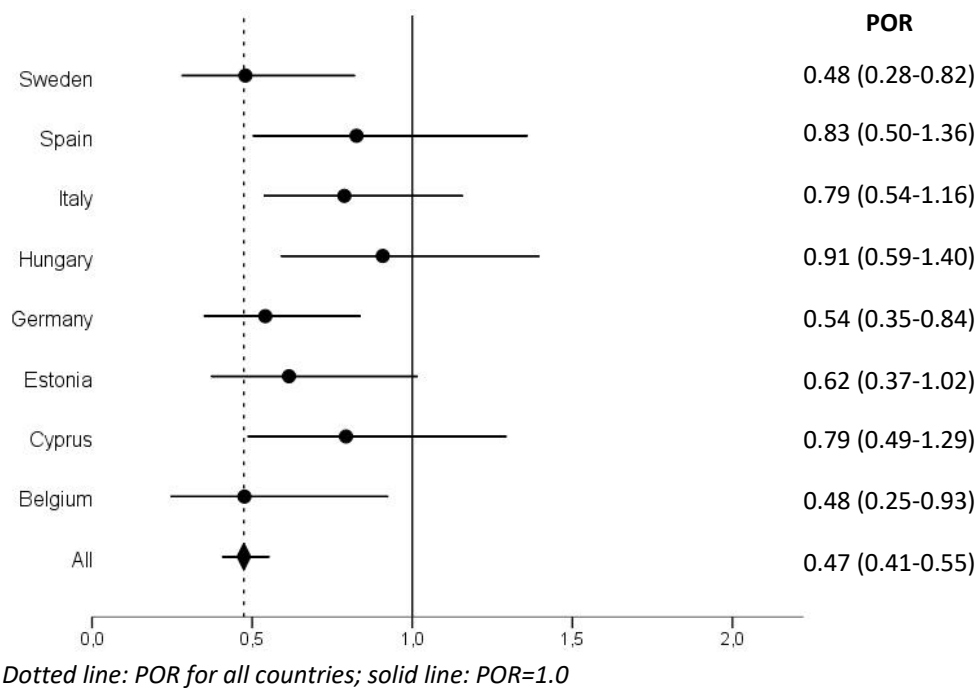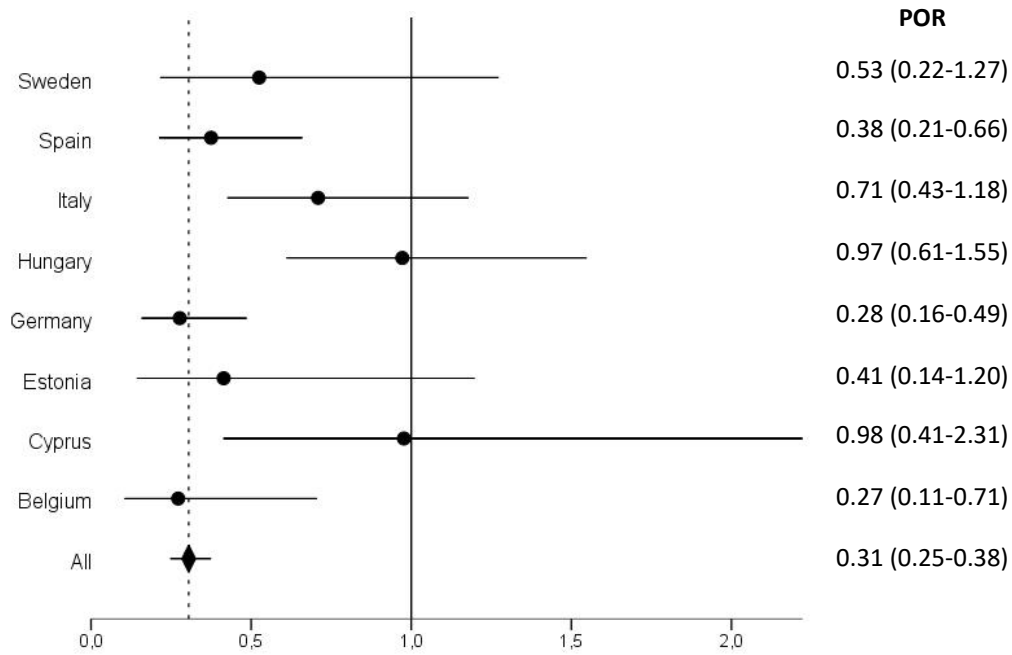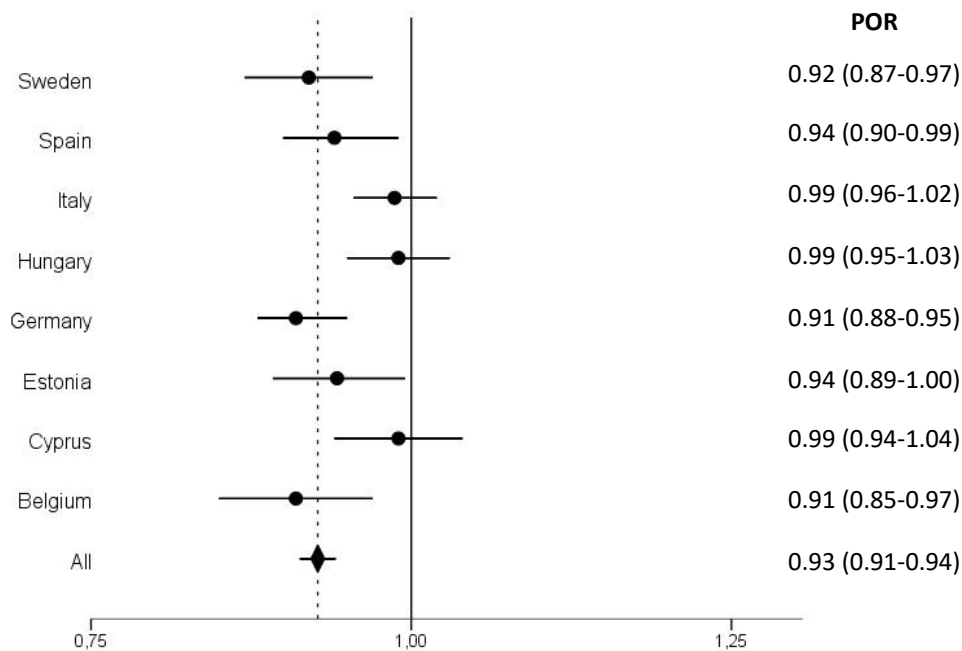|	POR
Sweden	0.48 (0.28-0.82)
Spain	0.83 (0.50-1.36)
Italy	0.79 (0.54-1.16)
Hungary	0.91 (0.59-1.40)
Germany	0.54 (0.35-0.84)
Estonia	0.62 (0.37-1.02)
Cyprus	0.79 (0.49-1.29)
Belgium	0.48 (0.25-0.93)
All	0.47 (0.41-0.55)

Dotted line: POR for all countries; solid line: POR=1.0

Figure 1b: SES indicator component: Parental occupational position
Prevalence odds ratios for overweight/obesity with 95% confidence interval

	POR
Sweden	0.53 (0.22-1.27)
Spain	0.38 (0.21-0.66)
Italy	0.71 (0.43-1.18)
Hungary	0.97 (0.61-1.55)
Germany	0.28 (0.16-0.49)
Estonia	0.41 (0.14-1.20)
Cyprus	0.98 (0.41-2.31)
Belgium	0.27 (0.11-0.71)
All	0.31 (0.25-0.38)

Dotted line: POR for all countries; solid line: POR=1.0

Figure 1c: SES indicator component: Parental education
Prevalence odds ratios for overweight/obesity with 95% confidence interval

	POR
Sweden	0.92 (0.87-0.97)
Spain	0.94 (0.90-0.99)
Italy	0.99 (0.96-1.02)
Hungary	0.99 (0.95-1.03)
Germany	0.91 (0.88-0.95)
Estonia	0.94 (0.89-1.00)
Cyprus	0.99 (0.94-1.04)
Belgium	0.91 (0.85-0.97)
All	0.93 (0.91-0.94)

Dotted line: POR for all countries; solid line: POR=1.0

Figure 1d: Additive SES indicator
Prevalence odds ratios for overweight/obesity with 95% confidence interval

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Appendix
Table A: Description of study regions

	Belgium	Cyprus	Estonia	Germany	Hungary	Italy	Spain	Sweden
Intervention region								
Name	Geraardsbergen	Strovolos	Tartu	Delmenhorst	Pecs	Atripalda/ Monteforte I/ Volturara I	Zaragoza 1. District	Partille
Province	East-Flanders	Nicosia District	Tartumaa	Lower Saxony	Baranya	Avellino	Zaragoza	Västra Götaland
Size (population)	31,380	100,000	101,965	79,000	156,567	25,309	57,199	33,614
Pop density (inh/sqm)	394	na	2,538	1,195	963	1,314/ 444/129	660 (whole Zaragoza)	585
Citizenship Non nationals in %	na	na	20	7.9	7.4	1.6	2.2	13.4
Control region								
Name	Aalter	Paphos	Tallinn	Wilhelmshaven	Zalaegerszeg	Avellino/ Forino/ Pratola Serra	Huesca	Alingsas, Mölndal
Province	East-Flanders	Paphos	Harjumaa	Lower Saxony	Zala	Avellino	Huesca	Västra Götaland
Size (population)	18,841	51,000	396,852	81,000	62,158	65,569	49,312	95,805
Pop density (inh/sqm)	230	na	2,555	759	622	1,867/ 259/453	323	80/415
Citizenship Non nationals in %	na	na	28.9	5.2	4.5	1.4	4.1	11.4
Linear distance in km	46	120	185	68	190	5-22	74	11-33

Source: Data from project partners